The Salmon Source

An Educator's Guide

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Preface

April 2018

Dear California Educators,

The Salmon Source has served thousands of Classroom Aquarium Education Program students and hatchery education projects statewide since the California Department of Fish and Wildlife originally published it over a decade ago. It came time to revise the Salmon Source with the implementation of the Next Generation Science Standards and Common Core curriculum. We are proud to present this updated edition correlated with California's most current education standards.

Salmon are one of California's most iconic species. The determination displayed during their spawning migration from the Pacific Ocean to faraway inland rivers, is symbolic of the California way. Faced with seemingly insurmountable obstacles and miniscule odds of success, Gold Rush pioneers flocked to the same faraway rivers in search of prosperity. Most came up short. The same is true for California's salmon today.

As we manage our sensitive salmonid populations in the face of a changing climate, unpredictable ocean conditions, increasing demands for water, and challenges with implementation of inland restoration measures, there is an elevated need to grow awareness and foster broad stewardship partnerships to conserve our native fishery heritage.

We have a responsibility to educate current and future generations of California students on the importance of fish and wildlife habitat conservation. The revised Salmon Source is an excellent tool for this purpose. The lessons provided here span issues of salmonid life cycle, physiology, ecologic needs, watershed issues and management practices. Some lessons meld the arts and humanities with sciences for an interdisciplinary approach to learning. A unique lesson reinforces student learning in the field of genetics with active learning about the role of fish hatcheries in maintaining genetic diversity.

Just as the grit of Gold Rush pioneers led to a prosperous California, if educators continue to help young people connect with fish, wildlife and the outdoors, the future is bright. Whether in their own backyards, urban greenbelts, or remote areas from Sierra ridgetops to ocean seafloors, this curriculum can help make the connections between our actions and the health of ecosystems, and therefore provide California a future of unmatched biodiversity.

Clark Blanchard
Assistant Deputy Director
Communications, Education and Outreach

The Evolving Story of Salmon in California

Like all other animals and plants in California, salmon are an integral part of the web of life. But unlike some other life forms, salmon and their dramatic life history simultaneously conjure up images of life's struggles as well as its grandeur, the dangers of journeying through rivers and oceans as well as the drive to overcome endless obstacles on the way to successful reproduction.

For thousands of years before humans began to settle the West, salmon have lived in the rivers, streams and ocean waters of California, evolving over time and adapting to the particular climatic and geologic conditions that shape their environment. For these salmon, adaptation has meant evolving ways to reproduce despite torrential rains that could transform a bubbling brook into a raging river, droughts that could dry up entire streams, landslides that could bury a whole generation of young salmon, poor oceanic conditions with warm water and a sparse food supply, and predators at every point along the way. Faced by such selective pressures, salmon have managed to persist and attain that crucial balance between a seeming over-abundance of eggs produced during reproduction and mortalities suffered throughout their life cycle.

The arrival of settlers in California changed the equation. Over the course of a few generations, salmon began to experience an exacerbation of the environmental forces to which they had adapted and with which they lived in balance. Water flow changed when rivers were dammed, construction linked to urbanization produced continuous streams of mud and sediments to creeks where young salmon were emerging from their eggs, logging robbed the clear, cool spawning streams of crucial shade from trees, and road construction created numerous barriers preventing salmon from swimming up or downstream.

In addition to these exacerbations of 'natural' selective pressures, populations of salmon were now faced with challenges they had never before experienced and to which they had not evolved any adaptive responses. With greater frequency, industrial waste products and household chemicals were polluting freshwater environments, animal and plant species not native to California (whether introduced intentionally or unknowingly) were changing the predator-prey relationships and competitive dynamics among the species that had evolved in California waterways, and technological advances made it possible to catch salmon with hugely impacting efficiency.

The effects of all these changes on salmon populations were as predictable as they were inevitable. The growth of California's human population, along with rapid urban development and extensive industrial activity, placed increasing strain on aquatic environments and their inhabitants. Over the course of a few decades, many salmon runs experienced massive declines or even local extinctions. Though none of the Pacific salmon species that have historically populated California's rivers have become entirely extinct, the two most common, Chinook and coho salmon, are now protected under the federal or state Endangered Species Act (ESA).

Even protection under the ESA, however, is neither a guarantee for long-term survival of a species, nor assurance of rapid recovery. Recovery of an endangered species requires the collective will and commitment of the people of the state and their political leaders, as well as awareness and action on the part of each individual. In this context, education leading to an understanding of salmon biology and ecology plays an important role in restoring healthy populations of salmon in California.

(continued)

Introduction

The exercises contained in this workbook were designed by scientists and professionals engaged in higher education and natural resource management. They cover a broad spectrum of topics related to salmon biology and ecology aimed at grades three through eight. These activities have been correlated by grade level to California Department of Education content standards in multiple disciplines. It is recommended that formal and non-formal educators employ those activities specified for use with the grade level / age of students with whom they interact. Students are likely to express keen interest in the activities during the period of time that salmonid eggs are hatching out and the young fry are developing.

Assessing the children's level of knowledge before experiencing the unit and, then again, after having raised the fry and completing the designated activities is one way to demonstrate the value of this educational program. The Department of Fish and Wildlife appeals to educators who are using this program to assist us in evaluation of this program by administering the student assessment provided and communicating results with your DFW regional Classroom Aquarium Education Program (CAEP) representative.

Manfred Kittel

Fisheries Biologist
California Department of Fish and Wildlife

The Revised Salmon Source

The Salmon Source was originally written in 2007, when the 1998 California State Standards in Science were in effect. California adopted the Next Generation Science Standards (NGSS) in 2013, with adoption to be a several year process. Therefore this revision of The Salmon Source includes the 2013 NGSS.

The NGSS have some content at different grade levels than the 1998 California State Standards in Science. Some of the activities in this revision of The Salmon Source has been moved to different grade levels and adapted for appropriate developmental level as needed to align with the NGSS.

California adopted Common Core State Standards in English/Language Arts in 2011. This revision of The Salmon Source also correlates to those.

When used as part of a well planned curriculum, the activities in The Salmon Source can help students achieve state standards. A given activity, or even a 3-lesson unit, will not in itself assure mastery of standards.

Classroom Aquarium Education Program

The Department of Fish and Wildlife is committed to fostering the next generations of resource stewards through education programs for both the classroom and the outdoors. The Classroom Aquarium Education Program (CAEP) is one of these important programs.

Through a classroom experience of hatching fish eggs and coordinated activities, students experience first-hand the value of aquatic environments, the balance that must be met to maintain and preserve California's fisheries and aquatic habitats, and how their personal actions affect these valuable resources.

Instructors and their students set up an aquarium in the classroom, receive fish eggs under a special Department of Fish and Wildlife permit, and observe the fish as they hatch and develop. The experience may culminate in a field trip to a local stream or river where the fish are released. Critical to protection of the resource is release of fry into an appropriate watershed as designated by a DFW biologist. This is a hands-on, interdisciplinary project for grades K-12.

The CAEP is offered statewide in partnership with regionally-based community organizations. While the program has several names around the state, the essential learning elements and student experiences are similar. The prerequisite training workshops are held at locations throughout the state. Completion of a training workshop is required to receive eggs. Teacher training workshops are offered at least once a year in each region.

As the Department of Fish and Wildlife moves towards more fully integrating our education and outreach programs, we are identifying efforts that support and further enhance existing programs. *The Salmon Source* is one such effort that serves as a complement to the CAEP as well as other environmental education programs.

Visit the California Department of and Wildlife web site at www.wildlife.ca.gov to find out more about the Classroom Aquarium Education Program and how you can become involved.

Salmonid Background Information

Salmonids: Salmon, Steelhead and Rainbow Trout

Salmon and trout are closely related fish. They share many characteristics and are often found in the same rivers and streams in California. These fish, however, are not identical, and it is important to be aware of their differences. The words "salmonid," "steelhead" and "rainbow trout" appear frequently throughout this Educator's Guide. Let's take a moment to examine how the differences in these categories actually play out in the context of fish life cycle and life history.

All Pacific salmon, as well as rainbow trout, are classified as members of the genus *Oncorhynchus*. There are several unique species of salmon in this genus each having specific habitat needs and behavioral adaptations. These include Chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*O. kisutch*) and pink salmon (*O. gorbuscha*), but also rainbow trout (*O. mykiss*) and cutthroat trout (*O. clarki*). The fact that rainbow trout are grouped with Pacific salmon in the same genus reflects their similarity in physical features and in their ecological needs for survival. This genus *Oncorhynchus* is banded together with some other genera and grouped in the larger family Salmonidae. And so it is that all fish belonging to this family are referred to as salmonids.

While salmon and trout are very closely related, the differences between steelhead trout and rainbow trout are even smaller. Amazing as it may seem, steelhead and rainbow trout are the same species *Oncorhynchus mykiss* (*O. mykiss*). The two are genetically indistinguishable. Their life histories, however, are dramatically different. Populations of *O. mykiss* that spend their entire lives in a freshwater environment, whether stream or lake, are called rainbow, or resident trout. On the other hand, some populations of *O. mykiss* that were spawned in coastal streams migrate out to the ocean for some period of their life cycle. These migratory trout are then called "steelhead" trout. Although genetically identical, rainbow trout and steelhead trout become physically very different as their bodies adapt to different environments. This is most obvious when comparing their adult size. Freshwater rainbow trout typically reach a weight of one to five pounds at maturity. Sea-run steelhead trout are able to grow substantially larger and may attain a weight of up to forty pounds.

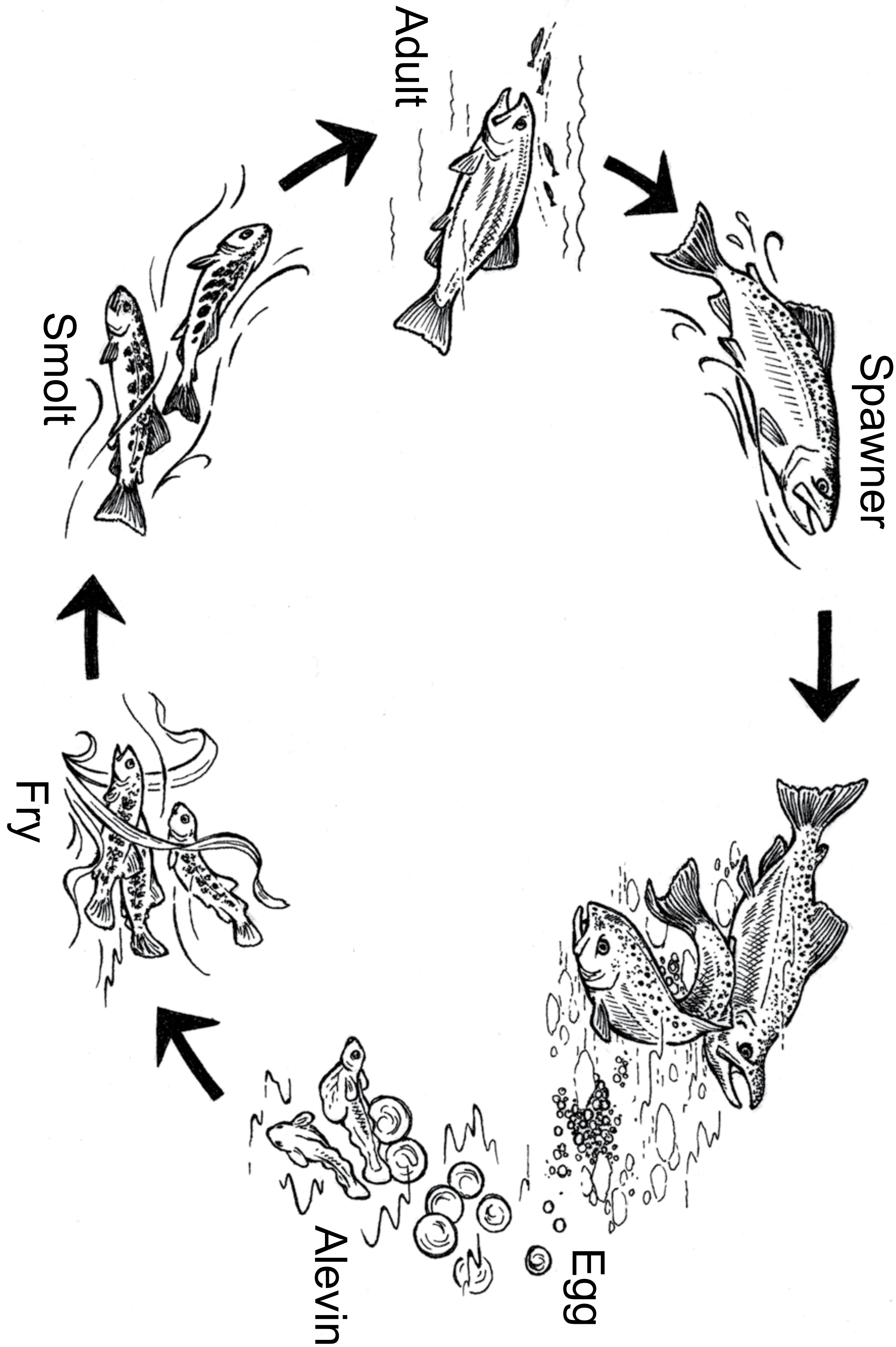
The phenomenon of different life histories within the same species applies with some other salmonids as well. For example, cutthroat trout, which are found in the same rivers as salmon in northern California can become anadromous, spending part of their life in the ocean and returning to freshwater to spawn, or, alternatively, some cutthroat trout spend their entire lives in a freshwater environment.

Migratory life history and physical similarity with salmon are the main reasons why steelhead trout are often included in general references to the group of Pacific salmon. However, the life cycle of steelhead trout differs in a significant way from that of a typical Pacific salmon. For salmon, spawning activity marks the end of the adults' lives and the beginning of a new generation. But steelhead trout are able to spawn more than once. Steelhead trout are able to migrate back to the ocean after spawning in a freshwater stream, and have the ability to return in a subsequent year to spawn again. This capacity for multiple spawnings also applies to rainbow trout. In direct contrast to the steelhead trout cycle, Pacific salmon usually undergo a single round-trip migration from freshwater to the ocean and back to their natal stream for spawning.

Following their first and only chance to reproduce in a coastal stream, Pacific salmon will soon die near the place where they spawned. Similarly, when steelhead trout die, though it may be after multiple spawnings have been accomplished, they will also die close to the place where they last laid their eggs. The decomposition of the adult salmonid carcasses in the streams where their offspring will start their own life plays an important ecological role. Some of the carcasses provide food for predators, such as otters and coyotes. Some of the nutrients from the decomposing fish are taken up by algae and decomposers, entering the food web that ultimately will provide energy to the new generation of salmon and trout after hatching.

Manfred Kittel and David W. Moore

California Department of Fish and Wildlife


Adult
Spawner
Egg
Alevin
Fry
Smolt

How to use The Salmon Source

The Salmon Source is a sequential grade level salmonid curriculum aligned with California State Content Standards. This curriculum was designed to bring salmonid education into classrooms of interested teachers not raising fish, as well as to support teachers participating in the Classroom Aquarium Education Program (CAEP). This was a joint project between the California Department of Fish and Wildlife and Humboldt State University.

An extensive search was conducted to find the best existing salmonid activities. The three activities for the third, fourth, fifth and sixth grade units were chosen based on the results of an expert panel review by educators, interpreters, biologists and community partners involved in conducting teacher trainings for CAEP. Minor modifications to the original activities were made based on the results of activity field testing in classrooms. The seventh and eighth grade activities are included as a supplement to the curriculum for educators who wish to teach about salmonids at a more advanced level.

Permission to reproduce these activities was received from the original copyright holders. Contact information for each activity's original source is provided at the end of each activity.

Organization of Activities

Activities are presented by grade level units, from third through eighth grade. There are three activities for each of the third through sixth grade units. There are two supplemental activities each for the seventh and eighth grades. Each unit begins with an overview of what the activities in that unit will teach.

Each activity begins with an overview of what students will do in the activity, time required to complete the activity, setting, topic, objectives, content standards the activity meets, skills needed for students to do the activity, key vocabulary, and materials required.

Each activity provides background information for the educator, steps for preparation, detailed procedural directions, potential extensions to the activity, and acknowledgement of the original source of the activity.

This curriculum is designed to educate students about salmonids. While some activities have students working in teams, activities are not designed to be competitive. Materials are therefore referred to as activities in order to encourage meaningful learning among students.

Assessments

Each third through sixth grade activity and unit ends with a twelve question assessment of knowledge. Students should be able to answer all of the questions after completing an activity or unit. These questions directly relate to the California State Content Standards for each grade. Answers to assessment questions are provided for the educator in an appendix to the curriculum.

Appendices

The appendices include a glossary of key vocabulary, maps of salmonid distribution throughout the state of California, a universal correlation chart for all activities, and answers to the assessment questions.

Grade 3 Overview

This unit introduces students to the life of salmonids. Students will learn about growth, change, and factors affecting survivability by exploring the salmon life cycle. Students will discover that what people do with water in their watershed affects other watersheds all over the planet. Students will understand that the water they use every day connects them to both past and present day people, plants, and animals everywhere.

Activity	Time (mins)		Setting	CA Content Standards	Topic
	Prep	Activity			
The Salmon Story	15	50	Indoor	NGSS: 3-LS1-1, 3-LS3-1, 3-LS4-3, 3-LS4-4	Life Cycle
Hooks and Ladders	15	45	Outdoor	NGSS: 3-LS4-3, 3-LS4-4, 3-5ETS1-2	Limiting Factors
Water Wings	15	90	Outdoor	NGSS: 3-LS4-3, 3-LS4-4, 3-ESS2-1	Habitat Conservation

The Salmon Story
American River Salmon published by the **California Department of Fish and Wildlife.**

Hooks and Ladders
Salmonids in the Classroom: Primary. Reprinted with the permission of **Fisheries and Oceans Canada.**

Water Wings
Adapted with permission from Project WILD K-12 Curriculum and Activity Guide.
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3 The Salmon Story

Original Curriculum Provided by: California Department of Fish and Wildlife

Overview

In this activity students create a salmon life cycle bracelet using eight to twelve different colored beads. Each bead represents a part of the life cycle in a story they construct.

Time Required

One fifty minute session

Setting

Indoor or Outdoor

Topic

Life Cycle

Objectives

(1) Describe the parts of the salmon life cycle. (2) Identify hardships and obstacles salmon encounter during the migration cycle.

California Standards

NGSS: 3-LS1-1, 3-LS3-1, 3-LS4-3, 3-LS4-4

Common Core English:

SL 3-1, 3-2, 3-3, 3-4

L 3-1, 3-3, 3-4, 3-6

Skills

Fine motor skills, creativity

Key Vocabulary

Life cycle, migration

Materials

- Medium sized Pony beads; at least 12 colors (more if possible)
- Satin or leather cording
- Storybook: *Salmon Stream* or *The Salmon*

Background Information

The ***life cycle*** of a Chinook salmon begins when the female deposits eggs in a shallow gravel depression, called a ***redd***, that she digs. Once the male fertilizes the eggs, the female covers the eggs with clean gravel. Newly hatched salmon, called ***alevin***, live in the gravel and survive by absorbing proteins from their ***yolk sacs***. After a few weeks, the yolk sacs are gone and the small fish, known as ***fry***, emerge from the gravel and move into deeper water to find food on their own.

Salmon remain in ***freshwater*** streams feeding and growing for many months or even years before migrating downstream to the ocean. These small salmon are called fingerlings. Before the fingerlings enter the ocean, their bodies change in preparation for the ocean ***saltwater***. They spend time in an ***estuary***, an area where saltwater and freshwater meet and mix. This process of change is called ***smoltification***, and the salmon are now called ***smolts***.

Chinook smolts grow to adults in the Pacific Ocean. In the ocean the salmon grow rapidly by feeding on other fish, shrimp and crustaceans. The salmon also encounter many dangers including sharks, killer whales and other marine mammals, and humans who are also fishing for salmon.

After two to five years in the ocean, they begin the ***migration*** that guides them back to their birth site. Salmon have an inherent ability to return to their original streams. Juvenile salmon ***imprint*** or memorize the unique odors of their home stream. As returning adults they use their sense of smell to guide them upstream where they hatched. Once in their home stream, salmon ***spawn*** and die.

Preparation

1. Create a salmon life cycle bracelet to use as an example.

Procedure

1. Ask students if they have heard the term migration. Define the term and provide an example (ducks migrate each year). Do other animals migrate? Introduce the fact that some fish migrate.

2. Read students the book, *Salmon Stream* or *The Salmon*. The story follows the life cycle of the Pacific salmon. After the story, have students discuss each stage of the salmon's life. Use the life cycle illustration.

3. Explain that each student is going to create a story about the life of a salmon. Show the students the salmon life cycle bracelet. Explain that the bracelet forms a circle like the life cycle. The bracelet, which is a form of art, can be used to tell a story about the salmon. Throughout time people of all cultures have used art to tell stories and to teach. Ask if anyone knows a culture that uses storytelling and art to teach. Write down ideas, for example, totems and cave paintings.

4. Show the students the colored beads. Each student will decide the colors they will use to represent each stage of the life cycle. Students can designate colors for obstacles or hazards that their salmon will encounter during its life. Each bead will tell a part of the story about the salmon as it grows, changes, and travels.

5. Have students choose about eight to twelve beads of different colors. Cut a piece of cording twelve inches or longer per student. Knot one end of the cord and have students create their story bracelet.

   It may be helpful to have a parent volunteer or older student help tie the bracelets when the students finish.

6. Have students share their stories first in small groups of three to five, then to the class. Encourage students to share the story bracelet with their family.

Extensions

1. Have students write out their salmon life story and illustrate it.

2. Use music or rhythm to add to the story.

3. Create a life cycle puzzle. Provide each student with a copy of a large circle. Have students divide the circle into six equal parts (like slicing a pie). In each section have them write the word for one part of the salmon life cycle (spawning adults, eggs, alevins/fry, fingerlings, smolts, ocean salmon). Have students draw a picture to represent each stage. When drawings are complete, the circle can be cut out and the sections cut apart. Students can then assemble and reassemble this circle as a puzzle.

Original Resource

American River Salmon published by the **California Department of Fish and Wildlife.**

California Department of Fish and Wildlife
1416 Ninth Street, Room 1280
Sacramento, CA 95814
Phone: 916.322.8933

Suggestions for Colors of Beads and their Significance

Salmon Stages

Orange- salmon egg
Red- alevin
Light blue- fry
Blue- fingerlings
Teal blue- smolts
Gray- ocean salmon
Light green- returning adults

Habitat

Clear- freshwater
Dark blue- ocean

Predators

Purple- large fish
Dark gray- seal
Black- orca (killer whale)
Yellow- humans
Brown- bear

Food

Light brown- insects
Pink- shrimp
Lavender- small fish

Assessment

Name: ____________________________

1. Salmon alevins get all the food they need from their _________________________.

2. An animal that chases salmon because it wants to eat them is called a _________________________ on the salmon.

3. Salmon can remember the smell of the stream where they were born.

   This is called _________________________.

4. Salmon travel a long way from the stream to the ocean.

   This is called __________________________.

5. When a male salmon comes back to spawn his body looks different. He now has:
   (Circle one)
   (A) bigger eyes
   (B) a longer tail
   (C) a hooked snout
   (D) rougher scales

6. For a salmon trying to swim upstream, the hardest thing to jump over is a:
   (Circle one)
   (A) log
   (B) waterfall
   (C) boulder
   (D) dam

7. To find its way back to its home stream, a salmon uses its sense of:
   (Circle one)
   (A) sight
   (B) hearing
   (C) smell
   (D) taste

8. Salmon living in the ocean eat:
   (Circle one)
   (A) swordfish and whales
   (B) shrimp and crustateans
   (C) insects and spiders
   (D) algae

9. An estuary is a body of water found at the end of a river near the ocean. Tell why a salmon has to spend part of its life in this place.

____

____

10. Why would sharks in the ocean suffer if there were not very many salmon?

____

____

11. Imagine you are a salmon living in the ocean and your home stream has been polluted. Will you be able to find your way home? Why or why not?

____

____

12. Imagine you are fishing for salmon in a river. Would you catch a bigger salmon if it were swimming a long way upstream or a long way downstream? Why?

____

____

Overview

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

Time Required

One sixty minute session

Setting

Outdoors or large indoor area

Topic

Limiting Factors

Objectives

(1) Describe how some fish migrate as part of their life cycles. (2) Identify the stages of the life cycle of one kind of fish. (3) Describe limiting factors affecting Pacific salmon as they complete their life cycles. (4) Generalize that limiting factors affect all populations of animals.

California Standards

NGSS: 3-LS4-3, 3-LS4-4

3-5ETS1-2

Common Core English:

SL 3-1, 3-2, 3-3, 3-4

L 3-1, 3-3, 3-4, 3-6

Skills

Walking, jumping

Key Vocabulary

Life cycle, limiting factors, population, migration

Materials

- Large playing area (100 ft x 50 ft)
- About 500 feet of rope or string or six traffic cones for marking boundaries (masking tape may be used if area is indoors)
- Two cardboard boxes
- 100 tokens (3” x 5” cards, poker chips, macaroni, etc.)
- Jump rope

Background Information

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

The ***life cycle*** of the Pacific salmon begins when the female deposits 1,000 to 5,000 eggs. The eggs are deposited in a shallow gravel depression, called a ***redd***, that she digs by flapping her tail from side to side. Once the eggs are deposited, the male fertilizes them; then both fish nudge the gravel back over the eggs to offer as much protection as possible. The eggs are susceptible to factors such as predation or oxygen deprivation. Within a few days, both the male and female parent salmon die, their ***decomposing*** bodies providing nutrients to the ***aquatic ecosystem***.

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

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

Hooks and Ladders

Original Curriculum Provided by: Council for Environmental Education

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

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

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

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

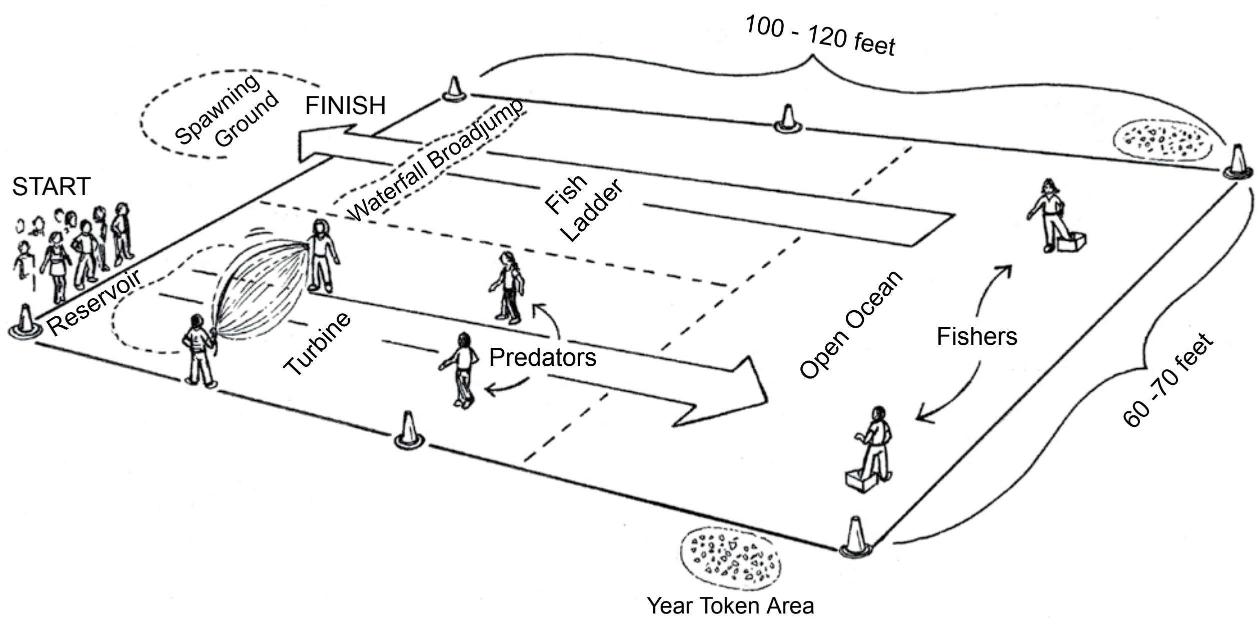
Another threat to salmon is overfishing. Overfishing, combined with habitat destruction, is viewed by biologists as a cause for the decline of salmon populations.

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

Preparation

1. Set up a field before the activity, including spawning grounds, reservoir, downstream, upstream, and ocean. The area must be at least 100 feet by 50 feet. (See diagram.)

2. Have students wear sturdy gym shoes.



Procedure

1. Ask the students what they know about the life cycles of fish that live in their area. Do any local fish migrate to spawn? (Mullet, shad, lake trout, striped bass, suckers, carp, and salmon are examples of fish that migrate to spawn.) Ask the students if they know what a limiting factor is (a reason or cause that reduces the population of an organism.) Using information in the background section, discuss some natural limiting factors, such as lack of vegetation to keep stream water cold.

2. Take the class to the activity area. Tell them that the purpose of this activity is to learn about the life cycle of salmonids and the limiting factors they face. To learn this, each student will become part of the salmonid journey from the home stream to the ocean and back to the home stream. Emphasize that this is not a competition, but a learning exercise to see what happens to the salmonid population.

3. First, walk the students through the activity area, explaining what happens to salmonids at each limiting factor and how the simulation will work at that stage. Begin with all the newly hatched juvenile salmon in the spawning ground. The salmon first move into the reservoir above the dam. In order to simulate the disorientation that salmon face because of a lack of current to direct them on their journey, they must stay in the reservoir while they count to 30.

4. The salmon then start their journey downstream. The first major limiting factor that the salmon encounter is the turbines at the dam. At most dams, escape weirs guide migrating salmon past the turbines. Sometimes salmon become trapped by the turbine. In order to simulate this, two students will swing a jump rope for the salmon to jump through. The student salmon cannot go around the jump-rope swingers, but they can slip under the swingers' arms if they do not get touched while doing so. A salmon dies if the turbine (jump rope) hits it. The turbine operators may change the speed at which they swing the jump rope. Any salmon that "dies" at any time in this activity must immediately become part of the fish ladder. The student is no longer a fish, but becomes part of the physical structure of the human-made fish ladders now used by migrating salmon to get past barriers such as dams. The students who are the fish ladder kneel on the ground as shown on the next page, with one body space between them. Later, the salmon that survive life in the open ocean will pass through the fish ladder to return to the spawning ground.

5. Once past the turbines, the salmon must pass some predatory wildlife. The predators 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.

6. Once in the open ocean, the salmon can be caught by fishers waiting in fishing boats. Since salmon can spend four years in the ocean, the salmon must move back and forth across the ocean area in order to gather four tokens. Each token represents 1 year of growth. Once each fish has four tokens (4 year's growth), that fish can begin migration upstream. The year tokens can only be picked up one at a time on each crossing. Remember, the salmon must cross the entire open ocean area to get a token. The "4 years" that these trips take make the salmon more vulnerable; thus they are more readily caught by the

fishers in fishing boats. The fishers have one foot in their cardboard box boat and tag the salmon with two hands to catch them. For this simulation, the impact of this limiting factor creates a more realistic survival ratio on the population before the salmon begin the return migration upstream.

NOTE: Both the predatory wildlife in the downstream area and the people fishing in the open ocean must take dead salmon to the fish ladder site. This action moves the predators and fishing boats off the field regularly, helping to provide a more realistic survival ratio.

7. When four of the year tokens have been gathered, the salmon can start upstream. The salmon must walk through the entire pattern of the fish ladder. This 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.

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

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

9. Above the falls, the two predators who started the simulation as the predators below the turbines have now become the last set of limiting factors faced by the salmon. They represent bears-one example of predatory wildlife. Again, remember that the predators must catch the salmon with both hands. If they catch a salmon, they must then take the student they caught to become part of the structure of the fish ladder.

10. The activity ends when all the salmon are gone before the spawning ground is reached- or when all surviving salmon reach the spawning ground.

11. Now that the students are familiar with the salmonid life cycle and the limiting factors and they know how to simulate these in the activity, they are now ready to start the simulation. Assign roles to each of the students. Some will be salmon; others will be potential limiting factors to the salmon. Assign the students roles as follows:

a. Choose two students to be the turbine team. They will operate the jump rope, which represents the turbines in hydroelectric dams. Later in the simulation, when all the salmon have passed the turbine going downstream,

those students move to the upstream side to become the waterfall-broad jump monitors.

b. Choose two students to be predatory wildlife. They will be below the turbines where they catch salmon headed downstream. Later in the activity, when all the salmon are in the sea, these same two predators will patrol the area above the "broad jump" waterfalls. There they will feed on salmon just before they enter the spawning ground.

c. Choose two students to be humans in fishing boats catching salmon in the open ocean. The students in the fishing boats must keep one foot in a cardboard box to reduce their speed and maneuverability. They must tag salmon in the ocean with two hands to catch them.

d. 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 wildlife accordingly.

12. After the simulation, engage the students in a discussion. Explore topics such as:
    a. the apparent survival or mortality ratio of salmon
    b. the role of the barriers
    c. the role of the predatory wildlife and the people fishing
    d. where the losses were greatest
    e. where the losses were least
    f. what the consequences would be if all the eggs deposited made the journey successfully
    g. what seemed realistic about this simulation and what did not

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

Extensions

1. Write a report on the life cycle of one of the species of salmon (e.g., Chinook or king, chum or dog, pink or humpback, coho or silver, sockeye or red, Atlantic). Create a mural showing the life cycle of this salmon.

2. Research and illustrate the life cycle of any local fish. If possible, look for one that migrates.

3. Compare how the life cycle of a Pacific salmon is similar to and different from the life cycle of one or more local fish.

4. Investigate similarities and differences in the migration and life cycles of an Atlantic and a Pacific salmon. Investigate the life cycle of salmon in the Great Lakes region of the United States.

5. Visit fish hatcheries that work with migratory species and investigate how they function.

6. Explore ways that dams can be modified to let fish safely pass downstream and upstream. Design the "perfect" fish ladder.

7. Investigate and discuss commercial fishing for salmon. Investigate and discuss personal, including recreational, fishing for salmon.

8. Find out about laws protecting migratory species, including fish.

9. Consider this approach, and try the activity again:

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

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

   Describe some of the possible effects on salmon from increased limiting factors as a result of human activities and interventions. Discuss possible positive and negative effects on both people and salmon from these increases in limiting factors affecting salmon. When the activity reaches "the present," predict what might happen to salmon in the future. Recognizing the complexity of the dilemma, discuss possible actions, if any, that might be taken to benefit both people and salmon.

Original Resource

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Assessment

Name: ______________________________

1. Animals, such as sharks, that are higher up in the food chain than salmon are called ________________________.

2. Migration is when a salmon ___________________from one habitat to another.

3.A limiting factor for salmon can cause their population to become __________________.

4. Salmon depend on plants because plants provide __________________ to keep the water cool.

5. A predator is most likely to catch a salmon if the salmon is:
(Circle one)
(A) hungry
(B) tired
(C) active
(D) healthy

6. A salmon migrates from the stream to the open ocean when it is a:
(Circle one)
(A) alevin
(B) fry
(C) smolt
(D) adult

7. An example of a limiting factor created directly by humans is:
(Circle one)
(A) drought
(B) floods
(C) predators
(D) dams

8. Tree branches help keep stream water:
(Circle one)
(A) warm
(B) cool
(C) shallow
(D) active

9. Imagine there were more orcas in the ocean than there are now. Would the salmon population go up or down? Why?

____

____

10. Why does a salmon grow so quickly during its time in the ocean?

____

____

11. Imagine if all the salmon that hatched survive to spawn. Over time, would that have positive or negative effects on the ecosystem?

____

____

12. Why would fewer salmon survive if plants along a stream were cut down?

____

____

Water Wings 3

Overview

In this activity students will learn the water cycle and the importance of water in the environment. Students will visualize a simulated field trip and then create artwork and poetry.

Time Required

Two 45 minute sessions (one for art and one for poems and water cycle discussion)

Setting

Indoor and Outdoor,

Outdoor for first part of activity if appropriate site is available

Topic

Habitat Conservation

Objectives

(1) Illustrate the water cycle. (2) Describe the interrelatedness of the world's waters. (3) State the importance of water to people, plants, and animals.

California Standards

NGSS: 3-LS4-3, 3-LS4-4, 3-ESS2-1

Common Core English:

SL 3-1, 3-2, 3-3, 3-4

L 3-1, 3-3, 3-4, 3-6

W 3-4, 3-5, 3-6, 3-10

Skills

Listening, writing

Key Vocabulary

Evaporation, condensation, precipitation

Materials

- Recorded music, water sounds, or "ecosystem" recordings of an aquatic habitat
- Art materials (water-based paints such as acrylics, water color, or poster paints, brushes, paper, containers for water)
- Writing materials

Background Information

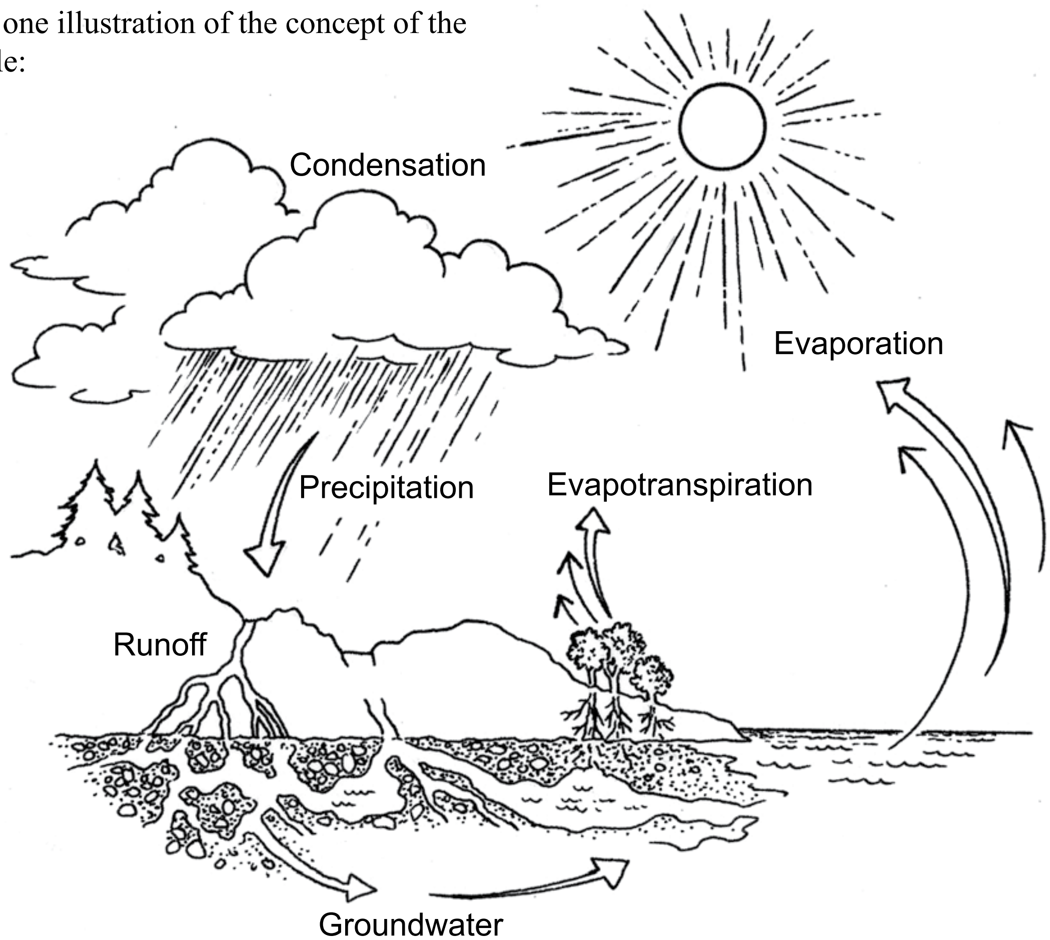
There is, in a sense, only one body of water on Earth. Its rivers reach out in sinuous paths from the hearts of every continent. All water, everywhere, is somehow connected. Almost everyone can easily see and sometimes physically touch this universal body of water in some form, perhaps by turning on a water faucet or by looking at clouds moving high in the sky. Lakes, ponds, and inland seas are webbed together by waters flowing across the surface of the land or in the seeping flow of ground water. Through ***evaporation***, ***condensation***, and ***precipitation*** the atmosphere transports water from place to place.

Plants are an especially active part of the ***water cycle*** in many ways, including transpiration. Transpiration is a process by which plants lose moisture through their leaves by evaporation. People seldom think of the waters of the world as being connected into one body. Maps emphasize the continents and political boundaries on land. Geographers have named dozens of seas, which in reality cannot be delineated from each other, similar to the way that territorial boundaries on land tend to be more political than geographical.

Human beings are linked to the planet's watery world. Our bodies are approximately 75 percent water. Each molecule within us has been part of the oceanic realm in times past. Molecules of our bodies' water may have flowed in streams, lofted in air, or been locked in glacial ice. Other animals and plants are also tied to the planet's waters, directly and indirectly. Living things are partly made of water; all life depends on water in some way.

The continuous dynamic of the movement of water is called the water cycle. The concept of the water cycle is a way to view the moving connectedness of water in its many forms.

Here is one illustration of the concept of the water cycle:



Preparation

1. If at all possible, the students should visit a real stream, pond, lake, river, or beach. Try to choose one where human-made sounds are at a minimum. If possible and not dangerous, allow the students to touch the water during the simulated field trip portion of this activity. Consider the possibility of taking battery-operated tape recorders on the field trip to tape some of the natural sounds the students experience so you can later play it back in the classroom.

   If the outdoor field trip is not possible, then try to use a tape player with recordings of natural ecosystems. The sounds of oceans, rivers, streams, swamps, or brooks are often available on tape from bookstores, music stores, and shops that specialize in nature. A number of selections of contemporary music are excellent. You can also make your own tape recordings.

Procedure

1. Ask the students to sit or rest quietly in a comfortable position. Begin the simulated field trip. If water is available, invite the students to relax and listen carefully to the water, or to musical sounds. These sounds are simply background for the ideas you are going to ask them to visualize in their minds.

   NOTE: Educators may want to modify the water images in the text for local regions.

"You are to try to imagine the things you will hear me describing. Sit comfortably and close your eyes…Relax, and do your best to picture what I am describing… You are sitting on the edge of a stream (lake, ocean, etc.)… Your bare feet are swinging in clean, clear water… The water feels good, but it is cool… You feel a current washing over your feet, pulling at them… Think about the water flowing past your feet until it reaches a larger stream… The water connects you with the larger stream… Feel its more powerful flow… See the green trees and ferns on the banks… The larger stream carries the water past farmlands, cities, factories, and forests until it eventually reaches the sea…

"Through your feet and the movement of water you can sense the ocean… Now stretch your mind and realize that you interconnect with all the world's oceans… You are now touching one single body of water that stretches all around the world… Your own body contains water that is part of this system… Your touch laps against the shores of the Pacific Ocean; it flows under the Golden Gate Bridge in San Francisco Bay. It pours from the sky, dark and gray… It drenches an Alaskan native who shivers on the Arctic shores before her parka begins to warm her. It glistens on the back of a Greek boy who tugs fiercely on fishing nets in the warm Mediterranean Sea… Water connects your feet with every stream flowing into the oceans around the world… You can reach up the rivers to the hearts of the continents… You can feel the wiggle of the hippopotamus that just dove into an African river… You can feel an alligator silently sliding toward a bird in the Florida Everglades… You can feel beavers busily building a dam on a stream in Europe…

"Pretend there is no roof above you. Keep your eyes closed and imagine water, thousands of tons of it, in great fluffy, white clouds. Your reach touches all the whales, all the dolphins, all the sharks. You are also connected with the mythical creatures that live only in the minds of people in the past- mermaids, citizens of Atlantis, and the mythical monsters that swim in Loch Ness. Your feet feel the flow of the current of the miles-wide Amazon River in South America, the ancient Nile River pushing north through Africa, the Colorado River thundering with a boatful of river rafter through the Grand Canyon. Your watery embrace wraps all around the Earth. And, of course, the water flowing over your feet connects you with everyone else who is now sitting, with feet dangling in a stream, wondering where the water goes. It is time to come back. Bring the limits of your senses back from the world's rivers and oceans, back to your feet, back to where you are. When you feel ready, you may open your eyes."

4. Once the visualization is complete, ask the students to open their eyes. Explain that each student has his or her own private journey even though all the students heard the same words. Explain to them that in a moment you will ask them to close their eyes again to find one place on the journey through the world's waters that was their favorite and you will ask them to try to remember what that picture was like.

5. Ask them to relax again and have them try to recreate the picture in their minds. Tell them to look at the detail- the colors, the plants and animals- and to try to capture it all in one scene. Have them pay particular attention to the role of water in the lives of people, plants, and animals.

6. After several minutes, ask the students to open their eyes. Provide the art materials and ask them to quietly paint the picture of their favorite place.

   Optional: Educators may want to provide an opportunity for some or all of the students to talk briefly about their favorite places.

7. Once the pictures are complete, ask the students to write various short forms of poetry that express some of their feelings about water and its importance. Here are a few examples of poetic forms that can be used.

Haiku: Haiku, a Japanese lyric verse form having three unrhymed lines of five, seven, and five syllables, traditionally invokes an aspect of nature or the seasons. Traditionally and ideally, a haiku presents a pair of contrasting images: one suggestive of time and place, the other a vivid but fleeting observation. Working together, they evoke mood and emotion. The emphasis is syllabic, not rhyming. For example,

The fish swam by me
Nothing left but the ripple
My heart beat faster

Cinquain: The word "cinquain" is derived from the French and Spanish words for five. The cinquain is a poetic form, originated by the American poet Adelaide Crapsey (1878-1914), comprising five unrhyming lines of, respectively, two, four, six, eight, and two syllables. Each line has a mandatory purpose and number of syllables or words. These are (1) the title in two syllables (or words), (2) a description of the title in four syllables (or words), (3) a description of action in six syllables (or words), (4) a description of a feeling in eight syllables (or words), and (5) another word for the title in two syllables (or words). Here are two examples, the first using syllables and the second using words:

Osprey
Fishing eagle
Moves above dark water
With graceful strength it finds its meal
Seeker

Sea Otter
Mammal of living waters
Swimming, sleeping, eating, diving, basking, playing,
Sensitive indicator of the quality of continuing life
Still here

Diamante: Diamante is a poem shaped in the form of a diamond. It can be used to show that words are related through shades of meaning from one extreme to an opposite extreme, following a pattern of parts of speech like this:

noun
adjective adjective
participle participle participle
noun noun noun noun
participle participle participle
adjective adjective
noun

For example,

Stream
Small, clear
Rippling, moving, growing
Life, plants, animals, people
Rushing, sustaining, cleansing
Connected, universal
Ocean

Free verse: Free verse is poetry in which the author is free to invent its form. It may or may not rhyme. For example,

Water strider
I watch you stand on glass
that bursts apart to my gentlest touch.
You dash, you dart and exhaust the eyes
that try to follow.
I think you are teaching me something
I will know
on some day like this-
but in a time long after
You are gone.

Optional: Display the pictures and poetry in a circle around a world map. With yarn, connect the pictures that the students painted of their favorite places to the sites where they appear on the map.

8. Using the background information, discuss the "one body of water" metaphor. Emphasize the concept that all the waters of the world are interrelated and connected. Help the students see that the air is also part of that connection. It is the air that carries the waters back to the rivers from the sea. Point out that watersheds are the places where the air rains its water back down on the Earth's surface and where it accumulates. Discuss the importance of water to people, plants, and animals. A human body is 75% water. Salmonids need streams with enough water to swim in.

9. Using the background information, explain the stages of the water cycle. Ask the students to describe how their favorite places, which they illustrated in their paintings, are a part of the water cycle.

   You might want to point out that the water they used in their paintings has evaporated from the pictures and is back in the water cycle again!

Extensions

1. Find out the annual rainfall and climate in the area that you chose to paint.

2. Trace the migratory path of a salmon, tuna, or whale. Then describe the qualities of the different water environments that the animal experiences.

3. Choose a body of freshwater near you and trace its path to the sea.

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Assessment

Name: ______________________________

1. All water is connected and, in a sense, there is only ___________ body of water on Earth.

2. Water moves through plants, and plants move water when ____________________________ moves it out through their leaves.

3. Through the stages of the water cycle, water is ________________ from one place to another.

4. In one way or another, all life on Earth depends on __________________.

5. All waters in the world are:
   (Circle one)
   (A) separate
   (B) connected
   (C) detached
   (D) independent

6. The stage of the water cycle directly before precipitation is called:
   (Circle one)
   (A) transpiration
   (B) evaporation
   (C) condensation
   (D) runoff

7. A water molecule moves from a lake to a cloud by (hint: the heat from the sun helps this happen):
   (Circle one)
   (A) evaporation
   (B) condensation
   (C) precipitation
   (D) transpiration

8. A human body is made up of approximately how much water?
   (Circle one)
   (A) 25%
   (B) 50%
   (C) 75%
   (D) 90%

9. Why is the water underground important to plants and trees?

____

____

10. Why does most of the evaporated water come from the ocean?

____

____

11. If water evaporated from one lake and rained on a different lake, how did it move through the air to get there?

____

____

12. Imagine you are a spawning salmon trying to get upstream and there has been two years with little rain. Would you be more or less likely to get upstream? Why?

____

____

3 Unit Assessment

Name:

1. Salmon alevins get all the food they need from their ________________.

2. Salmon can remember the smell of the stream where they were born. This is called
   ____________________.

3. Animals, such as sharks, that are higher up in the food chain than salmon are called
   __________________.

4.All water is connected and, in a sense, there is only ________________body of water on earth.

5.To find its way back to its home stream, a salmon uses its sense of:
   (Circle one)
   (A) sight
   (B) hearing
   (C) smell
   (D) taste

6. An example of a limiting factor created by humans is:
   Salmon go through their life cycle stages in order. Tell which one is the best order – but be careful, some stages have been left out! (Circle one)
   (A) egg, fry, alevin
   (B) alevin, fry, smolt
   (C) fry, alevin, smolt
   (D) smolt, fry, alevin

7. A water molecule moves from a lake to a cloud by:
   (Circle one)
   (A) evaporation
   (B) condensation
   (C) precipitation
   (D) transpiration

8. A predator is most likely to catch a salmon if the salmon is:
   (Circle one)
   (A) hungry
   (B) tired
   (C) active
   (D) healthy

9. Why does a salmon grow so quickly during its time in the ocean?

____

____

10. Imagine you are fishing for salmon in a river. Woud you catch a bigger salmon if it were swimming a long way upstream or a long way downstream? Why?

____

____

11. Imagine you are a spawning salmon trying to get upstreasm and there has been two years with little rain. Would you be more or less likely to get upstreasm? Why

____

____

12. Why would sharks in the ocean suffer if there were not very many salmon?

____

____

Grade 4

Overview

Activities explore internal and external structures of salmon that are essential in supporting their growth and survival across a variety of aquatic habitats. Students will complete a paper dissection of a salmon, learning about similarities between people and salmonids and discovering how analogous structures perform similar functions. Students will explore salmon's excellent sense of smell, a unique adaptation salmonids have evolved to help them successfully migrate from freshwater to the sea and then back again.

Activity	Time (mins)		Setting	CA Content Standards	Topic
	Prep	Activity			
Parts of a Fish	15	50	Indoor	NGSS: 4-LS1-1	Anatomy/ Adaptation
Inside Out	30	100	Indoor	NGSS: 4-LS1	Anatomy
Smelling the Way Home	30	50	Indoor/ Outdoor	NGSS: 4-LS1-1, 4-LS1-2	Adaptation

Original Curriculum Provided By:

Parts of a Fish
***Salmonids in the Classroom: Primary. Reprinted with the permission of* Fisheries and Oceans Canada.**

Inside Out
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Smelling the Way Home
***Salmonids in the Classroom: Primary. Reprinted with the permission of* Fisheries and Oceans Canada.**

Overview

In this activity students will learn the external anatomy of the salmon and the function that each feature serves. Salmon have adapted these features for survival. Students will compare parts of the salmon to features that plants and humans have.

Time Required

One fifty minute session

Setting

Indoor

Topic

Anatomy, adaptations

Objectives

(1) Define "adaptation" and identify and explain adaptations salmon have. (2) Compare and contrast the external features of salmon and humans.

California Standards

NGSS: 4-LS1-1

Common Core Engilsh:

SL 4-1

L 4-1, 4-3, 4-6

Skills

Identification, comparison

Key Vocabulary

Adaptation, gills, fins

Materials

- Classroom plant such as a bean plant
- Writing supplies
- Copies of activity page
- Poster showing parts of a salmon
- Option: a fresh or frozen salmon

Background Information

Salmon have adapted different external features to help them survive in their ***environment***. An ***adaptation*** is a feature that has changed over time to be more useful in a particular environment.

Each part of a salmon serves a specific function to help it live in its watery environment. The salmon's head contains eyes, ears, mouth, teeth, nostrils and gills. To breathe, fish take water into their mouth, then close their mouth and push the water out through their gills. The gills are full of blood vessels that absorb oxygen dissolved in the water as it passes through the gill openings. Fish can use their nostrils to smell scents in the water and to recognize the scent of their home stream.

Salmon have six bony fins on their body which are mainly used for balance and steering. There are two pectoral fins near the head, two pelvic fins on the belly, an anal fin behind the belly, and a dorsal fin on the center of the back. Salmon have an adipose fin with no known use.

The tail, also known as the caudal fin, helps the fish keep balance, and pushes the fish forward through the water. Female salmon also use the tail to dig the ***redd*** in which they lay their eggs.

Like most fish, salmon have a line of special cells along each side of their bodies. The cells, known as the ***lateral line***, are extremely sensitive to pressure, and help fish sense movements and objects in the water.

A salmon's body is torpedo shaped, which allows it to move easily through the water with the least amount of energy. Scales and skin cover the body of the salmon. Scales are small hard plates, like fingernails, but they overlap like shingles on a roof and protect the salmon from ***predators***, as well as from bruising. Salmon also have a slime layer that makes them slippery and protects them from disease organisms in the water.

Salmon have some features in common with people, like a mouth, a nose, and eyes. There are also features that are not shared, such as fins and tails.

Preparation

1. Make copies of student activity page.

Procedure

1. Have students identify the parts of a plant and describe what each part does.
   The stem holds up the plant, the leaves collect sunlight and make food, the roots hold the plant in the ground and collect moisture, etc.

2. Have students identify the parts of a human and describe what each part does.
   The legs hold people up and let people move, arms let people hold things, the mouth lets people eat, etc.

3. Have the class use a poster of a salmon (or a fresh or frozen salmon) to identify the external body parts, i.e., head, mouth, eyes, nostril, gills, body, lateral line, fins (pectoral, pelvic, dorsal, anal, adipose), tail, skin, scales. Discuss the function of each part using the background information provided.

4. Define the term "adaptation" and discuss how salmon have adapted to their freshwater and saltwater environments.

   Option: Some independent education suppliers, stores and catalogs carry cloth fish, 3-D models and posters that could help you to introduce the external (and internal) body parts.

5. Have students make and label their own drawing of a fish (or place labels on the drawing provided).

6. Make a list or Venn diagram of overlapping circles with the class to identify features in fish and humans that are similar and different.
   Both have a mouth, a nose, and eyes, but fish have a lateral line, fins, tails, scales and they use gills to get oxygen from the water. People have a neck, arms, legs and hair and use lungs to breathe air.

Extensions

1. Have older students make a chart comparing the functions of the body parts of fish and humans.
   To move, people use legs, fish use tails; to breathe, people use noses, fish use mouth and gills, etc.

2. If you wish to teach your students the internal features of a salmon, refer to "Inside Out" in the Grade 5 section.

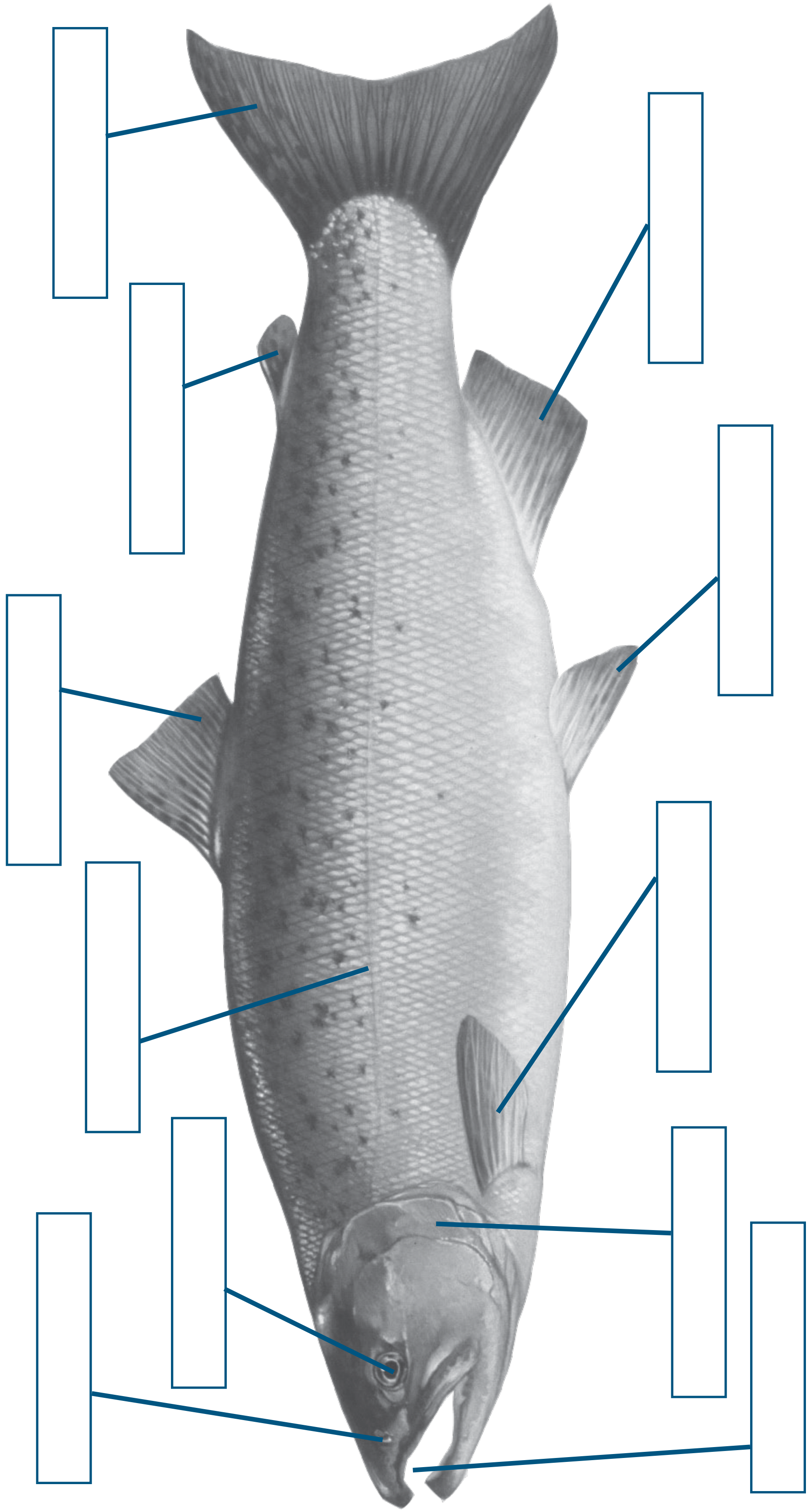
Original Resource

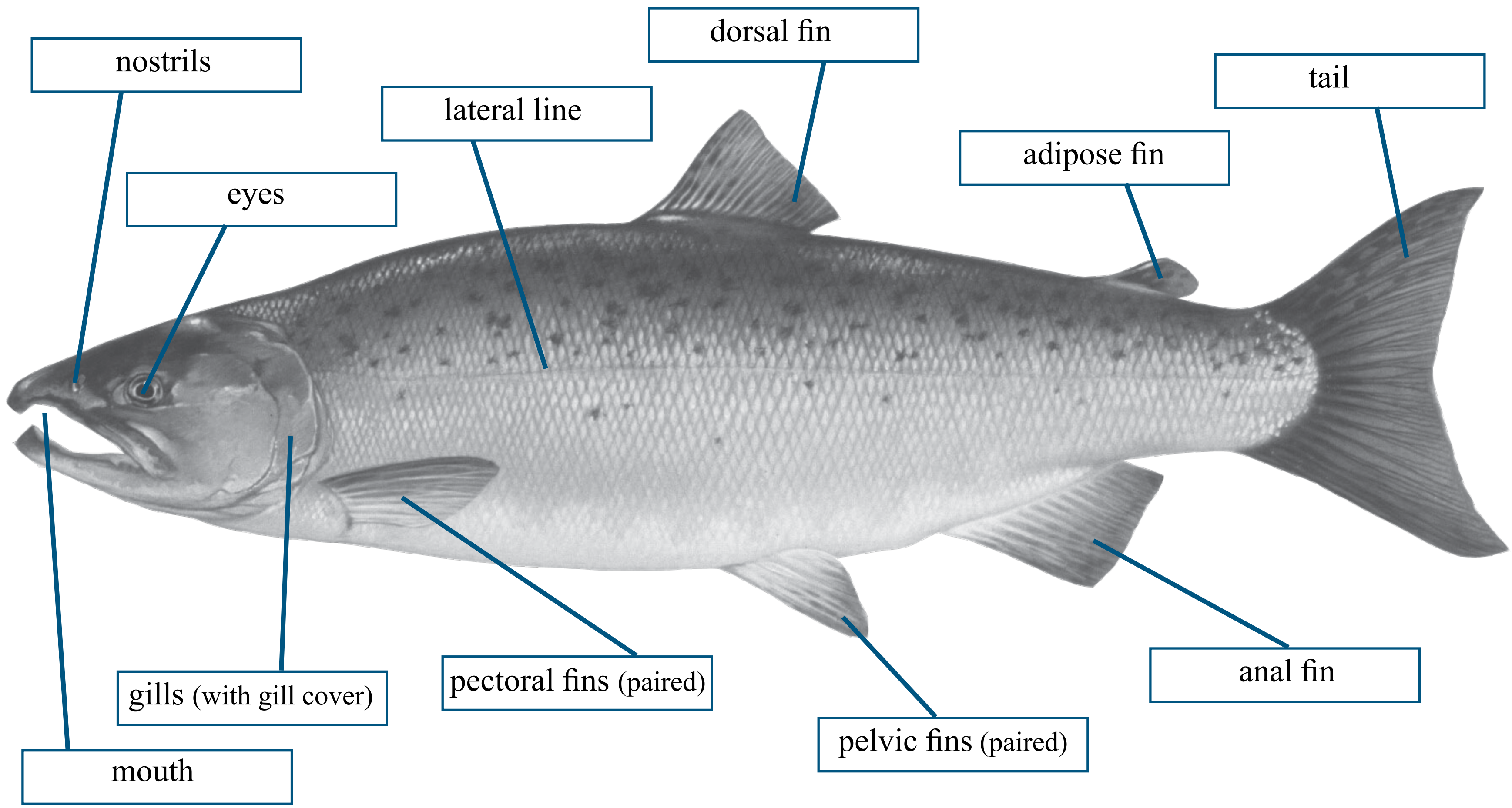
Salmonids in the Classroom: Primary. Reprinted with the permission of **Fisheries and Oceans Canada.**

Stewardship and Community Involvement Unit
Habitat and Enhancement Branch
Fisheries and Oceans Canada
555 West Hastings Street
Vancouver, B.C. V6B 5G3
Canada
Phone: 604-666-6614

Student Activity Page

Name:





Fins- help salmon turn and balance
Tail- moves salmon forward
Eyes- let salmon see
Scales- give salmon protective covering

Nostrils- let salmon smell water
Mouth- let salmon eat and breathe
Gills- extract oxygen from water

Assessment

Name: ______________________

1. Gills are used to take ________________________ out of the water.

2. Both people and salmon have tiny openings called _____________________ to smell things.

3. Humans have lungs to breathe. Instead of lungs, salmon have _____________________.

4. Salmon are adapted to move and balance their bodies in water by using their _______________.

5. The part of the salmon that senses water moving around them is the:
   (Circle one)
   (A) scales
   (B) lateral line
   (C) adipose fin
   (D) eyes

6. A salmon and a person both have:
   (Circle one)
   (A) scales
   (B) gills
   (C) eyes
   (D) lungs

7. The part of the salmon like a human's skin that protects them is the:
   (Circle one)
   (A) tail
   (B) eyes
   (C) fins
   (D) scales

8. The salmon's tail is a big help for the salmon to:
   (Circle one)
   (A) move forward
   (B) turn
   (C) balance
   (D) move sideways

9. What does the dorsal fin help the salmon do when it is swimming?

____

____

10. Salmon have some features in common with people, like a mouth, nose, and eyes. Tell what other features that are not shared.

____

____

11. What might happen if a salmon lost a lot of its scales? Tell why this would be good or bad.

____

____

12. How does the long, thin body of the salmon help it get away from predators?

____

____

Smelling the Way Home 4

Overview

This experiment demonstrates how a scent can be used to identify a location. It leads to a discussion of how salmon identify their home stream by the scent of the water.

Time Required

One fifty minute session

Setting

Indoor or Outdoor

Topic

Adaptations

Objectives

(1) Identify how salmon navigate back to their home streams. (2) Identify some hazards and obstacles that may prevent a salmon from reaching its home stream.

California Standards

NGSS: 4-LS1-1, 4-LS1-2

Common Core English:

SL 4-1

L 4-1, 4-3, 4-6

Skills

Sense of smell

Key Vocabulary

Migration, spawning, scent, adaptation

Materials

- Variety of strongly scented substances that students will recognize (preferably not artificial or allergenic scents)
- Opaque containers with perforated lids (e.g., plastic film canisters)
- Option: Cotton balls
- Copies of Observation Page
- Writing supplies

Background Information

After spending from one to seven years in the ocean, depending on the ***species***, salmon return to their home stream to ***spawn*** a new generation. Mature salmon find their way to the mouth of their home stream where they hatched. Scientists think salmon use ocean currents and water temperature to find their way back.

When they get near their home stream, the scent of its water helps them identify the right one. Each stream has its own unique scent created by the vegetation, rocks, and soil in and around it. The water entering the stream from smaller streams and springs also contributes to the unique scent of the stream.

Salmon have the ***adaptation*** of an excellent sense of smell that is far better than a human's sense of smell. This adaptation helps salmon survive because it allows them to find their home stream to spawn the next generation.

Preparation

1. Place a variety of strongly scented substances, such as orange, banana, mint, toothpaste, maple syrup and chocolate, in plastic film canisters (or other opaque containers) with holes in the top. You may prefer to place the scents on cotton balls in the containers.

   Avoid perfume or artificial scents that might cause allergic reactions.

2. Determine names of local streams in your area and assign a scent to each one.

Procedure

1. Discuss with the class how people find their way on a trip. If necessary, prompt them with questions, such as:

   "How do you know when you are going in the right direction?"
   By using memories and familiar sights as landmarks.

   "How do you know where to turn?"
   By using memories and landmarks.

   "How do you know when you have arrived at your destination?"
   By using memories and landmarks.

   "What do you do if the road is blocked?"
   Look for another way until you find a familiar landmark.

2. Have students, in pairs, describe to each other or map a trip they know how to take, e.g., from school, swimming pool or a friend's house to home. Have the pairs list any landmarks or memories that help them find their way home and know when they have reached their destination. Model this activity for students, if necessary.

3. Explain that one way salmon find their way home is by the scent of their home stream. They also use other factors, such as water temperature and current. Many things can give a stream a special smell, including the rocks, soil, and types of plants found there. This activity tests how to use scents to identify a home.

4. Ask the class to name any smells that identify a place they know.
   A bakery, swimming pool, laundry, garbage, garden, etc.

5. Using the Observation Page, ask the class to predict whether students could use scents to find a home area of the classroom.

6. Divide the class into groups of salmonids (e.g. Chinook, coho, steelhead) and assign each salmonid group a home stream. Have the groups sniff their home stream's scent from the container.

7. Place the containers in different parts of the room. You may wish to have the students cover their eyes while you distribute the containers around the room.

8. Have students find their home stream by sniffing each sample to identify the scent.

   Option: Since steelhead are able to spawn more than once, after everyone has identified their home stream, have the steelhead group leave the room for a few minutes. While they are out of the room, add a substance to all of the containers that will mask the original scent. Have the steelhead group reenter the room and try to find their home stream. When they are unable to, discuss with the class the effects of stream pollution on salmonids.

9. With the class, discuss whether or not the test supports the predictions. Have students use the Observation Page to describe the experiment and the results.

10. With the class, compare a salmon's sense of smell with a human's sense of smell.
    Salmon can smell under water, while people cannot. Salmon remember smells longer than people do. A salmon's sense of smell is more acute than a human's.

11. With the class, discuss how the salmon's excellent sense of smell is an adaptation that helps them survive.

Extensions

1. Use masking tape to mark a path on the floor representing a river system with tributary streams, and place a different home scent at each stream. Have students follow the river system to their home stream.

Original Resource

Salmonids in the Classroom: Primary. Reprinted with the permission of **Fisheries and Oceans Canada.**

Stewardship and Community Involvement Unit
Habitat and Enhancement Branch
Fisheries and Oceans Canada
555 West Hastings Street
Vancouver, B.C. V6B 5G3
Canada
Phone: 604-666-6614

Observation Page Name:

My prediction is (write or draw your prediction)

In this experiment I saw (write or draw your observations)

This experiment shows that

Assessment

Name: ______________________

1. Salmon swim from the ocean to their home stream so they can ________________.

2. Spawning salmon use their sense of ________________ to find their home stream.

3. A salmon's nostrils are much ______________ sensitive than a human's nostrils.

4. Salmon remember how to find the way back to their home stream. They can do this because many different smells are stored in their ____________________.

5. When a salmon first hatches it has a strong sense of:
(Circle one)
(A) hearing
(B) sight
(C) smell
(D) taste

6. To be sure they are home, salmon use their:
(Circle one)
(A) gills
(B) eyes
(C) nose
(D) mouth

7. How long must a salmon be able to remember the exact scent of its home stream?
(Circle one)
(A) hours
(B) days
(C) months
(D) years

8. Another way a salmon might remember its home stream is by the stream's:
(Circle one)
(A) color
(B) temperature
(C) depth
(D) cleanliness

9. Why does a salmon have the adaptation of a strong sense of smell?

____

____

10. Why would a salmon not be able to find its home stream if the water was polluted?

____

____

11. Imagine a salmon and a human both smelled the same water. Would the salmon or the human be able to tell more? Why?

____

____

12. Why does a salmon need to have a good memory for such a long time?

____

____

Overview

There is currently a great deal of controversy surrounding the use of dissection both in the world of research and in the classroom as an educational tool. This two-day lesson provides an alternative to dissection but could also be used as a lead into a real dissection. Using paper, scissors and glue sticks, students construct both the external anatomy and internal organs of a salmonid.

Time Required

Two fifty minute sessions

Setting

Indoor

Topic

Anatomy

Objectives

(1) Identify how salmon navigate back to their home streams. (2) Identify some hazards and obstacles that may prevent a salmon from reaching its home stream.

California Standards

NGSS: 4-LS1

Common Core English:

L 4-1, 4-3, 4-6

Skills

Reading, following directions, using scissors, fine motor skills

Key Vocabulary

Lateral line, fins, scales, operculum, redd, atrium, filaments, pyloric ceca, milt

Materials

- Copies and transparencies
- Scissors
- Pencils
- Glue sticks/paste/glue bottles
- Assortment of colored paper (can be scraps)
- Scotch tape
- Overhead projector

Background Information

In order to understand the ***salmonid***, you must know its form (or structure) and how they function. Fish have body structures, which enable them to live in a special ***environment***. The external structures consist of eyes, nostrils, lateral line, mouth, fins and scales. The eye of a fish is very different than that of a human. The lens of a fish eye is a sphere and has no muscular attachments but is suspended in a jelly-like medium (vitreous humor). While the human eye achieves focus by changing the thickness of the lens through muscle movement, a fish has a fixed focus and wider-angle range of vision.

Salmonids have a well-developed sense of smell and use this ability to seek out their home stream for ***spawning***. Their sense of smell is on the order of 100 times greater than a dog's sense of smell. Fish do not use their nostrils to breathe but have gills instead.

The ***lateral line*** is a series of specialized cells located along each side of the fish. These cells are connected to a delicate system of nerves, which allows the fish to detect low frequency vibrations in the water. This sensory system assists in navigation and schooling behavior as well as allows them to seek out ***prey*** and avoid ***predators***.

The mouth is used to catch and hold food of various types, but their food is not chewed before swallowing. In addition, the mouth is a very important part of the breathing process. Water is constantly taken in through the mouth and forced out over the filaments of the gills. The operculum (or gill cover) is the only readily visible external gill structure and serves primarily as protection for the more delicate internal gill structures.

Fins are the most notable external structures on a fish. Salmonids have two sets of paired fins (ventral and pectoral) and four single fins (dorsal, caudal, anal and adipose). All fins are used for balance with the exception of the adipose and caudal. The adipose is a small fleshy fin, which serves no known purpose and is often clipped by fishery managers to identify specific stocks of fish.

The most important fin is the caudal fin. Combined with the body muscles of the fish, this fin is the only means of propulsion. It is also used by the female during spawning to dig the ***redd*** in which they deposit their eggs.

Scales are salmonids protective barrier, much as our skin is. Scales grow in concentric patterns and can be used to determine the age and life history of the fish. Over the scales is a layer of mucous (slime coat), which further protects the fish from disease organisms and helps it slide through the water more easily.

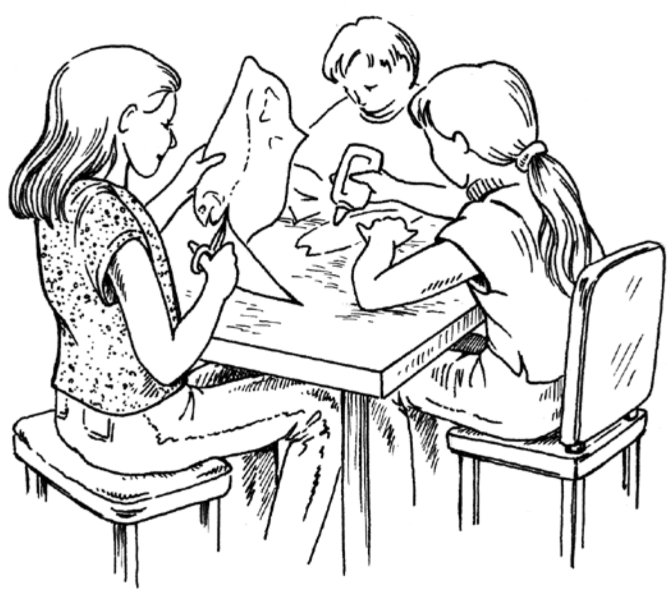
Students are less familiar with the internal anatomy of a fish than the external structure. The primary internal organs of a salmonid consist of gill filaments, heart, liver, gall bladder, digestive tract, spleen, float bladder, kidneys, ovaries or testes, and brain.

Fish gills are composed of two basic parts- the gill covers (external) and the gill filaments with its gill arch, and gill raker (internal). The gill covers (operculum) protect the very delicate filaments and, together with the mouth, force oxygenated water over the filaments. The filaments are richly laden with capillary vessels which expose the blood to the water to absorb oxygen and release waste products such as carbon dioxide, much like our lungs.

The heart is located directly below the gills and unlike the human heart, has only two chambers. The atrium is a dark red (almost black) sack like structure. It receives the deoxygenated blood and has little contractile ability. Blood then passes to the ventricle, a hard pink muscular structure. The ventricle is the pump, which sends blood to the gills to be oxygenated.

The liver, the largest organ of the fish, is a chemical factory and a storehouse. It produces bile, stored and concentrated in the gall bladder, which is used to break down fats in the digestive system. The liver receives digested food molecules, storing and measuring the flow of the products of digestion. The liver provides measured quantities of the products of digestion to the circulatory system where they reach the various tissues and organs of the body.

The digestive tract, consisting of the esophagus, the cardial stomach and the intestines, is where the fish processes and breaks down its food supply. The esophagus is the short, upper end of the digestive tract, which connects directly to the cardial stomach. The cardial stomach is the primary receptacle of ingested food. Salmonids also have a pyloric stomach (pyloric ceca), which increase the amount of surface area available for digestion with little finger-like appendages known as villi. The rest of the digestive tract is the intestines, which function to absorb nutrients before elimination of wastes at the vent.



Just posterior to the stomach, and attached but not connected to it, is a small, dark, red-black organ that is the spleen. The spleen is part of the circulatory system that stores and forms blood.

The float bladder is what keeps the fish buoyant in the water column. Without it the fish would either sink to the bottom or spend a great deal of energy maintaining its depth. It also helps in equalizing pressure at different depths.

The membrane just below the vertebral column covers the kidneys. The kidneys are long and dark in color and have two tubes leading from the posterior end to the urinary bladder. The kidneys filter the blood and eliminate waste products from the blood, including salt. Directly above the kidneys and in contact with the vertebral column is the dorsal aorta. It is the primary vessel supplying blood to the tissues.

The reproductive organs of the salmonid are attached to the vent (urogenital opening). The ovaries, if female, may be in different stages of development. The testes, if male, are white flaccid organs that produce sperm (milt). Fertilization for salmonids is external. The female lays the eggs in the excavated redd and the male releases a cloud of milt, which settles over the eggs, carried by the flow of the water.

The fish brain is fairly simple when compared to ours. Primary structures include olfactory nerves and lobes, cerebrum, optic lobes, cerebellum, medulla and brain stem/spinal cord. While the structures are similar to ours, development is much different with a small cerebrum and highly developed optic lobes.

By studying the functions of individual organs of an organism and how they relate to specific biological systems (e.g. circulatory, digestive, etc.), students will gain a better understanding of their own anatomy. It is important for students to have an understanding of the form and function of anatomical structures of an organism in order for them to comprehend the specific adaptations that it has developed to interact with its environment. Students may then be able to make comparisons between their own anatomy and the anatomy of the organism they are studying.

Preparation

1. It is recommended to precede this activity with an opportunity for students to make external observations of a live fish. Salmonids have many physical features in common with goldfish which are easily viewable in a classroom setting. You may also wish to post color pictures of salmon.

2. Make overhead transparencies of external/internal anatomy, "Got Fins?" worksheet, and final fish form model (have the fins and internal organs cut apart for placement with the students during the activity).

3. Make copies of "Got Fins?" worksheet, External Fish form (Day 1), and the Internal Fish form (Day 2) for each student.
   Note: You may want to copy the External and Internal sheets on heavier stock to make it easier to use as a fish "book"; the main body forms could also be glued to a file folder before cutting out.

Procedure

Day One: External Anatomy

1. Pass out the "Got Fins?" worksheet to each student and project one on the overhead projector.

2. Have students name and label the worksheet as you fill it in on the overhead projector. Encourage students to name and

list the function of each of the fins based on their observations. It is helpful to leave the overhead on for reference as you move on to the model making. *"I will pass out to you your external anatomy sheet. When you get it, you can cut out the two body sides. So you don't lose all your various fins, it is best to cut them out one at a time and glue then in place on the body. Notice there are two paired fins, the ventral and pectoral. As you attach the paired fins, be sure to only attach them at the base so you can flare them out on your final model."*

3. Circulate around the room to check for proper placement of fins. It is helpful to show them the cutout fins and their placement on the overhead as well.

4. Discuss similarities and differences of fish and human anatomy. A Venn diagram or T-chart can be created on the back of the "Got Fins?" worksheet.

5. Ask students why they think a fish is so streamlined? (could relate to car, boat and airplane design)

6. Ask students what adaptations salmon have developed for survival in their liquid environment.

Day Two: Internal Anatomy

1. Have students generate a list of human internal organs while you list them on the overhead. *"What organs do you think fish have in common with us? I'll highlight those you think we share, and we can compare our predictions later."*

2. Pass out the internal organ sheet to students. *"Are there any organs we forgot to list?"* List student responses. *"Are there any changes we need to make to our highlighted list?"* Have students make changes as needed.

3. Show students a diagram of final fish form model. Have this up in the front of the classroom. *"You will be using your fish from the previous lesson to glue in the internal organs. The final model will open to reveal the internal anatomy."*

4. *"Color in your internal organ sheet using a different color for each organ if possible. You will be making a color key for your fish model. When you finish coloring, cut out the different organs. Use the small diagram as an example to place the organs in their correct position on the inside bottom of your fish model. Place them all before you glue them to see if you want to hinge glue some so you can lift to see under them. Make a color key on the top inside of your model which identifies each internal organ by name."*

Extensions

1. Make a book using a fish form for each internal system (circulation organs, reproductive organs, digestive organs, etc.)

2. Create life size models of fish found in your area.

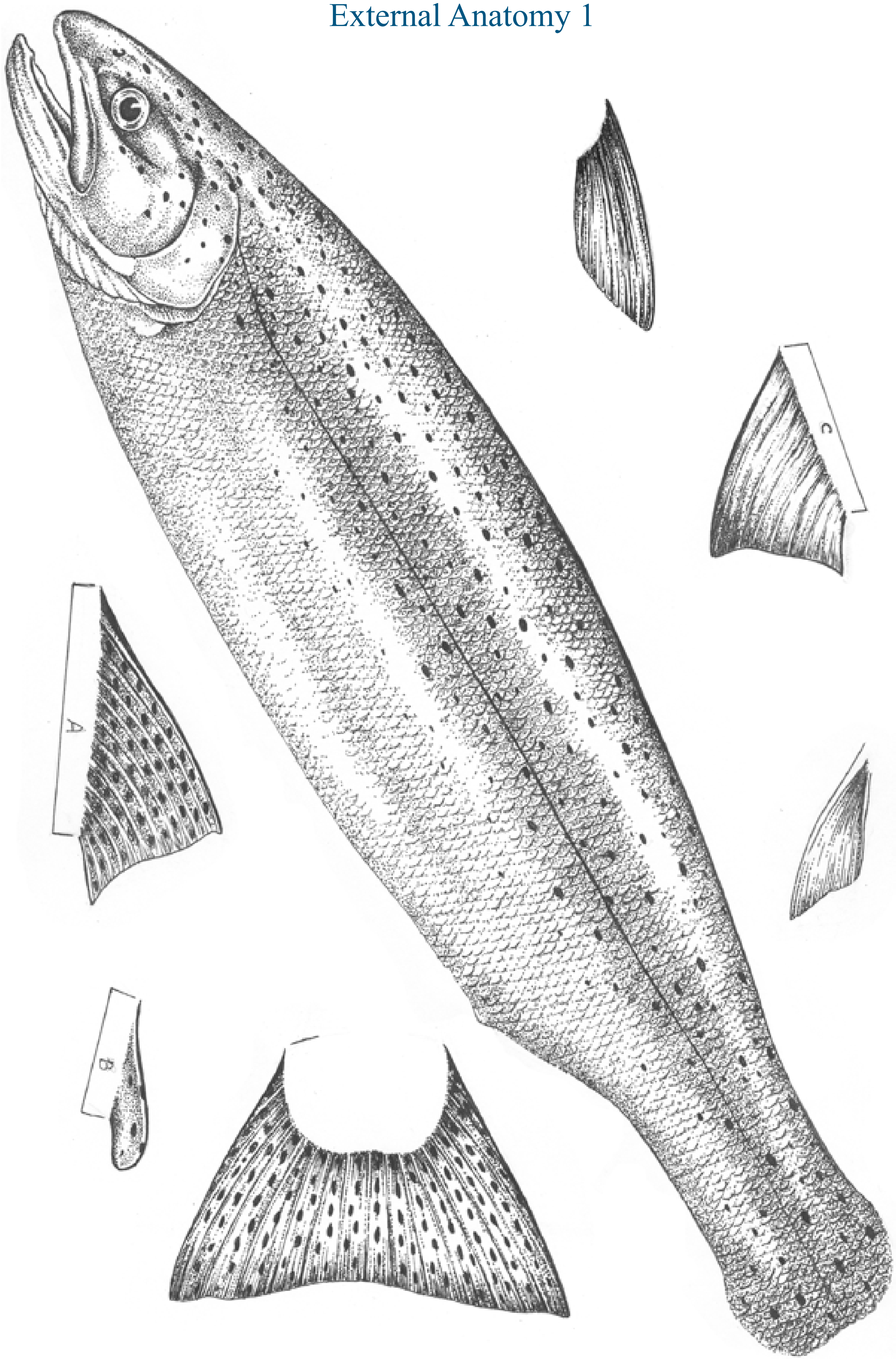
3. Build a life size class display out of paper mache.

Original Resource

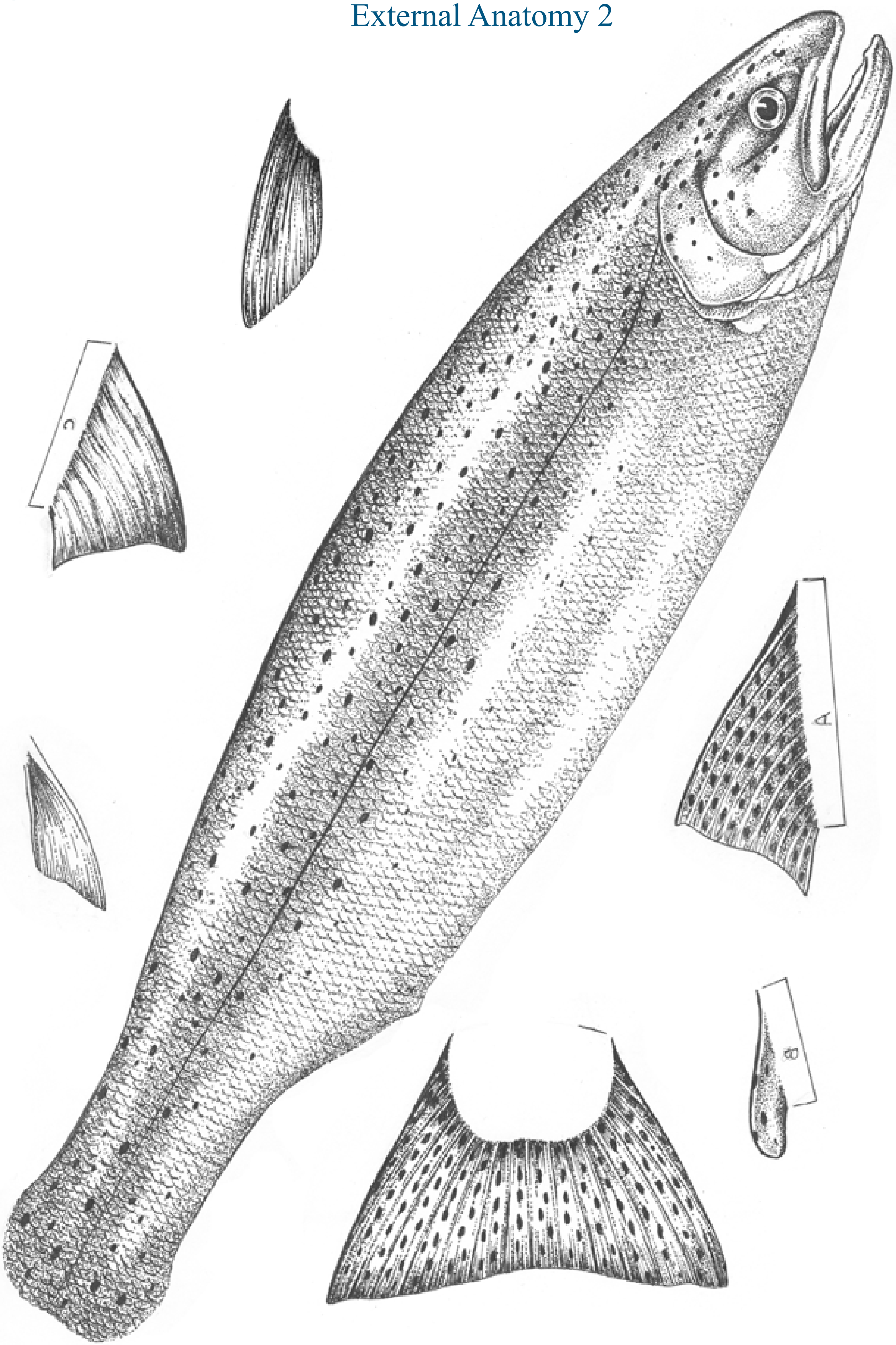
Salmon and Trout Education Program (STEP) Curriculum. © 2005 Monterey Bay Salmon and Trout Project. Used by permission.

Monterey Bay Salmon and Trout Project
825 Big Creek Road
Davenport, CA 95017
Web: www.mbstp.org

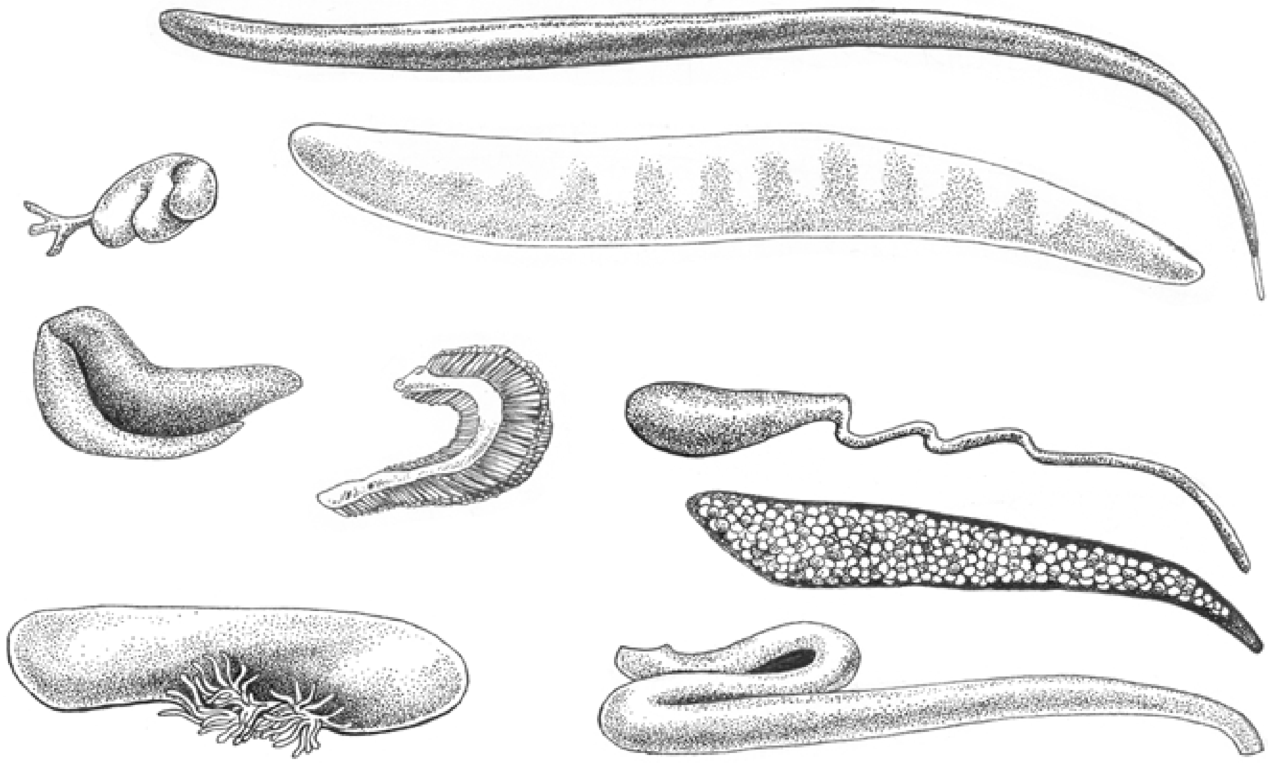
External Anatomy 1



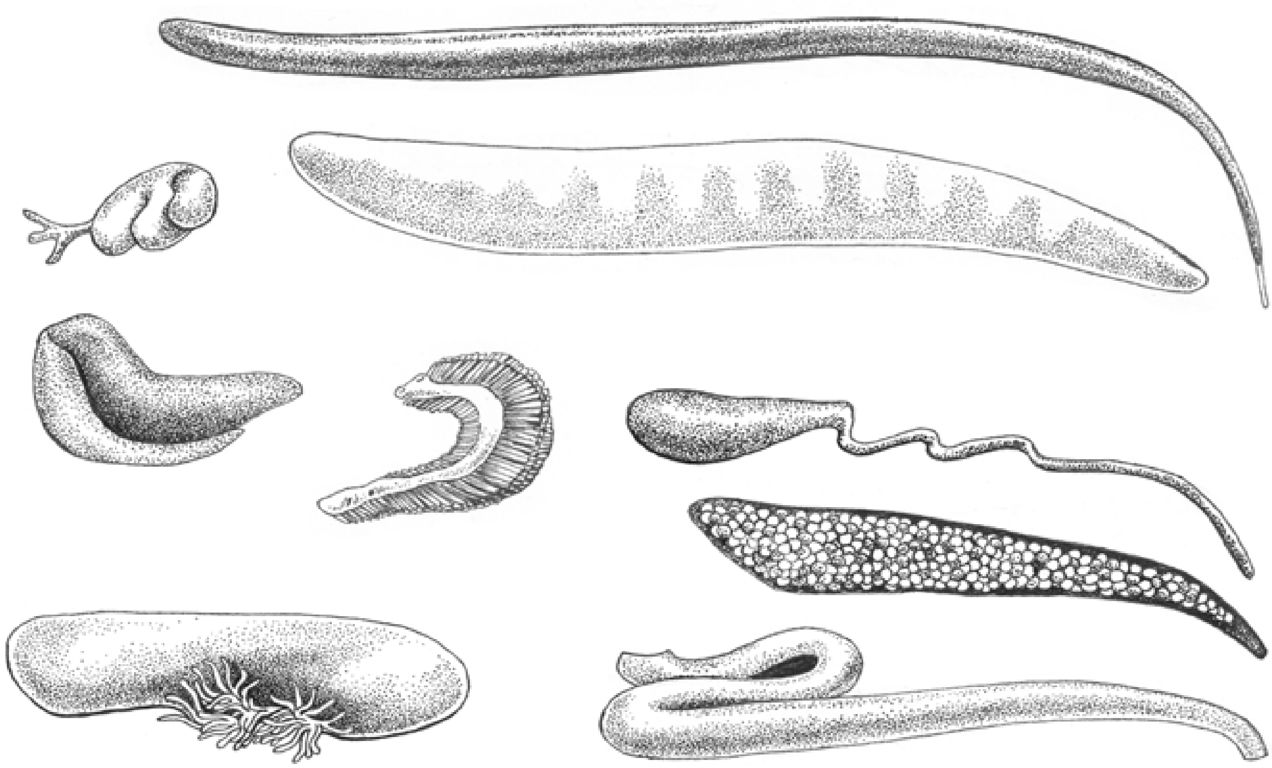
External Anatomy 2



Internal Anatomy

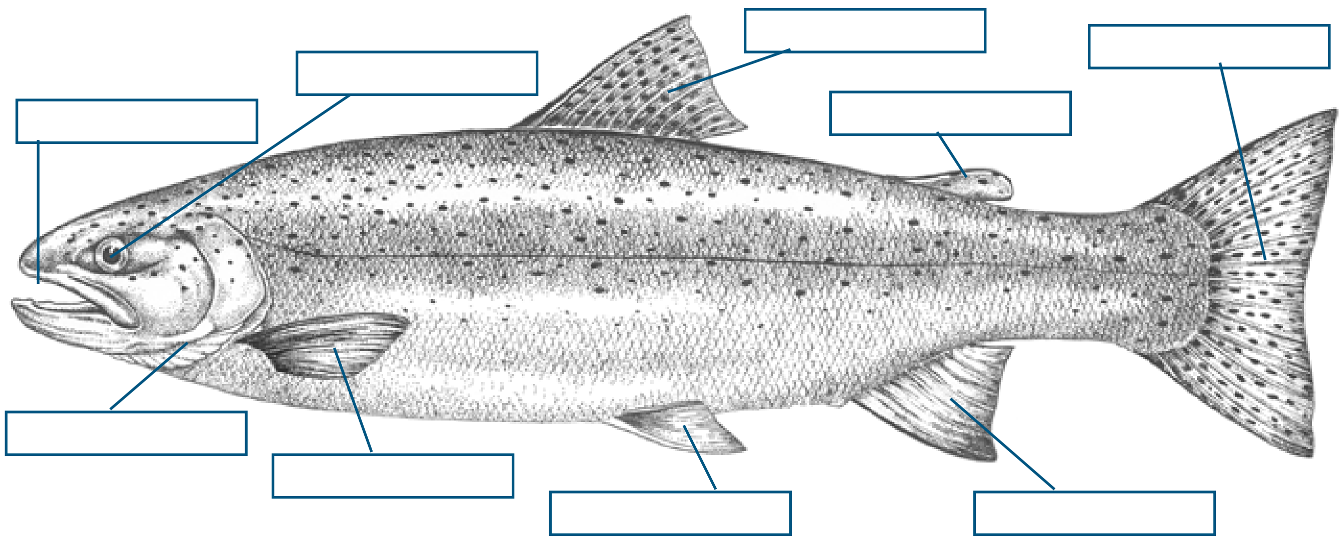


Internal Anatomy

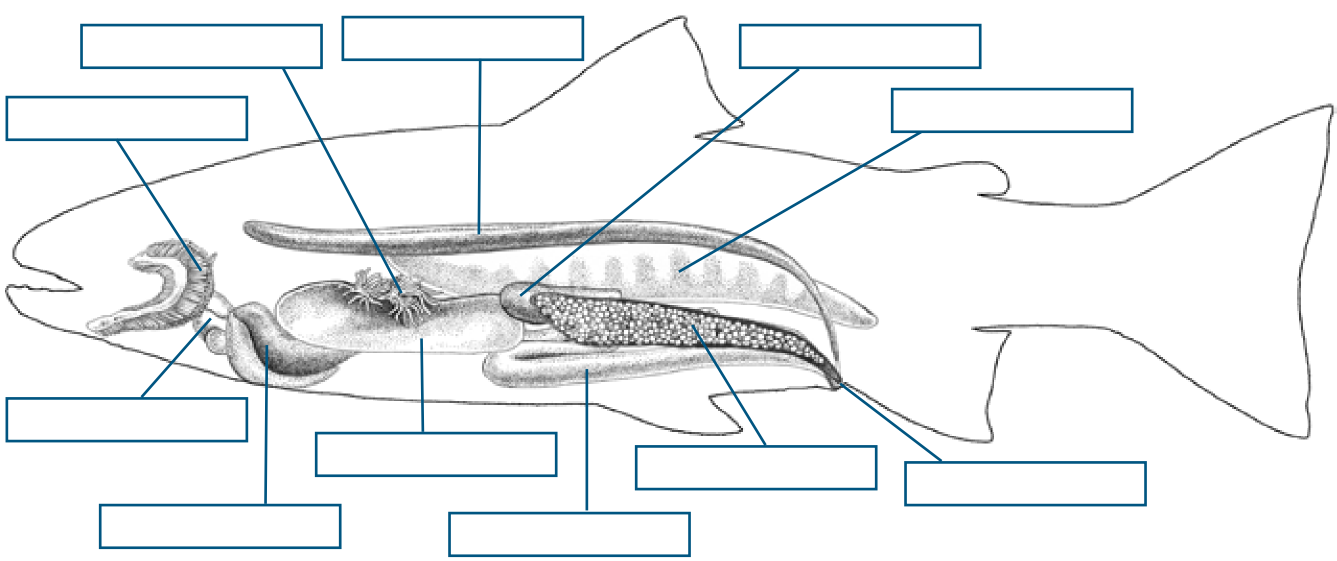


Got Fins?

External Anatomy

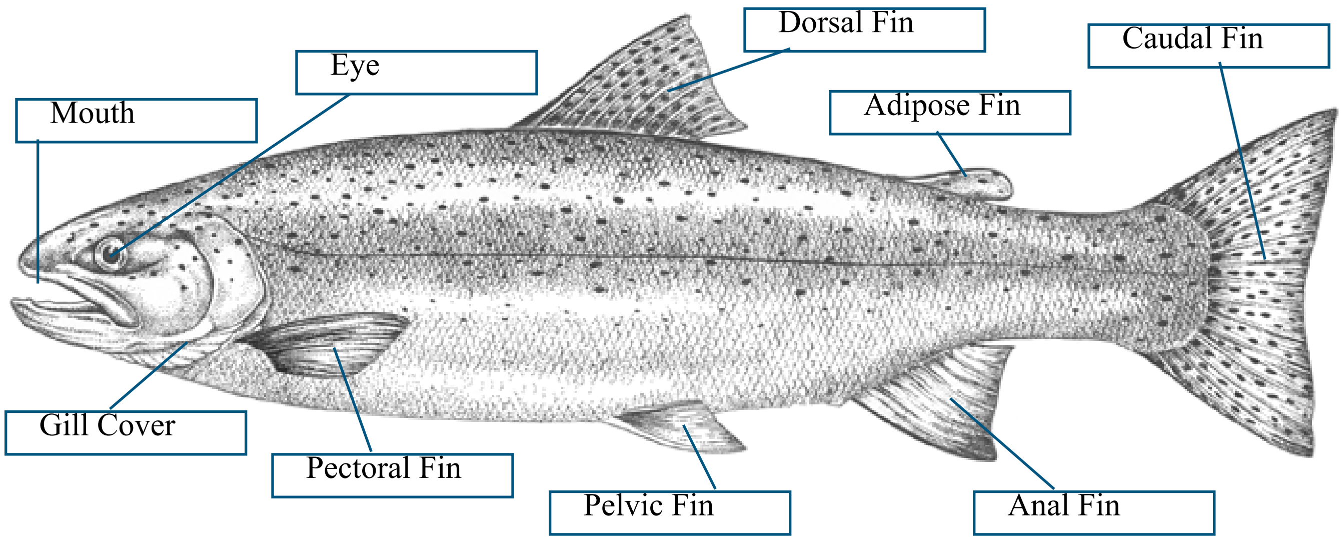


Internal Anatomy

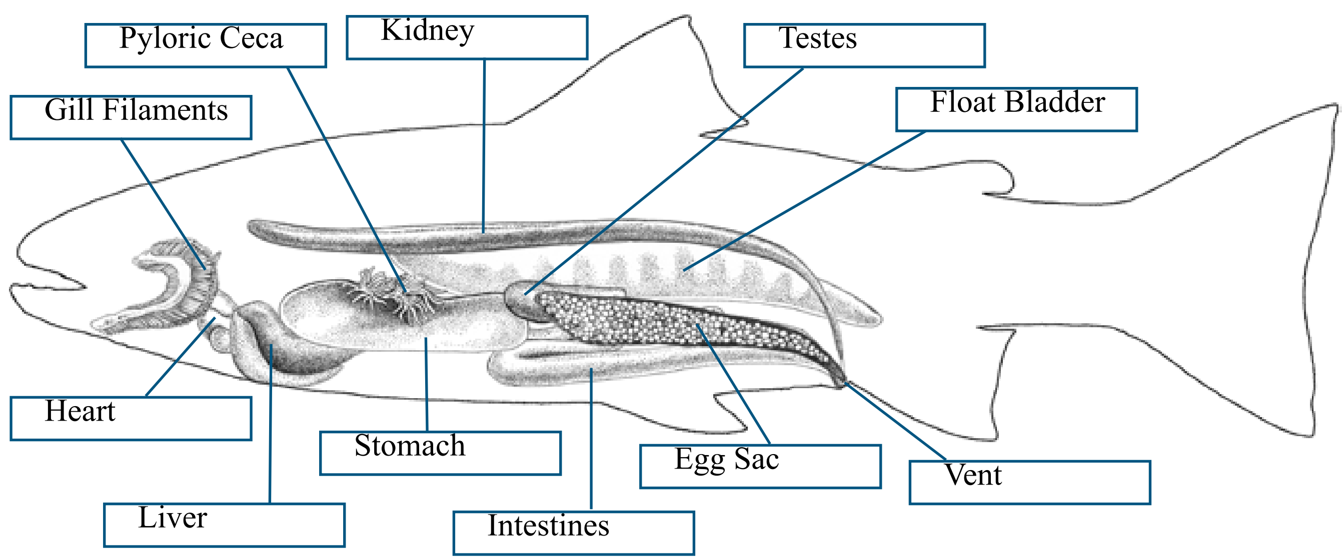


Got Fins? Teacher Key

External Anatomy



Internal Anatomy



*Note: The salmonid in this diagram has both male and female internal organs for ease of discussion.

Assessment

Name: ______________________________

1. The heart ventricle acts like a _______________ to send blood to be oxgenated.

2. The salmon's mouth is connected to its cardial stomach by the ______________________.

3. Fish have _________________ to protect their bodies from predators, parasites, and other injuries.

4. The most notable external structures on a fish are _______________ to send blood to be oxygenated.

5. The organ with the main function of removing waste from the blood is the:
   (Circle one)
   (A) kidney
   (B) intestines
   (C) gall bladder
   (D) liver

6. Finger like appendages to help with digestion called villi can be found in the:
   (Circle one)
   (A) esophagus
   (B) cardial stomach
   (C) pyloric stomach
   (D) intestines

7. A salmon's lateral line is part of what system?:
   (Circle one)
   (A) digestive
   (B) nervous
   (C) circulatory
   (D) respiratory

8. Unlike the human heart, the salmon heart has how many chambers?:
   (Circle one)
   (A) 1
   (B) 2
   (C) 3
   (D) 4

9. Imagine humans had eyes like salmon. Would it be harder or easier for humans to focus on something? Why?

____

____

10. Imagine a salmon did not have a float bladder. Would the salmon have to use more or less energy to stay in one place? Why?

____

____

11. Why does having a lateral line help salmon survive?

____

____

12. Why doesn't the atrium of the salmon's heart have to be very strong?

____

____

Name: ____________________

1. Salmon use their ________________ to take oxygen out of the water.

2. Salmon remember how to find the way back to their home stream. They can do this because many different smells are stored in their ________________________.

3. The salmon's mouth is connected to its cardial stomach by the __________________.

4. Salmon are adapted to move and balance their bodies in water by using their _______________.

5. What is name of the pair of fins with one found on each side of the salmon?
(Circle one)
(A) dorsal
(B) adipose
(C) anal
(D) pectoral

6. Unlike the human heart, the salmon heart has how many chambers?
(Circle one)
(A) 1
(B) 2
(C) 3
(D) 4

7. Another way a salmon might remember its home stream is by the stream's:
(Circle one)
(A) color
(B) temperature
(C) depth
(D) cleanliness

8. Finger-like appendages to help with digestion called villi can be found in the:
(Circle one)
(A) esophagus
(B) cardial stomach
(C) pyloric stomach
(D) intestines

9. Imagine a salmon did not have a float bladder. Would the salmon have to use more or less energy to stay in one place? Why?

____

____

10. How does the long, thin body of the salmon help it get away from predators?

____

____

11. Why does a salmon need to have a good memory for such a long time?

____

____

12. Why have salmon adapted to have a strong sense of smell?

____

____

Grade 5 Overview

This unit introduces the concept of an ecosystem. Students will learn that everything in an ecosystem finds connection within the food web, and small changes or seemingly unrelated events can have dramatic effects on a salmon population. Students will look at life cycle stages with emphasis on the physical needs and environmental hazards found in the life of a fish. In addition, through a mapped watershed model, students will explore where the biosphere and hydrosphere interact and provide key habitat for salmon.

Activity	Time (mins)		Setting	CA Content Standards	Topic
	Prep	Activity			
Team Salmon	15	45	Indoor	NGSS: 5-PS3-1, 5-LS1-1, 5-LS2-1	Biology
Aquatic Connections	15	45	Indoor/ Outdoor	NGSS: 5-PS3-1, 5-LS1-1, 5-LS2-1, 3-5ETS1-1	Ecosystem
Finding Your Ecological Address	15	50	Indoor	NGSS: 5-ESS2-1, 5-ESS2-1, 5-ESS3-1, 3-5-ETS1-1	Watershed

Team Salmon
Salmon Stewards: Bringing Salmon and Watersheds Into Your Classroom, a curriculum for Grades 4-6. Copyright by Pacific Science Center.

Aquatic Connections
Adapted from "Wetland Connections" in the Wild About Wetlands Classroom Kit produced by the Yolo Basin Foundation, and Some Things Fishy, A Teacher's Guide to the Feather River Fish Hatchery published by the California Department of Water Resources.

Finding Your Ecological Address
From The Fish Hatchery Next Door. This information has been provided courtesy of the Oregon Department of Fish and Wildlife.

5 Team Salmon

Original Curriculum Provided by: Pacific Science Center

Overview

This activity, which uses the jigsaw method, introduces the life cycle of salmonids, as well as salmon habitat needs. At the conclusion, each student has taught five other students about a life cycle stage, learned about the other five stages of the life cycle, and completed a Salmon Life Cycle sheet.

Time Required

One forty five minute session

Setting

Indoor

Topic

Biology

Objectives

(1) Understand the life cycle of salmonids and their habitat requirements. (2) Work in teams to research and share knowledge. (3) Take research notes.

California Standards

NGSS: 5-PS3-1, 5-LS1-1, 5-LS2-1

Common Core English:

SL 5-1, L 5-1

RI 5-1, 5-2, 5-4, 5- 9, 5-10

Skills

Teamwork, listening, speaking, writing

Key Vocabulary

Sediment, dissolved oxygen

Materials

Each student needs:

- Salmon Life Cycle Sheet
- Pen or pencil

Each Stream Team needs:

- Blank cards/paper for Stream Team names
- Life Cycle Stage cards (one set per station) Each set contains six cards: Egg, Alevin, Fry, Smolt, Ocean Adult, Spawner

Each Research Group needs:

- Salmon Life Cycle Information cards (one card per station) One of each card: Egg, Alevin, Fry, Smolt, Ocean Adult, Spawner

Background Information

Each successive salmon ***life cycle*** stage is associated with different ***habitat*** features.

First Stage- Egg

Thousands of eggs are laid in a ***redd*** (nest) in the gravel of a stream in fall or early winter. As the eggs grow and develop, an eye spot will show through the membrane of the egg. This is called the "eyed-egg" stage.

Be careful! Eggs are the most vulnerable stage of the salmon life cycle.

Needs:

1. Clean gravel with little or no ***sedimentation***. Too much sedimentation will bury and suffocate the eggs.
2. Sufficient streamside ***vegetation*** will keep the water in the stream cool and will protect the eggs from direct sunlight. High ultraviolet radiation or warm water will kill the eggs.
3. A good water flow will ensure that ***dissolved oxygen*** is available to the eggs and will wash egg wastes downstream.

Hazards:

1. Sedimentation
2. High water temperature
3. Low levels of dissolved oxygen in the water
4. Direct sunlight
5. Low flow of water
6. ***Predators***
7. Humans walking in stream
8. ***Pollution***

Second Stage- Alevin

Sometime in late winter or early spring, the ***alevin*** hatch from the eggs. The alevin's ***yolk sac*** is attached to its body, delivering a complete diet to the growing salmon. All the food it needs is absorbed from the yolk sac.

Alevins remain in the gravel for a few more weeks where they are protected from predators. Once they have absorbed their yolk sac, they are ready to emerge from the gravel.

Needs:
1. Clean, cold water
2. Dissolved oxygen (DO) in the water. The DO is absorbed through the vitelline vein in the yolk sac.
3. Good flow to ensure dissolved oxygen is available and that wastes are washed away

Hazards:
1. Warm or polluted water
2. Low levels of dissolved oxygen in the water
3. Low flow of water
4. Sedimentation
5. Humans walking in stream

Third Stage- Fry

In spring, alevins emerge from the gravel and become ***fry***. Fry are about one inch long. Some ***species*** spend time in the stream or a lake, while others start heading for the sea.

Fry are most active at night to avoid predators. Vertical stripes, or "***parr marks***," form on their bodies to offer ***camouflage***.

Needs:
1. Clean, cold water
2. ***Plankton*** and smaller insects to eat
3. Places to rest and hide- large woody debris and boulders create pools and hiding places.

Hazards:
1. Floods that can flush the fry downstream before they are ready
2. Droughts that can dry up pools
3. Predators- mostly larger fish, frogs and birds
4. Pollution
5. Removal of streamside vegetation warms the water and decreases hiding places.

Fourth Stage- Smolt

Salmon fry float downstream to an ***estuary***, where saltwater and freshwater mix. The smolts undergo change here before heading to the ocean. Their bodies prepare for the saltwater of the sea.

A smolt's body changes as it prepares to enter the saltwater. Its gills change, its body grows larger, and its coloring changes to be better camouflaged in the oceans.

Needs:
1. Clean, cold water
2. Good flow of water
3. Plankton and insects to feed on
4. Hiding places- especially eelgrass

Hazards:
1. Predators- birds, fish, mammals and anglers
2. Dams- the turbines in hydroelectric dams can kill smolt, and the "slackwater" pools formed behind dams are home to pikeminnow, which can eat hundreds of smolts.
3. Pollution
4. Low flow of water

Fifth Stage- Ocean Adults

The salmon have left the estuary for the ocean. Salmon spend one to seven years in the ocean, depending on the species. During its time in the ocean, a salmon may travel up to 3,000 miles away from its home stream in search of food.

Depending on its species, at some point a salmon will feel the need to return to its home stream. Scientists believe salmon use the stars and magnetic fields to navigate home, then use the sense of smell to locate their stream.

Needs:
1. Clean, cold saltwater
2. Food- smaller fish, shrimp, etc.

Hazards:
1. Pollution- including oil and fuel spills
2. Predators- seals, sharks, whales and humans

Sixth Stage- Spawner

As a salmon heads home, its body changes shape and color. These changes help it find a mate. Once a salmon enters its home stream, it stops eating. It faces many challenges trying to find both a mate and a suitable ***spawning*** site.

Since a salmon stops eating upon entering the stream, its body cannot repair any injuries. The salmon has a long journey upstream, and faces many obstacles. After it spawns, the salmon will die, adding nutrients to the stream.

Needs:
1. Clean, cold water
2. Clean gravel between 6 to 24 inches (15 to 61 cm) deep
3. Good water flow at the redd (nest) site
4. A mate
5. Deep pools in which to rest

Hazards:
1. Warm water: a stream with warm water has reduced dissolved oxygen.
2. Predators- bears and anglers
3. Dams may prevent salmon from moving upstream to a spawning site.
4. Pollution
5. Culverts
6. Disease

Students begin this activity by assembling into Stream Teams of six students. Within the Stream Teams, each student acts as an expert for a different stage of the salmon life cycle, which includes: egg, alevin, fry, smolt, sea-run adult and spawner. Students leave their Stream Teams and join with other experts who share their life cycle stage. For example, all the egg experts form one Research Group and meet at one station, while all alevin experts meet at another station. Each Research Group uses the appropriate Salmon Life Cycle Information Card to research the biology and habitat needs of their particular life cycle stage. After completing their research, all students return to their original Stream Team to share their research findings with other members of the group.

Preparation

1. Divide your class into teams of six students. These will be the Stream Teams. If you cannot make even teams of six students, then distribute extra students to existing teams. A team can have more than six students, but it must have at least six students to work correctly.

2. Set up the room with six stations (tables). The stations initially serve as meeting places for the Stream Teams, and later as meeting places for the six Research Groups. At each station, set up the cards for the Stream Team names. If you only have enough students for five teams of six, you will only need five Stream Team names. You will still need six stations for the Research Groups.

3. Photocopy activity sheets so that you have the appropriate amount, as described in the Materials section. Cut up Life Cycle Stage cards and Salmon Life Cycle Information cards. Distribute materials to the groups.

4. Optional: Photocopy and post Salmon Life Cycle.

Procedure

1. Have each team of six students sit at one of the Stream Team stations. Each team can create their own Stream Team name, or you can name the stations based on actual local streams (For example: Coal Creek or Kelsey Creek). Hand out a Salmon Life Cycle sheet to each student. Distribute one set of the Life Cycle Stage cards to each Stream Team and ask each student within the team to pick one card. If you have more than six students in a team, explore how two students can work together as co-experts on one life cycle stage.

2. Explain the overall procedures to the students: *"Your job is to become an expert on the salmon life cycle stage that you have been assigned (based on the Life Cycle Stage card you chose). In a few minutes, you will break up into Research Groups composed of other students who are the designated experts on the same life cycle stage (For example, a student who is an expert on smolt will team up with all other smolt experts). You will work with your Research Group to gather information about your life cycle stage and then will return to your original Stream Team to share your Research Group's findings."*

3. Stream Teams now break up into the six Research Groups. Have each expert meet with their Research Group at the station that corresponds with their life cycle stage (For example: egg experts all form a Research Group at the Egg Station). Hand out a Life Cycle Information card to the appropriate Research Group. Instruct the students to spend 10 to 15 minutes brainstorming information about their life cycle stage and its habitat needs. Research Groups use their Life Cycle Information card and their own knowledge of the subject to obtain information. You can also provide other information on the salmon life cycle that you may have in your classroom, library, or via the Internet. Remind students to take bullet point research notes on their Salmon Life Cycle sheet so they can report back to their Stream Teams.

4. After 10 to 15 minutes, ask students to return to their original Stream Teams to share their research findings. Each student in the team shares his/her research findings as all other students take notes on their Salmon Life Cycle sheet. At the end of the activity, each student should have his/her Salmon Life Cycle sheet completed for all six stages.

5. Ask each Stream Team to brainstorm a list of possible hazards to salmon in your watershed or a local stream or river.

6. Lead students in a discussion of positive actions that could alleviate or lessen the impact of the hazards. Refer to the Teacher Background Information cards for more detailed information on salmon habitat needs and hazards.

Extensions

1. Research where salmon spend the different stages of their life cycle in your watershed. Plot these places on a local map. Analyze possible hazards to salmon at each life cycle stage.

2. Research what species of salmon currently use waterways in your watershed. Plot the waterways used by salmon on a local map. Also research historical salmon runs. If historical salmon runs are depleted or no longer used, find out what has caused the change (for example, construction of a dam with no fish passage).

3. Be proactive! Have your students design a salmon enhancement project. Salmon enhancement projects are excellent opportunities for students to learn more about salmon and watersheds, as well as educating the community about the health of local waterways.

   Possible ideas include:

   a. Create a *Watershed Times* newsletter educating your community about your watershed.

   b. Start a project with your students to stencil storm drains with "Dump No Waste" to protect local watersheds. (Call your local city authorities for permission. Some city utility departments have kits available for classrooms to borrow.)

   c. Adopt a local stream. Students could participate in litter clean-up days, water quality monitoring, keeping a nature journal or native vegetation plantings.

   d. Create a slide show or video about a local creek and use it as an education tool for other grades in your school, your school science fair, PTA events or community events.

   e. Start a Classroom Aquarium Education Program raising salmonid eggs in your classroom and releasing them into a creek or lake as approved by the California Department of Fish and Wildlife.

If you are in an area to develop an enhancement project, please note the following:

Students sometimes build unrealistic expectations during salmon enhancement projects because they believe that their action will restore a degraded stream or bring salmon back to spawn. This can lead to frustration. Help students understand that their actions, while important, are a small component of the action needed to enhance salmon habitat.

Original Resource

"Team Salmon" is excerpted from ***Salmon Stewards: Bringing Salmon and Watersheds Into Your Classroom***, a curriculum for Grades 4-6. Copyright by the **Pacific Science Center**.

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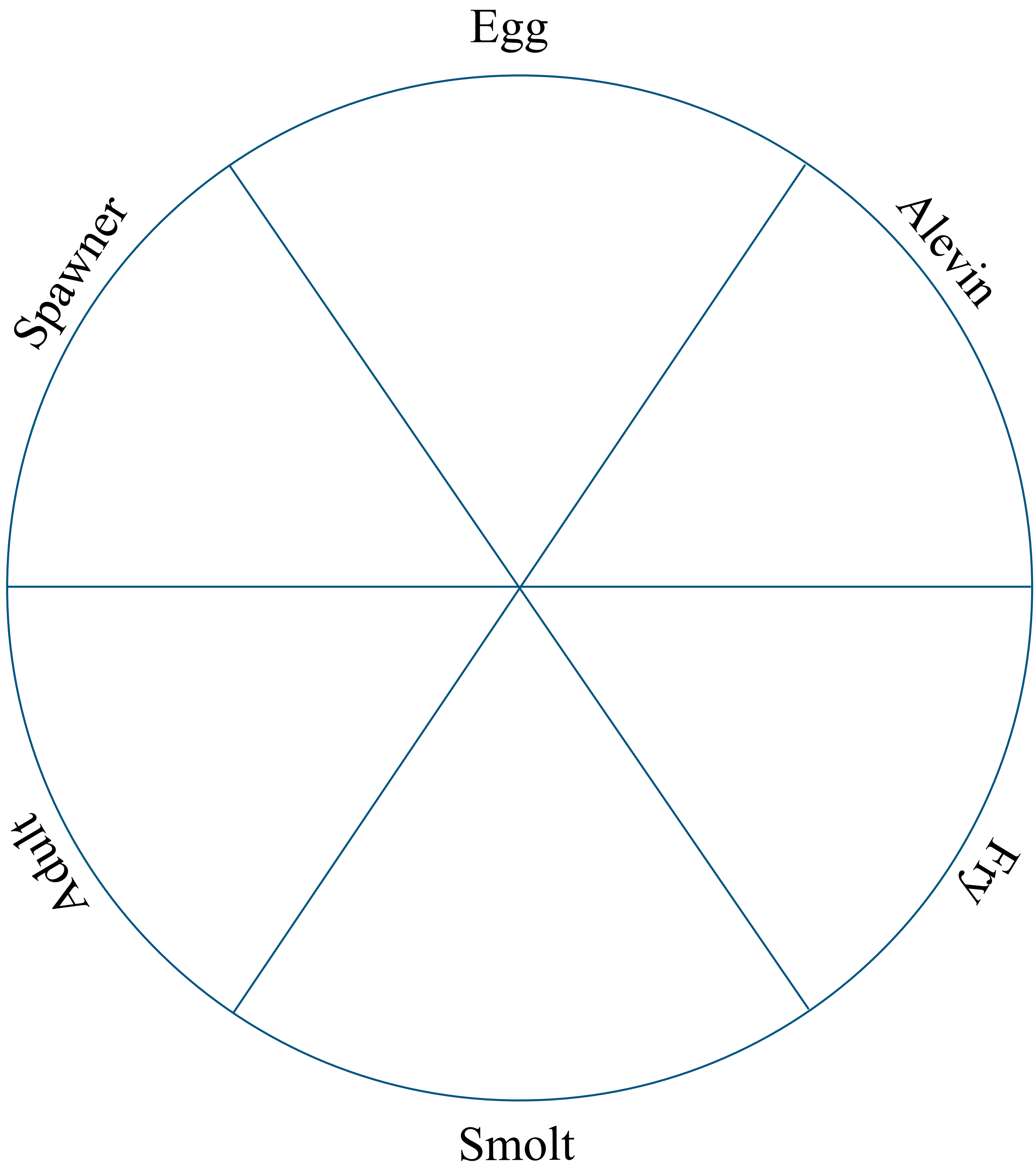
Web: http://www.pacsci.org/education/slough/salmonstewards.html

Salmon Life Cycle



Life Cycle Stage Cards

Set One	Set Two
Egg Expert	Egg Expert
Alevin Expert	Alevin Expert
Fry Expert	Fry Expert
Smolt Expert	Smolt Expert
Adult Expert	Adult Expert
Spawner Expert	Spawner Expert

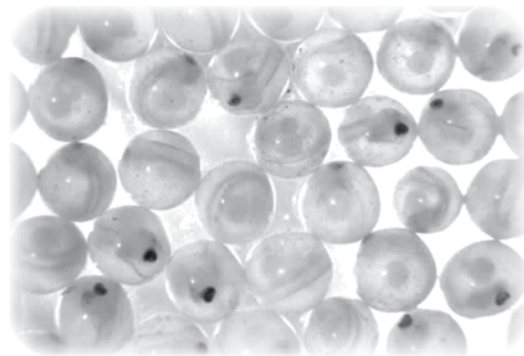
Salmon Life Cycle Information Cards

Egg

Your egg, along with thousands of its brothers and sisters, was deposited and fertilized in a nest (redd) in the gravel of a stream. Your egg was laid in fall or early winter. As your salmon grows and develops within its egg, it has very specific needs for survival.

Your egg needs:

1. Clean, cold water
2. Clean gravel in the bottom of the stream with little or no fine sand in between the gravel
3. Plants growing alongside the stream to shade the water and keep it cool
4. Flowing water to bring oxygen to the egg

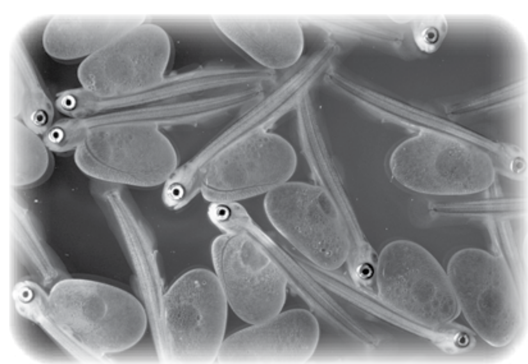


Alevin

Sometime in late winter or early spring, your salmon hatched from its egg as an alevin. Your alevin has a yolk sac still attached to its body. All of the food it needs is absorbed from the yolk sac. Your alevin lives in gravel at the bottom of the stream.

Your alevin needs:

1. Clean, cold water
2. Flowing water to bring oxygen to it
3. Plants growing alongside the stream to shade the water and keep it cool



Fry

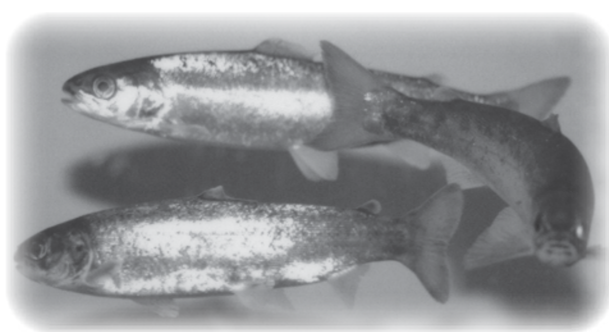
In spring, your alevin comes out of the gravel. It is now a fry and is one inch (2.54 cm) long. Your fry hangs out in pools where the water is calm. Watch out! Frogs, birds and other fish want to eat your fry for lunch.

Your fry needs:

1. Clean, cold water
2. Plankton (small floating plants and animals) and small insects to eat
3. Places to rest and hide from predators- especially in pools behind boulders and logs

Smolt

Your salmon is bigger now and has traveled downstream to an estuary (where saltwater and freshwater mix). Your smolt will stay in the estuary until its body gets used to the saltwater of the sea. Watch out! Birds, mammals and other fish want to eat your smolt for lunch.



Your smolt needs:

1. Clean, cold water
2. Plankton (small floating plants and animals) and insects to eat
3. Places to rest and hide from predators- especially in eelgrass
4. Time to adjust to the saltwater

Ocean Adult

Your salmon has left the estuary for the ocean. Now it's all grown up! Salmon spend one to seven years in the ocean, depending on what kind of salmon they are. During your salmon's time in the ocean, it may swim up to 3,000 miles away from its home stream.

Your ocean adult needs:

1. Clean, cold saltwater
2. Food- smaller fish and shrimp

Spawner

As your salmon returns to its home stream by using its sense of smell, its body changes shape and color. These changes help it find a mate. Once your salmon enters its home stream, it stops eating. It faces many challenges trying to find both a mate and a good place to spawn.

Your spawner needs:

1. Clean, cold water
2. A mate
3. Clean gravel between 6 and 24 inches (15 to 61 cm) deep in which to deposit its eggs
4. Good water flow to bring oxygen to the eggs
5. Deep pools for resting or hiding

Assessment

Name: ______________________

1. After a young salmon emerges from the gravel for the first time, it is called a _____________.

2. Plants growing alongside a stream help keep the water _____________ for salmon to survive.

3. Part of a fry's diet is small, floating plants and animals called _______________________.

4. Dams may prevent salmon from getting upstream to _____________________.

5. Salmon fry need to live in:
   (Circle one)
   (A) gravel
   (B) pools
   (C) estuaries
   (D) ocean

6. Plants in the water help salmon survive by producing:
   (Circle one)
   (A) carbon dioxide
   (B) phosphates
   (C) oxygen
   (D) sediment

7. A salmon feeds off its yolk sac when it is a:
   (Circle one)
   (A) egg
   (B) alevin
   (C) fry
   (D) smolt

8. Which of the following is good for salmon?
   (Circle one)
   (A) fuel spills
   (B) direct sunlight
   (C) drought
   (D) clean gravel

9. Why do salmon spend time in an estuary before completing their journey to the ocean?

____

____

10. Why would fewer salmon smolts survive if eelgrass were taken away?

____

____

11. Imagine all the food in a stream disappeared. Would this affect a spawning salmon? Why or why not?

____

____

12. Why would people walking in streams hurt salmon?

____

____

5 Aquatic Connections

Original Curriculum Provided by: Yolo Basin Foundation and California Department of Water Resources

Overview

In this activity students will discover the diverse elements that interact in the world of salmon and steelhead. Students will become a part of that aquatic ecosystem and explore the myriad of interactions within it. Finally, students will make hypothetical changes in the ecosystem in order to test John Muir's idea- Is everything truly connected?

Time Required

One forty-five minute session

Setting

Indoor or Outdoor

Topic

Ecosystem

Objectives

(1) Name at least five components of the ecosystem to which salmon and steelhead belong. (2) Describe at least three connections between elements of that ecosystem. (3) Describe a hypothetical change that could occur in the ecosystem and explain its effect. (4) Discuss the roles that humans can play in that ecosystem. (5) Describe how energy flows through an aquatic ecosystem and give an example.

California Standards

NGSS: 5-PS3-1, 5-LS1-1, 5-LS2-1

3-5ETS1-1

Common Core English:

RI 5-1, 5-2, 5-3, 5-4, 5-9, 5-10

SL 5-1 L 5-1

Skills

Reading, thinking.

Key Vocabulary

Ecosystem, nutrients, decompose

Materials

- 500 ft of string (not yarn because yarn can stretch and pull apart easily)
- "Aquatic Ecosystem Component" cards

Background Information

Any natural ecosystem is a set of complex interactions, and ***aquatic ecosystems*** are no exception. Salmon eat and in turn are eaten. Plants require nutrients and act as a food source, oxygen is consumed as well as produced, and people act in some cases as exploiters and in others as protectors. The diverse components of an aquatic ecosystem result in a system that is truly greater than the sum of its parts.

Preparation

1. Copy and cut apart "Aquatic Ecosystem Component" cards.

2. Plan to use a quiet area of the playground or a large indoor space where students will be able to hear each other speak.

Procedure

1. Read to the students John Muir's quote: "When you try to change a single thing, you find it hitched to everything else in the universe."

2. Ask the students to share their ideas about what Muir meant. Do the students agree?

3. Explain that in this activity, each student will become a part of a system that includes plants, people, animals, and their environment (an ecosystem.)

4. Have the students sit in a circle. Pass out the "Aquatic Ecosystem Component Cards." Have students read the cards silently to themselves and raise their hand if they need help understanding new vocabulary. Then have them hold the cards so that everyone in the circle can see them.

5. Tell students they will be making connections within the ecosystem using information on the cards. In addition to doing this, students should also be thinking of what ecosystem component they would like to be. Their decision should be based on which component they think has the best chance of survival.

6. Making the web. Stand in the center of the circle with the string. Starting with the sun, have each student read the information on his/her card (a copy of the students' information is included should the teacher or other strong reader need to assist.)

7. Each student's part will end with a question for the class to discuss and answer. The answer chosen will determine which student is to read his or her information next. The student reading the information is responsible for making sure the class answers correctly.

8. Use the string to follow the path of the students reading and answering questions. Continue to unwind the string until everyone is attached to some point along the string. Ask students to lift the web so there is room to walk under it bringing the string from one person to the next.

9. Once the web is complete, discuss the following questions (keeping the web intact).

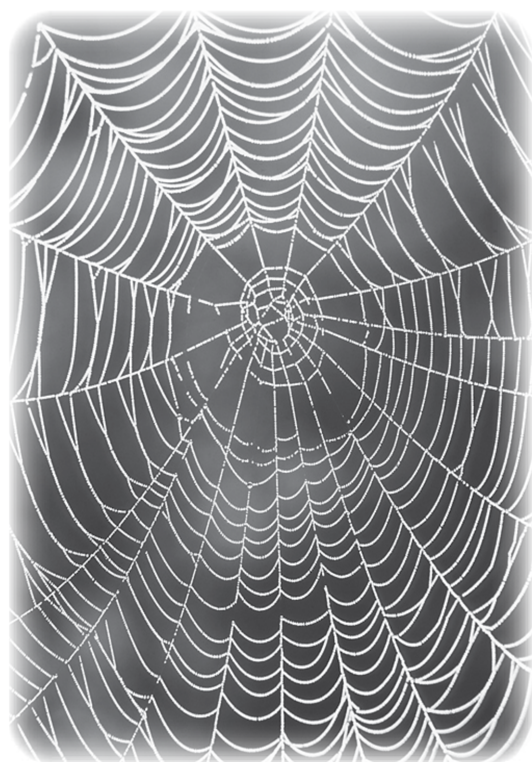
a. *"Are components of this ecosystem connected?"*

b. *"What does the pattern we have created remind you of?"* (Connections in an ecosystem are not like links in a chain; the connections are as complex as the strands in a spider web.)

c. "*What would happen if we made some changes to any part of this system?"*

California often experiences times of lower rainfall. In these times of drought there is less water available to an ecosystem. Let's say that our ecosystem is experiencing a drought. Raise your hand if you represent water in some form. Just those people, give two short, gentle tugs on the twine. Who felt it? Is there anyone who was not affected by the drought?

Let's take a look at our policymakers. What would happen if they decided not to put any limits on when and how many salmon could be caught? What might happen to the number of salmon in the ocean? Remember, if there are fewer adult salmon, then there are fewer salmon at every life stage, so anyone who represents salmon give two tugs on the twine. Who feels the effect? How?



Now let's say that way up in the mountains, a forest is logged. When the rains come, much soil and debris are washed into the stream. This sediment in the water eventually settles on the river bottom. If it settles on salmon or steelhead eggs, how would they be affected? How would this affect other parts of the ecosystem?

d. (Start rolling up the string at this point or have the class put it down.) Does John Muir's quote apply to this ecosystem?

e. Are people a part of the ecosystem we have been discussing? Where?

f. What negative effects could people have on the system?

g. How could negative effects be minimized?

h. What positive effects could people have?

i. Were all of the changes that we discussed caused by humans? Which ones were not? Can you think of other changes that might be caused by nature?

10. Ask the students what ecosystem component they decided would have the best chance at survival. Explain that the components that will most likely survive the longest are the human made physical structures, such as dams and fish hatcheries.

Original Resource

"Wetland Connections" adapted from ***Wild About Wetlands: Classroom Resource Kit***. Created by the **Yolo Basin Foundation.**

Yolo Basin Foundation
P.O. Box 943
Davis, CA 95617
Phone: (530) 758-1018

and

Some Things Fishy, A Teacher's Guide for the Feather River Fish Hatchery published by the **California Department of Water Resources.**

California Department of Water Resources
Public Affairs Office
1416 - 9th Street, Room 150-4
Sacramento, CA 95814
Phone: (916) 653-9892

Master Script

1. I am the **sun**. Plants use my energy to make food. Even simple water plants like…Guess who.

2. I am **algae**. In the water, I grow on the bottom, rocks, and other things or float, depending on my kind. When I make food from the sun's energy, I use some of it to stay alive, but I store some of it too. I am eaten by tiny water insects called … Guess who.

3. I am an **aquatic insect**. I use some of the energy I get from plants such as algae to live, but I store some of it, too. I am a source of food and therefore energy for this small fish … Guess who.

4. I am a **perch**. I use the energy I get from eating aquatic insects to swim and stay alive, but I store some of the energy in my muscles, body fat, and other body parts. When small, I am also food and therefore, an energy source for this amphibian…Guess who.

5. I am a **bullfrog**. The energy I get from eating fish and other animals helps me to stay away from predators who might try to eat me for energy. Such as this reptile…Guess who.

6. I am a **garter snake**. Although I am a predator, I am also prey. I could easily become food energy for this long-legged wading bird…Guess who.

7. I am a **great blue heron**. I feed along the edges of waterways by day, but at night I like to roost high up in a …Guess what.

8. I am a **cottonwood tree**. I am only found in areas where my roots can always get water. That is why I am so common along these waterways…Guess where.

9. I am a **river**. Water that flows along my path can be traced from high in the mountains all the way to the ocean. I am a highway for these fish that swim upriver to spawn (reproduce)… Guess who.

10. I am a **spawning salmon**. When I am an adult, I swim upriver until I reach a place to spawn. Female salmon spawn by laying eggs. Male salmon spawn by fertilizing the eggs so that they can become fish. Spawning is the end of my life cycle. Not long after I spawn, I become a … Guess what.

11. I am a **dead salmon**. When I swam upstream to spawn, I stopped eating and put all my energy into reproducing. The condition of my body gradually worsened until I died. I still play a very important role. My decomposition adds nutrients to the stream. I become food for lots of plants and animals such as this relative of a crab …Guess who.

12. I am a **crawdad**. I look like a small lobster and also feed on small fish, snails, and insects. I am food for this playful aquatic mammal…Guess who.

13. I am a **river otter**. I rely on crawdads as one source of food. One of the requirements for my habitat is that I have plenty of this …Guess what.

14. I am **unpolluted river water**. I carry lots of nutrients to plants and animals that live in and around me. I also have molecules of this gas dissolved in me…Guess what.

15. I am **oxygen**. Fish use their gills to take me out of the water, but I am also absorbed by these small, round living things that will eventually become a fish…Guess what.

16. I am **salmon eggs**. As my parents traveled upstream they were followed by a fish that eats me for energy. Part of its name even sounds like an animal that would steal eggs…Guess who.

17. I am a **steelhead**. I am a rainbow trout, and I spend part of my life in the ocean. I am a very popular sport fish for these humans who try to catch me for recreation…Guess who.

18. I am an **angler**. Some people call me a fisherman, but since women like to fish too, the word angler includes everybody. I make sure that I am a good sport by following special rules designed to protect the fish. Also, if I am over sixteen years old, I have to buy one of these permits that allow me to fish…Guess what.

19. I am a **fishing license**. Some of the money anglers pay for me is used to improve the places where fish spawn. One form of improvement or restoration involves adding these small rocks to a river or stream…Guess what.

20. I am **gravel**. Spawning salmon and steelhead look for a gravel bed in just the right place. Their eggs will have a safe place to develop until they hatch and become…Guess what.

21. I am **salmon or steelhead alevins**. In two to five years, I will return to this gravel to spawn. If there is not enough spawning area in my home river, sometimes I develop in these human-made fish nurseries…Guess what.

22. I am a **fish hatchery**. I am often built along a river because one of these human-built structures blocks fish from traveling upstream to their former spawning beds…Guess what.

23. I am a **dam**. I was built to collect and store water for all kinds of uses. One group of people use the water stored behind me to grow their crops…Guess who.

24. I am a **farmer**. Although I depend on water from dams, the original source of that water is something I really depend on…Guess what.

25. I am **rain and snow**. I come from clouds that form as water evaporates from the earth. My biggest source of moisture is this huge body of water…Guess what.

26. I am the **ocean**. Some animals, such as salmon and steelhead, spend only part of their life living and feeding in my waters. In fact, this is where many adult salmon are caught by these people who make their living from fishing…Guess who.

27. I work in the **commercial fishing industry**. A group of people decide how long I can fish each year and how many fish I am allowed to catch…Guess who.

28. I am a **policymaker**. I consult with biologists when I write fishing regulations. The number of this large fish left in the ocean is affected by my decisions…Guess who.

29. I am an **adult salmon**. Policymakers' decisions do have an effect on our population size, but so does the amount food available to us in the ocean. One of our major sources of food is this shrimplike animal…Guess who.

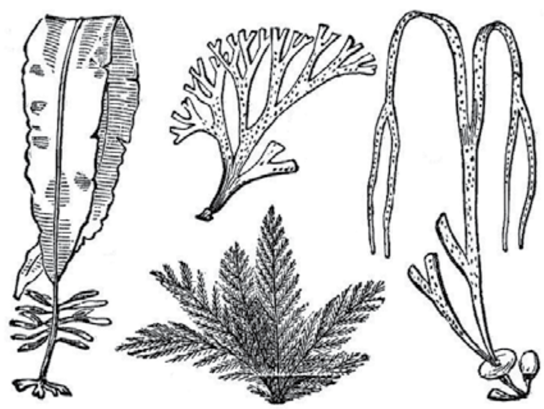
30. I am **plankton**. Animal plankton is called zooplankton, and plant plankton is called phytoplankton. Like plants, phytoplankton depends on this energy source to make its own food…Guess who.

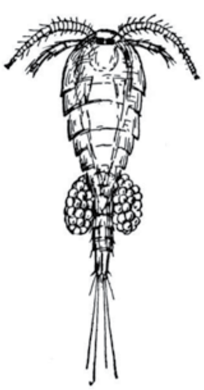
The **sun.** The End (and the Beginning)

Aquatic Ecosystem Component Cards

I am the **sun**. Plants use my energy to make food. Even simple water plants like…Guess who.

I am **algae**. In the water, I grow on the bottom, rocks, and other things or float, depending on my kind. When I make food from the sun's energy, I use some of it to stay alive, but I store some of it too. I am eaten by tiny water insects called … Guess who.



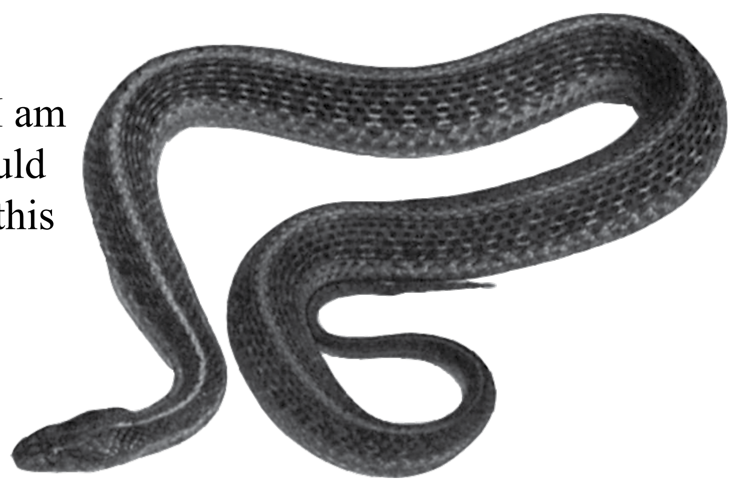


I am an **aquatic insect**. I use some of the energy I get from plants such as algae to live, but I store some of it, too. I am a source of food and therefore energy for this small fish … Guess who.

I am a **perch**. I use the energy I get from eating aquatic insects to swim and stay alive, but I store some of the energy in my muscles, body fat, and other body parts. When small, I am also food and therefore, an energy source for this amphibian… Guess who.

I am a **bullfrog**. The energy I get from eating fish and other animals helps me to stay away from predators who might try to eat me for energy. Such as this reptile… Guess who.

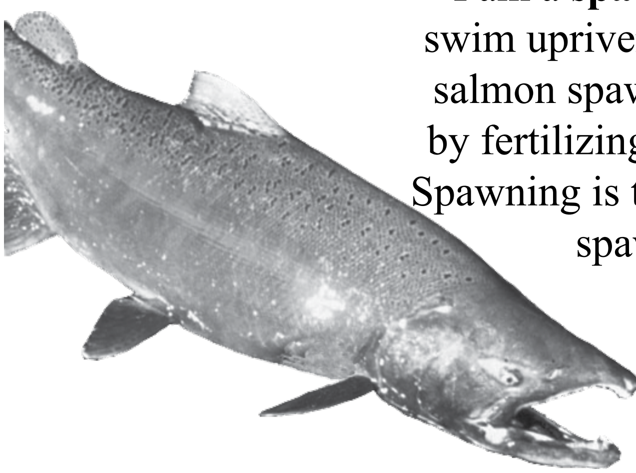
I am a **garter snake**. Although I am a predator, I am also prey. I could easily become food energy for this long-legged wading bird… Guess who.



I am a **great blue heron**. I feed along the edges of waterways by day, but at night I like to roost high up in a …Guess what.

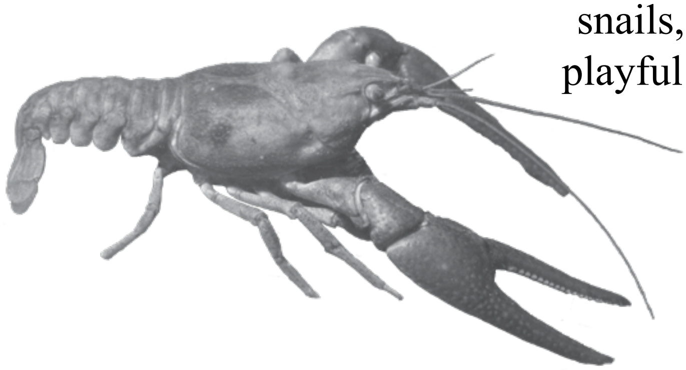
I am a **cottonwood tree**. I am only found in areas where my roots can always get water. That is why I am so common along these waterways…Guess where.

I am a **river**. Water that flows along my path can be traced from high in the mountains all the way to the ocean. I am a highway for these fish that swim upriver to spawn (reproduce)… Guess who.



I am a **spawning salmon**. When I am an adult, I swim upriver until I reach a place to spawn. Female salmon spawn by laying eggs. Male salmon spawn by fertilizing the eggs so that they can become fish. Spawning is the end of my life cycle. Not long after I spawn, I become a …Guess what.

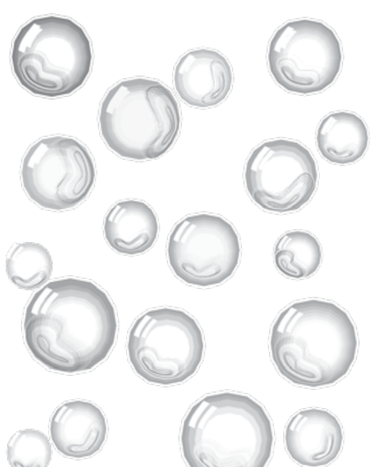
I am a **dead salmon**. When I swam upstream to spawn, I stopped eating and put all my energy into reproducing. The condition of my body gradually worsened until I died. I still play a very important role. My decomposition adds nutrients to the stream. I become food for lots of plants and animals such as this relative of a crab …Guess who.



I am a **crawdad**. I look like a small lobster and also feed on small fish, snails, and insects. I am food for this playful aquatic mammal…Guess who.

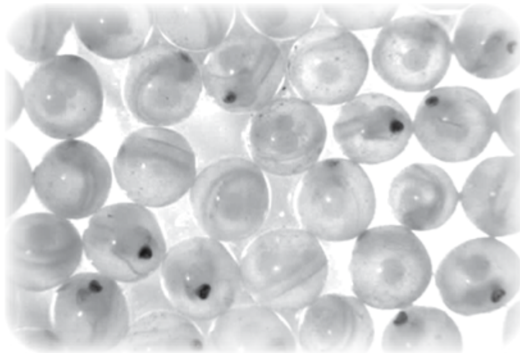
I am a **river otter**. I rely on crawdads as one source of food. One of the requirements for my habitat is that I have plenty of this …Guess what.

I am **unpolluted river water**. I carry lots of nutrients to plants and animals that live in and around me. I also have molecules of this gas dissolved in me… Guess what.

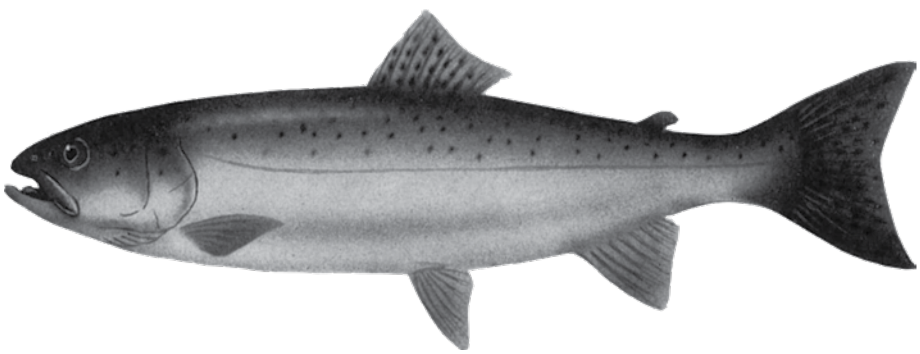


I am **oxygen**. Fish use their gills to take me out of the water, but I am also absorbed by these small, round living things that will eventually become a fish…Guess what.

I am **salmon eggs**. As my parents traveled upstream they were followed by a fish that eats me for energy. Part of its name even sounds like an animal that would steal eggs…Guess who.



I am a **steelhead**. I am a rainbow trout, and I spend part of my life in the ocean. I am a very popular sport fish for these humans who try to catch me for recreation…Guess who.

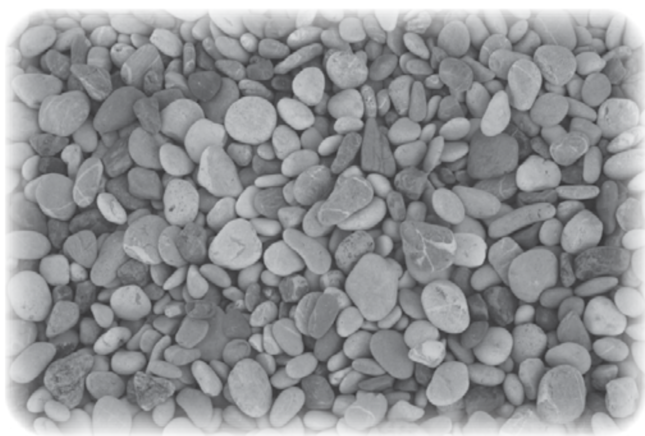


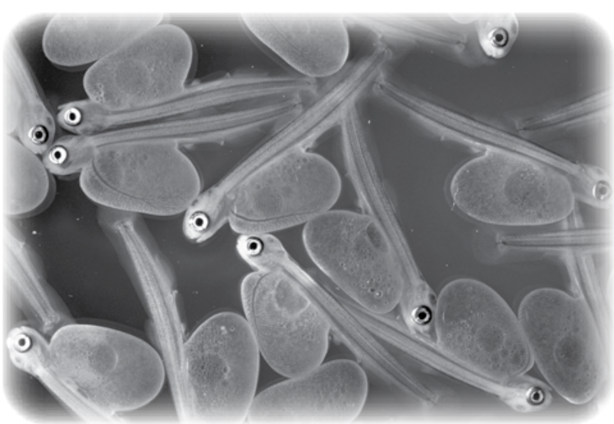
I am an **angler**. Some people call me a fisherman, but since women like to fish too, the word angler includes everybody. I make sure that I am a good sport by following special rules designed to protect the fish. Also, if I am over sixteen years old, I have to buy one of these permits that allow me to fish…Guess what.

CALIFORNIA DEPARTMENT OF FISH & WILDLIFE

I am a **fishing license**. Some of the money anglers pay for me is used to improve the places where fish spawn. One form of improvement or restoration involves adding these small rocks to a river or stream…Guess what.

I am **gravel**. Spawning salmon and steelhead look for a gravel bed in just the right place. Their eggs will have a safe place to develop until they hatch and become… Guess what.





I am **salmon or steelhead alevins**. In two to five years, I will return to this gravel to spawn. If there is not enough spawning area in my home river, sometimes I develop in these human-made fish nurseries… Guess what.

I am a **fish hatchery**. I am often built along a river because one of these human-built structures blocks fish from traveling upstream to their former spawning beds… Guess what.

I am a **dam**. I was built to collect and store water for all kinds of uses. One group of people use the water stored behind me to grow their crops… Guess who.

I am a **farmer**. Although I depend on water from dams, the original source of that water is something I really depend on… Guess what.

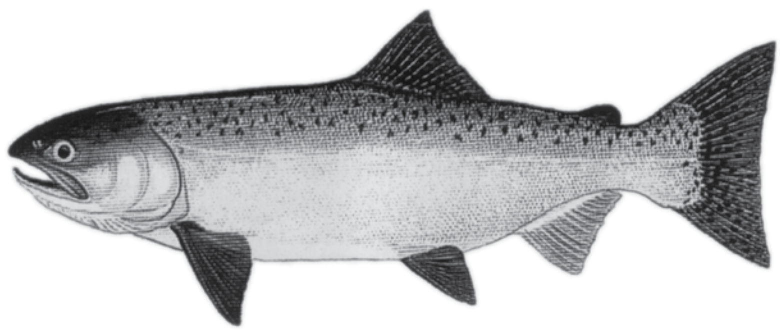
I am **rain and snow**. I come from clouds that form as water evaporates from the earth. My biggest source of moisture is this huge body of water…Guess what.

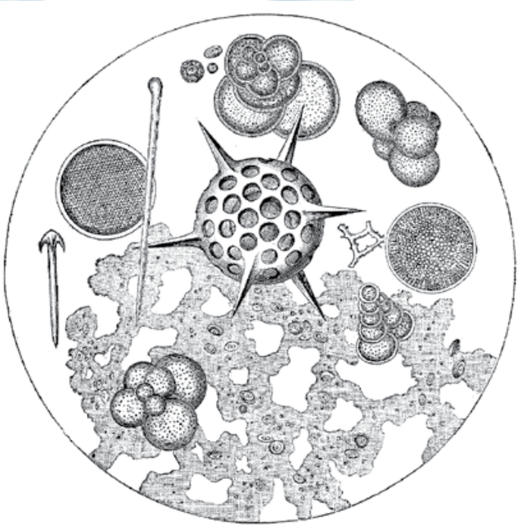
I am the **ocean**. Some animals, such as salmon and steelhead, spend only part of their life living and feeding in my waters. In fact, this is where many adult salmon are caught by these people who make their living from fishing… Guess who.

I work in the **commercial fishing industry**. A group of people decide how long I can fish each year and how many fish I am allowed to catch… Guess who.

I am a **policymaker**. I consult with biologists when I write fishing regulations. The number of this large fish left in the ocean is affected by my decisions…Guess who.

I am an **adult salmon**. Policymakers' decisions do have an effect on our population size, but so does the amount food available to us in the ocean. One of our major sources of food is this shrimplike animal…Guess who.





I am **plankton**. Animal plankton is called zooplankton, and plant plankton is called phytoplankton. Like other plants, phytoplankton depends on this energy source to make its own food… Guess who.

Assessment

Name: ____________________

1. The food in the ecosystem that connects the sun with animals is ____________________.

2. One change can affect the whole ecosystem because everything in an ecosystem is ____________________________.

3. Spawning salmon deposit their eggs in small rocks called _______________________.

4. After spawning, a dead salmon becomes __________________ for plants and animals.

5. Plants get most of their energy from the:
   (Circle one)
   (A) sun
   (B) ground
   (C) water
   (D) air

6. Connections within the ecosystem look most like a:
   (Circle one)
   (A) chain
   (B) web
   (C) row
   (D) layer

7. A connection between living and non-living parts of the ecosystem could be:
   (Circle one)
   (A) crawdad and river otter
   (B) salmon alevins and steelhead
   (C) bullfrog and garter snake
   (D) gravel and salmon fry

8. When a salmon decomposes, the stream benefits most from its:
   (Circle one)
   (A) nutrients
   (B) sediment
   (C) pollution
   (D) oxygen

9. Imagine all the plants along a stream disappeared. Why would this affect the entire ecosystem?

____

____

10. Why do human actions on one element of an ecosystem affect so many other elements?

____

____

11. Why would improper logging near a stream have a negative effect on salmon eggs?

____

____

12. Imagine that fewer salmon return to a stream to spawn. Would the crawdad population increase or decrease? Why?

____

____

5 Finding Your Ecological Address

Original Curriculum Provided by: Oregon Department of Fish and Wildlife

Overview

In this activity students will locate their own ecological addresses and watersheds using local maps. Students will understand how water moves from one place to another in a watershed and how human activity in one part of a watershed affects that entire watershed.

Time Required

One fifty minute session

Setting

Indoor

Topic

Watershed

Objectives

(1) Identify an ecological address and watershed. (2) Explain how water moves in a watershed. (3) Understand the role of human activity in a watershed.

California Standards

NGSS: 5-ESS2-1, 5-ESS2-1, 5-ESS3-1

3-5-ETS1-1

Common Core English:

RI 5-1, 5-2, 5-4, 5-9, 5-10

SL 5-1, 5-2, 5-4

Skills

Mapping, reading

Key Vocabulary

Ecological address, watershed, runoff

Materials

- California watershed map provided
- State highway map or other map showing streams and rivers in your local area
- Paper for drawing their own watershed "maps"
- Colored pencils or markers (can be shared by a group of students)
- String or yarn (about one foot per student)
- Copied student readings, if used

Background Information

All land on Earth is part of a ***watershed*** and all people live in a watershed. A watershed is a system that is made up of all the land area from which water, sediment and dissolved materials drain to a common watercourse or body of water. Most activities that are done on the land have some effect on the watercourses that drain the watershed.

An "ecological address" includes the name of the watershed in which one lives, as well as each successively larger stream and watershed up to and including the major river from which the largest watershed usually takes its name. This system also includes the large lakes or the ocean into which that river feeds. These are the systems subject to ***pollution*** from failing septic tanks, excess lawn fertilizers, carelessly disposed crankcase oil, and other wastes from human activities. These systems are also affected by ***silt*** resulting from disturbed soils in the watershed.

When people have a greater understanding of their ***environment***, they gain awareness of how their personal actions, local laws and regulations, and everyday business practices affect the integrity and stability of their ecological address and their larger biological community.

Preparation

1. Make copies of student readings and maps. You may wish to substitute the maps provided with local maps of your area.

2. If possible, have your class visit a local stream to see how water flows downhill to the ocean.

Procedure

1. Use one or both student readings to prepare students for this activity and complete the student activity.

2. Begin by asking students to share their home mailing or street addresses. Write a few of them on the chalkboard. Explain that these postal addresses have been devised by society- that they are "social" addresses. They are important because people need to be located within their community by family, friends, and services such as the mail, police, fire or ambulance.

3. Now tell students that they all have another kind of address, called an ecological address. Invite students to discuss the meaning of the word "ecological," eliciting from them the understanding that it refers to the relationship between an organism and its environment. Just as a postal address tells people one way that they are connected to a community, the ecological address tells people how they are connected to the land on which they live. In this activity, the ecological address will be based on an ecological feature they have just started learning about- the watershed.

4. Have students discuss the term "watershed." Let students share their definitions from the student activity page. Try to develop a class definition, which should approximate this: ***all the land area that drains into a particular body of water***. Tell students that they will be locating their own ecological addresses by finding and learning about the watershed where they live.

5. To help students understand the concept of a watershed, trace the outline of your hand, wrist and part of your arm on the chalkboard. Color in the space between your fingers and label your arm "Green River". Tell students that this outline is a model for a watershed area. Your fingers represent streams that feed into the larger river (your arm). The colored space between your fingers is land, where people live. Let students know that a watershed's name is usually taken from the stream or river that serves as the main collector of all the water in the watershed. Ask students what the watershed you just drew would be called (The Green River Watershed). Write the name on the board.

6. Ask students how large they think watersheds can be, then how small they can be. They should recall some of this from their reading. Impress upon the students that large watersheds include many small watersheds. The Mississippi River has the largest watershed area in the United States, taking in runoff from thirty-one states drained by the Platte and Missouri Rivers which are tributaries of the Mississippi. With its headwaters at the far north near Lake Superior, the Mississippi River eventually flows to sea in the Gulf of Mexico.

7. Students are now ready to work with the California watershed map (page 89). Divide the class into pairs of students and give each pair a copy of the watershed map. Tell them that the outside boundaries of the Russian River watershed are ridges of high elevation, and that runoff from rain that falls inside of this boundary can increase the flow within the Russian River system- and none other.

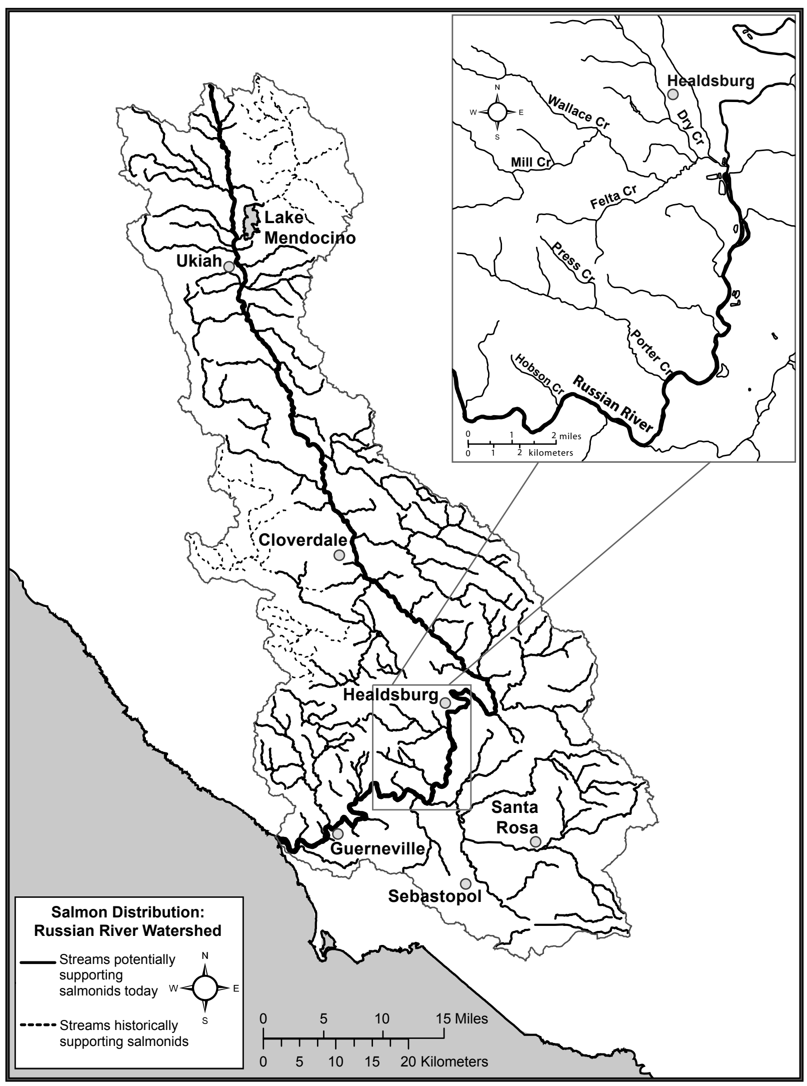
8. Have them locate a stream called Porter Creek. Also have students locate the point where Porter Creek runs into the Russian River. Explain that Porter Creek is a tributary stream to the Russian River which runs into the Pacific Ocean.

9. Next have students locate the Dry Creek watershed by drawing a line around it with pencil or marker. Then have them locate the Mill Creek watershed. Mill Creek is a small watershed that feeds into several larger tributaries that are all a part of the Russian River watershed area. Have students compare the map showing the entire Russian River watershed with the smaller inset map. How do the smaller watersheds they've located fit into the Russian River watershed as a whole? Smaller watersheds are often said to be "nested" within a larger watershed. Make sure all teams have correctly identified the watersheds before asking the following questions:

a. *"If you lived in the town of Healdsburg, in which watershed (or sheds) would you live?"* (You would actually live in the Dry Creek watershed, which is part of the larger Russian River watershed.) Remind students that a large watershed is made up of many smaller watersheds, and that Dry Creek and Russian River would both be correct answers to the question.

b. *"If you lived in Ukiah, in which watershed would you live?"* (Russian River)

10. Suggest that everyone lives in a watershed, and ask students to explain why this is true. (All land has waterways running through it that drain into larger waterways. For example, in most urban areas rainwater feeds into storm drains. The drains then feed into nearby streams or rivers.)



11. Using a local map that shows streams and rivers, have each student name the watershed in which he or she lives. Explain that this watershed is the student's ecological address, and that this address describes how he or she is connected to the land and water system that drains it. In urban areas that are hilly, a city map will be needed to determine the exact watershed in which a house might be found. Depending on the proximity of waterways, the watershed named should reflect that students' ecological addresses can have several components, from the smallest watershed they can observe to a larger watershed of which the smaller one is a part. Have some students share their ecological addresses while other students follow along their own maps.

12. Have students make a "map" of their ecological address. The map need not be to scale, but it should represent the watershed(s) in which the students live. As an alternative or additional activity, have the entire class make a larger map of the watershed on large sheets of paper.

13. Have students brainstorm a list of what they think can happen to water as it moves through a watershed. Highlight the things that are caused by human activity. These might include actions such as discarding oil or other wastes into a stream, clearing land (removing vegetation), or washing cars with soaps that contain phosphates (non-biodegradable chemicals). Then have students determine how and where these chemicals would travel in their watershed. They can do this by tracing the path from the smallest tributary in the smallest watershed as it empties into larger and larger watershed areas. Have students repeat the activity, this time looking at non-human influences on watersheds, such as heavy rains, wind, and other natural phenomena.

14. Have students calculate how many miles or kilometers of stream and river are in their watershed, using the "scale of miles" on the published map. Using string to follow a curving waterway on the map can make measurement easier and more accurate. This measurement will help make clear to students the amount of area impacted by human activities affecting the watershed system.

Extensions

1. Build a list of who and what uses your watershed- from people to fish to wildlife. For each, make a list of the effects on the watershed.

Original Resource

The Fish Hatchery Next Door. This information was provided courtesy of the **Oregon Department of Fish and Wildlife.**

Oregon Department of Fish and Wildlife
Information and Education
3406 Cherry Avenue N.E.
Salem, OR 97303-4924
Phone: (503) 947-6002

Adapted maps and text provided by:

California Department of Fish & Wildlife
Office of Communications, Education & Outreach
1416 Ninth Street, Room 1280
Sacramento, CA 95814
Phone: (916) 322-8911

Finding Your Ecological Address

Student Reading

Water runs downhill- we all know that. The instant that a drop of rain hits the earth, it begins its journey to the ocean (If it falls as snow, it has to wait until it melts!). Of course, not all water drops make it to the ocean. Some are taken up by the roots of plants and are transpired into the air through the plant's leaves. Some evaporate in puddles, or other areas that hold water. Some filter down into underground areas, moving slowly downhill. But most water drops end up as runoff, the water that finds its way into creeks, streams and rivers.

This long or short journey to the ocean takes place within a watershed. If you were to stand in a streambed and look upstream at all the land the stream drains, you would be looking at the stream's watershed. Almost all the area of a watershed is land- not water! And almost everything that affects the stream that drains it happens on that land. In other words, ALL land on Earth is in a watershed.

Watersheds can be big or small. A mud puddle has a watershed of only a few square feet. The Columbia River in the Western United States has a watershed that is 258,000 square miles. The biggest watershed in the country is the Mississippi River, which drains all the land between the Rocky Mountains and Appalachian Mountains!

Watersheds are separated by ridges, called divides. The Continental Divide of the United States, for example, is in the Rocky Mountains. All the rain and snow falling on the west side of the divide flows into the Pacific Ocean. All the rain and snow falling on the east side of the divide, sooner or later, ends up in the Atlantic Ocean.

Now, write your own definition of a watershed:

____

____

____

____

Wherever You Are- It's a Watershed

Student Reading

Since all land is part of a watershed, it follows that all the factors that affect the land also affect the watershed.

The boundary between two watersheds is called a divide. A watershed is drained by a network of channels that increase in size as the amount of water and sediment they must carry increases.

Streams are dynamic systems with channels that collect and convey surface runoff generated by rainfall, snowmelt or groundwater discharge. The shape and pattern of a stream is a result of the land it is cutting into and the sediment it carries. The stream is forever evolving, always in the process of change.

The climate of an area obviously plays a big part in the processes within the watershed. Land and water are linked directly by the water cycle, usually in the form of rain or snow. Runoff, the gravity-powered journey of water downstream, erodes the rocks and soil of the watershed. At least some of the water percolates into the soil as groundwater. Except for high rainfall events, most of the water running in streams is from groundwater. Humans remove both groundwater and water in streams from the watershed for their own uses. Some of that water is returned to the watershed, sometimes not as clean as it was when removed.

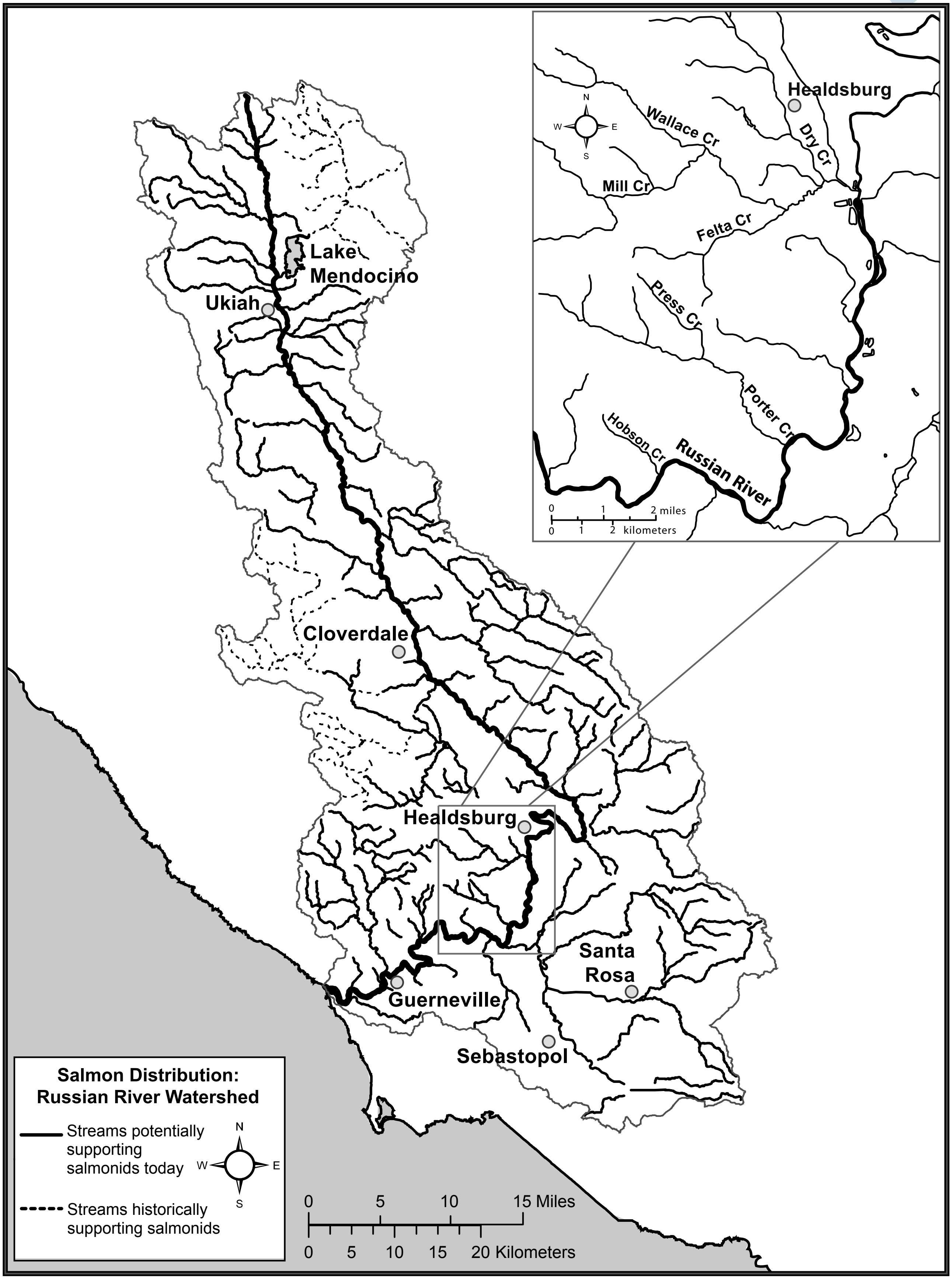
The shape and slope of a watershed affect the speed of runoff, erosion and the amount of water that can percolate into the soil. The steeper the slope, the greater the possibility for rapid runoff and erosion. The makeup of the soil and rocks within the watershed (some being easier to erode than others) is another factor affecting the rate of erosion and deposition.

Plant cover benefits a watershed. Grasses, forbs, shrubs and trees intercept rain and reduce the force with which it strikes the ground. The plant canopy reduces the effects of wind, and slows runoff and erosion. Plant material also falls into the stream, delivering a vital food and energy source to the creatures of the stream. Plant roots bind together the soil, and reduce erosion by stabilizing stream banks and slopes.

Human activities continue to both help and hurt the watersheds. Activities such as agriculture, recreation, timber harvest, livestock grazing, urban and industrial development, and mining can be harmful if they are not done carefully. Management of watersheds and their river basins is part of being careful with watersheds, and includes such activities as land use planning, zoning, permitted and prohibited land uses or types of development, restrictions on water use and water developments, pollution control, and citizen involvement in repairing watersheds and management decisions. We call this stewardship, and we are all responsible for it.

Stewardship is alive and well in California! People from all walks of life are coming forward to volunteer to help restore damaged watersheds, "adopt" portions of streams and rivers, assist the California Department of Fish and Wildlife and other agencies in monitoring fish populations, and teach young people to be responsible anglers. There is much work to be done, but with help from people, watersheds and public attitudes toward them can be improved.

Rivers, hillsides, mountain tops, bottom lands, and even groundwater are all part of one system. They are linked together directly by the water cycle and watershed. The combination of climatic conditions, soil types, topography, plant cover, and drainage systems define the character of each watershed. We all live somewhere within a unique watershed. We could say that each of us has an "ecological address", one that tells us where we live in relation to the watershed above and below us, and defined by the plants and animals that live there with us.


Healdsburg
Wallace Cr
Dry Cr
Mill Cr
Felta Cr
Press Cr
Porter Cr
Hobson Cr
Russian River
0 1 2 miles
0 1 2 kilometers
Lake Mendocino
Ukiah
Cloverdale
Healdsburg
Santa Rosa
Guerneville
Sebastopol
Salmon Distribution: Russian River Watershed
Streams potentially supporting salmonids today
Streams historically supporting salmonids
N
S
E
W
0 5 10 15 Miles
0 5 10 15 20 Kilometers

Assessment

Name: ______________________________

1. All the land area that drains into a particular body of water is called a ___________________.

2. Controlling pollution is one way _________________ can become better watershed stewards.

3. Your location connected to the environment you live in is your __________________ address.

4. When rain travels over land into streams and rivers it is called ____________________.

5. The largest watershed in the United States is the:
   (Circle one)
   (A) Mississippi
   (B) Columbia
   (C) Missouri
   (D) Sacramento

6. Which of the following is the most helpful for a watershed?:
   (Circle one)
   (A) urban development
   (B) livestock grazing
   (C) mining
   (D) water recycling

7. You might share your ecological address with:
   (Circle one)
   (A) plants
   (B) animals
   (C) insects
   (D) all of the above

8. Rain and snow falling on land eventually run to rivers that all lead to:
   (Circle one)
   (A) oceans
   (B) lakes
   (C) ponds
   (D) groundwater

9. Why would you be able to live in two watersheds at the same time?

____

____

10. Imagine that you live far away from any stream, river, or ocean. Are you in a watershed? Why or why not?

____

____

11. Imagine your ecological address is in an area with a steep slope. Would you be more likely to have lots of erosion or just a little erosion? Why?

____

____

12. Why do river channels get bigger as they get closer to the ocean?

____

____

5 Unit Assessment

Name: ______________________________

1. Dams may prevent salmon from getting upstream to ___________________.

2. One change can affect the whole ecosystem because everything in an ecosystem is _________________________.

3. After spawning, a dead salmon becomes ____________________ for plants and animals.1

4. An ecological address connects a person to the _______________________ he or she lives in.

5. You might share your ecological address with:
   (Circle one)
   (A) plants
   (B) animals
   (C) insects
   (D) all of the above

6. When a salmon decomposes, the stream benefits most from its
   (Circle one)
   (A) nutrients
   (B) sediment
   (C) pollution
   (D) oxygen

7. A salmon feeds off its yolk sak when it is a:
   (Circle one)
   (A) egg
   (B) alevin
   (C) fry
   (D) smolt

8. Connections within the ecosystem look most like a:
   (Circle one)
   (A) chain
   (B) web
   (C) row
   (D) layer

9. Why would improper logging near a stream have a negative effect on salmon eggs?

____

____

10. Imagine that you live far away from a stream, river, or ocean. Are you in a watershed?

____

____

11. Imagine all the food in a stream disappeared. Would this affect a spawning salmon?

____

____

12. Why would people want to work as a community to restore damaged watersheds?

____

____

Grade 6 Overview

This unit teaches that people play a large role in changing the environment and salmonids respond to even the slightest changes. Clean, healthy streams are important for salmonid survival, yet very few streams contain all the ingredients necessary to create an inviting home. Students will learn the key habitat needs for salmonids. They will also assess how environmental factors, including human activities, have impacts on aquatic habitats.

Activity	Time (mins)		Setting	CA Content Standards	Topic
	Prep	Activity			
When It Rains It Pours	30	50	Indoor	MS-PS3-1, MS-ESS2-1, MS-ESS2-4,MS-ESS3-3	Human Inpacts
Coming Home	30	120	Indoor	MS-LS1-5, MS-LS2-1, MS-LS2-2, MS-LS2-3, MS-LS2-4, MS-LS2-5, MS-ESS3-3, MS-ETS1-1	Habitat Conservation
What's in the Water	30	45	Indoor	MS-LS2-2, MS-LS2-3, MS-LS2-4, MS-LS2-5, MS-ESS3-3, MS-ESS3-4, MS-ETS1-1	Water Quality

When It Rains It Pours
Salmon and Trout Education Program (STEP) Curriculum.

Coming Home
From ***The Stream Scene: Watersheds, Wildlife, and People***. This information has been provided courtesy of the **Oregon Department of Fish and Wildlife**.

What's in the Water
Adapted with permission from *Project WILD K-12 Curriculum and Activity Guide*. Copyright by the Council for Environmental Education.

6 When It Rains It Pours

Original Curriculum Provided by: Salmon and Trout Education Program (STEP)

Overview

This activity is a classroom demonstration by the teacher that illustrates the effect of stream velocity on the sediments in the water column. The teacher pours water from a pitcher at a high rate of flow into a gallon container, which simulates a stream environment. Students observe the results.

Time Required

One fifty minute session

Setting

Indoor

Topic

Human Impacts

Objectives

(1) Understand that sedimentation is a normal occurrence in a stream. (2) Identify human activity that increases the amount of sediment going into streams. (3) Identify positive and negative effects of increased run-off into streams. (4) Explain how increased sedimentation adversely affects salmonids at different life cycle stages.

California Standards

MS-PS3-1,
MS-ESS2-1, MS-ESS2-4,
MS-ESS3-3

Common Core English:
SL 6-1
L 6-1, 6-3, 6-6

Skills

Observation, inferring, predicting.

Key Vocabulary

Velocity, substrate, riparian corridor, impermeable surface, turbidity

Materials

- Three clear plastic gallon jars
- Approximately 2 cups of sand/silt gravel mix
- Approximately 1 cup of 1½"-2" stream type gravel (Noya gravel)
- Tap water to fill each jar ½ full
- 1 pitcher full of water

Background Information

Salmonids need clean, clear water for every stage of their ***life cycle***. A healthy stream usually runs cool and clear over a clean gravel bottom. ***Silt*** can smother incubating eggs and can cause problems for young and adult fish to extract oxygen. In a healthy, natural stream the flow of clean water usually remains steady. The ***riparian*** corridor of a stream acts as a great sponge to soak up heavy rainfall as well as a filter to eliminate excess ***sediments*** or surface pollutants from reaching the stream channel. This water is then released slowly into the stream. Since salmonid fry are small, it is important to prevent floods so young fish are not swept downstream.

Adult salmonids encounter problems with increased sediment in the water column primarily through difficulty in gill function. On the other hand, cloudy water can provide some protection from predators due to increased cover. In smaller coastal streams, adult fish generally ***migrate*** under the cover of darkness or in the upper portion of the water column in the semi-cloudy water following a rainstorm.

If the land beside a small stream is covered with asphalt, houses or other impermeable surfaces, rainfall cannot soak into the ground. As a result, rainwater rushes into the stream to create serious flooding and increased sedimentation. Careless land use practices, such as road construction beside streams, may allow loose soil to wash into the water and coat the gravel beds with silt.

For successful ***spawning***, salmonids require clean, stable gravel, permitting an adequate flow of water through the ***redd*** that will provide each embryo and alevin with a high concentration of ***dissolved oxygen*** and afford the removal of metabolic wastes such as carbon dioxide and ammonia. Increased stream velocity has a positive affect on stream dynamics by scouring out stream sediments from bed gravel and transporting it downstream to slower areas where it will deposit in pools until a higher flow moves it further downstream. Sedimentation is a natural occurrence in any stream.

Human activities impact the balance between rainfall and sedimentation and can overburden the ability of normal flow rates to move sediments downstream. Additionally, the increase of impermeable surface area in a watershed due to construction, roads and other activities, greatly alters the runoff profile in a stream. Rainfall in a relatively undisturbed ***watershed*** may percolate into a stream over a period of days after the rain ends. In a highly developed area, the runoff enters almost immediately and ends very soon after the end of the rainfall. This places a great burden on migrating fish which then have very little time to move up or downstream.

The careful planning of development within a watershed is critical when looking at sedimentation and the ability of normal rainfall to move the sediments out of the spawning areas.

Preparation

1. At least 48 hours before demonstration day, prepare the three-substrate environments.

2. Fill the bottom of two, one gallon jars with any combination of soil, sand, silt and gravel.

3. Fill the third with Noya gravel only.

4. Fill each of the three jars half full with water and let them stand for at least 48 hours.

5. Have a pitcher full of water available.

Procedure

1. Using the background information, begin by reviewing the stream habitat requirements of salmonids. Define "riparian corridor" and explain how it helps salmonid habitat.

2. Show students the first two substrate environments and ask them to pretend that these two jars represent stream or river bottoms.

3. Ask what circumstances might take place within the watershed that would cause a great deal of water to be delivered very quickly to the stream corridor. Most students will respond with "a big rainstorm" unless a dam is nearby.

4. Ask, *"What are the factors that might affect how quickly the water from a big rainstorm enters the stream or river?"* Students may respond with steepness of terrain (topography), runoff from roads and houses, storm drains (related to development), logging in the area, amount of trees and vegetation surrounding the river. Using the background information, define the term "impermeable surface" and give examples.

5. Ask students what they think occurs when runoff is large and rapid. (high turbidity from sediments in the stream column)

6. Pour the pitcher of water quickly into one of the first two jars.

7. Ask students to describe what they see.

8. List responses on the board.

9. *"How might this affect salmonids at different life cycle stages? Adult, smolt, fingerling, fry, alevin and egg?"*

   Adults: hinder migration and cover spawning beds with sediments

   Smolt: hinder downstream migration and limit food supply

   Fingerlings and fry: limit food by covering aquatic insects and their habitat, and difficult to extract oxygen due to clogging of gill filaments. Oxygenated water flows through the gills of a salmonid. When the water has a high content of tiny sediments these can become trapped in sensitive gill tissues and fish may suffocate.

   Alevins: may become trapped in gravel.

   Egg or Alevin: may become buried and suffocate due to lack of oxygen.

10. Ask students, *"Are there any benefits from this increased run off and sediments in the water column?"*

    These effects are harder to see in a simulation and a closed system, but in the natural stream environment these suspended sediments would also be carried away by the increased stream velocity. The increased velocity combined with the sediments helps to scour and clean the gravel beds, which could increase spawning habitat.

11. Next ask, *"What will happen if we decrease the velocity of the stream flow?"*

    Students may say there won't be as much sediment in the water. Water won't look so muddy.

12. Very slowly pour water from the pitcher into the second jar. You should get some clouding but not nearly as much as in the first demonstration. Note on the board again student observations compared to the first demonstration.

13. You may ask similar questions about what factors might cause runoff to be slower.

14. Students may respond with less steep terrain, less development and more vegetation.

15. Ask students, *"How could this be bad for salmonids?"*

    Students may see how it would decrease scouring/cleaning of spawning gravel, decreased aquatic insect habitat as sediment builds up, less oxygen as there is less turbulence from a smooth bottom stream, and there could be less access for fish to appropriate habitats as the gravel gets filled in with sediment.

16. Finally, use the third jar with clean gravel and quickly pour water from the pitcher.

17. Note student observations/comparisons on the board.

18. Ask students, *"Why was the water clear even though stream velocity was great?"*

    Students may see how the substrate was different with little or no sediment.

19. Ask, *"Where does sediment come from?"* List responses on the board. Erosion from natural processes should be one.

20. Ask, *"How do human activities within the watershed affect the sedimentation equation and what can be done about it?"* List responses on the board: change amount of logging (especially clear cutting), building construction, agricultural/ranching practices, which decrease riparian vegetation, etc.

Extensions

1. Quantify observations with turbidity tests.

2. Collect stream sediments from different areas and test for turbidity.

Original Resource

Salmon and Trout Education Program (STEP) Curriculum. © 2005 Monterey Bay Salmon and Trout Project. Used by permission.

Monterey Bay Salmon and Trout Project
825 Big Creek Road
Davenport, CA 95017
Web: www.mbstp.org

Assessment

Name: ______________________

1. Material that settles to the bottom of a stream is called ____________________________.

2. Roads and houses along a stream create an _____________________________ surface that prevents water from soaking into the ground.

3. The speed at which the water flows in a stream is called __________________________.

4. Since salmonid fry are so small, they could easily be swept downstream by a ______________.

5. A natural process that causes erosion is:
   (Circle one)
   (A) clear cutting
   (B) ranching
   (C) building
   (D) raining

6. In an undisturbed watershed, most rainfall from one storm will percolate into streams over a period of:
   (Circle one)
   (A) minutes
   (B) hours
   (C) days
   (D) months

7. Which of the following is a positive effect of runoff?:
   (Circle one)
   (A) severe flooding
   (B) excess sedimentation
   (C) waste removal
   (D) unstable gravel

8. Spawning salmonids benefit from some sediment because it helps them to:
   (Circle one)
   (A) hide
   (B) swim
   (C) eat
   (D) breathe

9. Why does lots of vegetation reduce stream sedimentation?

____

____

10. Imagine a road runs along the bank of a stream. After a heavy storm, how might salmonid fry be affected?

____

____

11. Why would a high stream velocity increase spawning habitat?

____

____

12. Why would a low stream velocity harm salmonid eggs?

____

____

6 Coming Home

Original Curriculum Provided by: Oregon Department of Fish and Wildlife

Overview

In this activity students learn about the habitat needs of salmonids. The ultimate goal of the advertisement is to communicate what salmon need to live and reproduce, impacts human activities have had on watersheds in the past, and how we can improve streams to attract salmon in the future.

Time Required

Two sixty minute sessions

Setting

Indoor

Topic

Habitat Conservation

Objectives

(1) Identify specific habitat needs of salmonids. (2) Understanding the role of humans in protecting salmonid habitat.

California Standards

NGSS: MS-LS1-5, MS-LS2-1, MS-LS2-2, MS-LS2-3, MS-LS2-4, MS-LS2-5, MS-ESS3-3, MS-ETS1-1

Common Core English:

SL 6-1, 6-2, 6-3, 6-5

L 6-1, 6-3, 6-6

Skills

Research, art, teamwork

Key Vocabulary

pH, dissolved oxygen, pollutants

Materials

- Old newspapers, magazines, and junk mail
- Butcher paper
- Art supplies
- 24" x 36" poster board or 1/4" foam core board
- Research materials (books, Internet)

Background Information

Most clean, healthy streams, no matter how small, can contribute to ***salmonid*** habitat. All salmonids (salmon, steelhead, and trout) spend at least a part of their life cycle in small streams. Some, like chum or pink salmon, may only spend a few weeks in the stream or the ***estuary*** before moving to the ocean, while others may spend three or more years before migrating. Young sockeye salmon move from small streams to rear in ***freshwater*** lakes for one or more years while still other species are permanent residents of large and small streams.

A single stream may appear insignificant as a producer of wild fish. But together, thousands of small streams throughout the Northwest account for a lot of fish production. Healthy streams are valuable, but they are fragile. They are easily damaged by poor agriculture and forestry practices, ***pollution***, mining, and urban development.

Wild salmonids need certain stream conditions to survive. Salmonids need clean water for every stage of their life cycle. A healthy stream usually runs cool and clear over a clean gravel bottom. The ***silt*** present in cloudy water can coat incubating eggs and surrounding gravel, preventing oxygen from reaching the eggs. Without oxygen the eggs will die. In a healthy, natural stream, the flow of clean water usually remains steady. The land on both sides of a healthy stream acts as a giant sponge to soak up heavy rains. This water is then released slowly into the stream. Slow release of ***groundwater*** also prevents small streams from drying up during the warm summer months.

Aquatic organisms, including fish, have a relatively narrow temperature range for survival. Shade provided by trees and other plants that grow beside the stream helps keep the water cool and within that acceptable range. Insects that feed on the leaves and branches of these streamside plants sometimes fall into the water providing food for the fish. Mayflies and other insects that land on the water's surface to lay their eggs are also eaten by fish. Some insect eggs hatch and become part of the stream food chain. These aquatic forms of insects live on, around, and among the rocks of the streambed. These insect forms are often carried along by the water current where they become part of the menu for a fish waiting downstream.

Small streams often contain natural debris such as root wads, fallen trees, and boulders. Fish use these structures to hide from their enemies which include larger fish, birds, and small animals.

Adult migratory salmonids, like salmon and steelhead, need a barrier-free route to their ***spawning*** areas. They also need cover, both in the stream and alongside it, for protection from ***predators*** and for shaded resting areas. Salmon usually return to spawn in the same stream where they hatched. No one knows for certain how they find their way back to the same stream, although one theory is that they can smell or actually taste the water chemistry of their home stream. When they enter freshwater, salmon stop feeding. Their journey upriver is made on the energy stored while living in the ocean. Within days of spawning, adult Pacific salmon die, contributing the nutrients in their bodies to the stream from which it originally came.

Once young fish hatch they also need barrier-free access as they distribute themselves both upstream and downstream where food and cover is available.

Preparation

1. Make copies of activity background information and directions for each student.

2. Gather examples of advertisements from magazines and newspapers that can be used as examples.

3. Schedule a time when students can present their advertisements to the class.

Procedure

Imagine a stream that begins in a wilderness headwater area, flows through farmland and finally through urban areas on its way to the Pacific Ocean. This stream needs salmon! Your job is to create an advertisement that will attract salmon to this stream. The advertisement will tell salmon how great the stream is and why it is a suitable place for salmon to live.

The ultimate goal of the advertisement is to communicate what salmon need to live and reproduce, impacts human activities have had on watersheds in the past, and how we can improve streams to attract salmon in the future.

1. Work in groups of three students.

2. As a group, look at examples of advertising campaigns in newspapers, a variety of magazines, and junk mail. Look for the common themes in all of the advertisements. Note how the advertisers have used color, headlines, text, pictures, charts, art work, and other features to convey the message.

3. Name your stream. Use this name to distinguish your stream from that of other groups.

4. Create a map of the stream and its watershed based on the description above. Determine where in the watershed the client wants salmon to spawn? Center your work in that area.

5. Organize your thoughts around the question "Why should salmon come and live in this stream?"

6. Create a planning guide around the main topics noted below. Use the questions following each topic to prepare for the advertising campaign and guide your research. Then, choose the points you want to emphasize in the advertisement.

a. **pH**: What is it; Why is it important; How have humans altered the pH of streams; What range do salmon like best; How can humans keep pH within acceptable ranges.

b. **Temperature**: Why are cool temperatures important to fish; How have human actions changed water temperatures in rivers and streams; What is the best temperature range for salmon; How can you protect a stream against drastic changes in temperature.

c. **Dissolved oxygen**: What is dissolved oxygen; Why is it important to fish and other organisms; How do dissolved oxygen concentrations change naturally; How do human activities change dissolved oxygen concentrations (for worse or better) in streams; How is dissolved oxygen related to temperature; What are the best levels for salmon; Do salmon need different amounts of dissolved oxygen during different parts of their life cycle.

d. **Sediment**: What is sediment; What is its source; What is its effect on a stream (good and bad); How are excessive sediment accumulations controlled.

e. **Food**: What are the food needs for salmonids; How does the stream provide for these needs.

f. **Stream habitat**: What are the physical habitat requirements of a stream that will meet the needs of various stages of a salmon's life cycle; How will your stream keep sediment in check.

g. **Pollutants**: How might fertilizers, pesticides, or other pollutants get into a stream; How might they harm a river or stream; How are pollutant problems solved.

h. **Watershed land use activities**: How might watershed activities like mining, forestry, ranching, and farming practices, commercial and recreational fishing, dams, and urban development affect rivers and streams and salmon (good and bad); What are some alternatives; How can watershed management activities be designed to be salmon-friendly.

i. **What does a healthy stream look like**: In the forest, passing through a farm, passing through a city?

7. Use butcher paper or other large pieces of paper to prepare a rough draft of the advertisement. Consider the following as you plan the display.

a. What key information will you include?

b. Where will you place the key information on the poster?

c. What colors will you use?

d. Who is your audience?

e. What are you trying to sell?

f. What graphics, pictures, or artwork will you use?

g. Will you include a map or picture of your stream to help illustrate your ideas or solutions?

h. Will you use cut-away drawings or tables and charts?

i. Will you use handwritten or typed headings? What will the headings say?

j. Will you use handwritten or typed blocks of text?

k. Will you add 3-D models? Hanging or attached?

l. Will you use interactive parts (flip cards with answers or facts) on the display?

8. Prepare the final advertisement as a tri-fold poster made from two pieces of 24”x36” poster board or ¼” foam core board.

Original Resource

The Stream Scene: Watersheds, Wildlife, and People. This information was provided courtesy of the **Oregon Department of Fish and Wildlife.**

Oregon Department of Fish and Wildlife
Information and Education
3406 Cherry Avenue N.E.
Salem, OR 97303-4924
Phone: (503) 947-6002

Assessment

Name: ______________________________

1. The banks of a healthy stream act like a ____________________ to soak up heavy rains.

2. An aquatic insect can be carried downstream by a water ___________________________.

3. The number of insects in a stream depends on the number of ___________________ there are for insects to eat.

4. A high level of ____________________ oxygen in stream water is important for salmon eggs.

5. An unhealthy stream will transport the most sediment when the weather is:
   (Circle one)
   (A) hot
   (B) rainy
   (C) cold
   (D) dry

6. In the food chain, insects are placed above:
   (Circle one)
   (A) salmon
   (B) birds
   (C) plants
   (D) crawdads

7. Which of the following is a primary food source for young salmon in a stream?:
   (Circle one)
   (A) insects
   (B) fish
   (C) leaves
   (D) eggs

8. The acidity of a stream is indicated by:
   (Circle one)
   (A) temperature
   (B) sediment
   (C) pH
   (D) dissolved oxygen

9. Why would urban development upstream affect salmon eggs downstream?

____

____

10. Why do salmon need cover in and around the stream?

____

____

11. Imagine pesticides were sprayed on a farm near a stream. Would there be more or less food in the stream for young salmon to eat? Why?

____

____

12. Why is a constant, slow release of groundwater throughout the year important?

____

____

6 What's in the Water?

Original Curriculum Provided by: Council for Environmental Education

Overview

Students analyze the pollutants found in a hypothetical river. They graph the quantities of pollutants and make recommendations about actions that could be taken to improve the habitat.

Time Required

One forty five minute session

Setting

Indoor

Topic

Water Quality

Objectives

(1) Identify major sources of aquatic pollution. (2) Make inferences about the potential effects of a variety of aquatic pollutants on wildlife and wildlife habitats.

California Standards

NGSS: MS-LS2-2, MS-LS2-3,
MS-LS2-4, MS-LS2-5,
MS-ESS3-3, MS-ESS3-4
MS-ETS1-1

Common Core English:
SL 6-1
L 6-1, 6-3, 6-6

Skills

Graphing, analyzing

Key Vocabulary

Point and nonpoint source pollution, chemical, thermal, organic, toxic

Materials

- Nine different colors of construction paper
- Graph paper
- Scotch tape or glue
- Pollutant Information Sheets
- 1/4 tsp measure (for paper punch tokens) or 1 Tbsp measure (for 1/2 in. square tokens)

Background Information

Waterways such as rivers, lakes, and ***estuaries*** are important to humans and wildlife alike. Waterways are used for drinking water, transportation, recreation, and ***habitat*** for many wildlife species. Approximately forty percent of our nation's rivers, lakes and estuaries are not fishable, swimmable, or potable because of ***pollution*** (Source: American Rivers). Pollutants enter waterways from either point or nonpoint sources. ***Point-source pollution*** is clearly defined, localized inputs such as pipes, industrial plants, sewer systems, and oil spills. Federal and state governments monitor and regulate pollution from point sources. Unfortunately, nonpoint sources are harder to detect and control, so they are, therefore, the major source of water quality problems. Nonpoint sources are indistinct inputs that do not have a clearly defined source, such as runoff of petroleum products from roadways or pesticides from farmlands.

Nonpoint-source pollution occurs when rainfall, snowmelt, or irrigation runs over land or through the ground, picks up pollutants, and deposits them into surface water or introduces them into ground water. Agriculture, forestry, grazing, septic systems, recreational boating, urban runoff, construction, physical change to stream channels, and habitat degradation are all potential sources of nonpoint-source pollution. Agriculture is the leading contributor to water quality impairments, degrading 60 percent of the nation's rivers and lakes. Runoff from urban areas is the largest source of water quality impairments to the nation's estuaries (Source: U.S. Environmental Protection Agency [EPA]).

The most common nonpoint-source pollutants are sediment and nutrients. These pollutants enter waterways from agricultural land, animal feeding operations, construction sites, and other areas of disturbance. Other common pollutants are pesticides, herbicides, pathogens, oil, toxic chemicals, and heavy metals. Unsafe drinking water, fish kills, destroyed habitat, beach closures, and many other severe environmental and human health problems result from these water pollutants (Source: EPA Office of Water).

Pollution can be categorized into the following types:

- toxic pollution: the introduction of toxic chemical substances into an ecosystem (e.g. acidic precipitation, contamination of water supplies by pesticides)

- thermal pollution: varying temperatures above or below the normal condition (e.g. power plant turbine heated water)

- organic pollution: oversupplying an ecosystem with nutrients (e.g. fertilizer inflow)

- ecological pollution: stresses ordinarily created by natural processes, such as

    1. Adding a substance that is not a naturally occurring substance in the ecosystem (e.g. extreme tides pour saltwater into habitats ordinarily protected from saltwater)

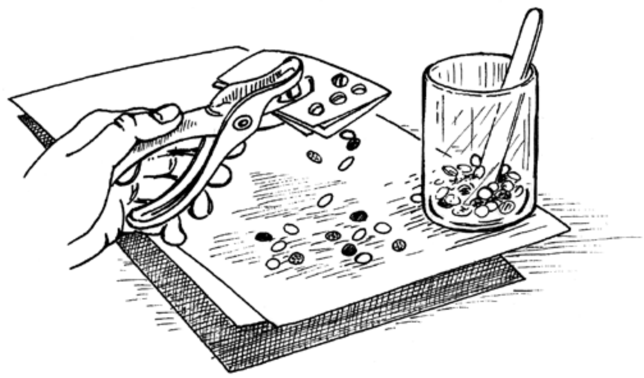
    2. Increasing the amount or intensity of a naturally occurring substance (e.g. abnormal increase in sediments in runoff water to produce silt)

    3. Altering the level or concentration of biological or physical components of an ecosystem (changing the amount of something that is already there) (e.g. introduction of aquatic plants via bird droppings, etc.)

In the definitions above, toxic pollution through the introduction of toxic chemical substances is clearly caused by humans. Organic pollution in lakes and rivers typically results when chemical fertilizers used in agriculture enhance living organisms. Thermal pollution is predominantly human caused through nuclear power plants, fuel-based electrical power production, other industrial activity, and by the removal of riparian canopy. Some hydroelectric dams also produce unnaturally cooled water with bottom discharge of water.

Surprisingly, these three forms of pollution (toxic, thermal, and organic) can take place without human intervention. When pollution takes place without human intervention, it is most often ecological pollution. Natural ecological pollution may be beneficial, be harmful, or have no effect on wildlife and wildlife habitat. Examples include acidic precipitation resulting from volcanic eruptions, runoff from landslides and avalanches sometimes killing plant and animal life, hot springs and geysers heating water above normal temperatures in lakes and streams, and shifts in oceanic currents affecting water temperature and weather patterns.

The state and federal governments have made advances to control water quality by regulating, monitoring, and enforcing clean water programs. Some recent examples of federal government water pollution control programs are the 1987 Clean Water Act Amendments to the 1977 Clean Water Act and the 1990 Coastal Zone Act Reauthorization Amendments. Public and private businesses are using more pollution prevention and pollution reduction initiatives to control water pollution. More citizens are also practicing water conservation and participating in more community area cleanups (Source: EPA Office of Water).



Preparation

1. Make 100 tokens of each of the nine colors of construction paper for a total of 900 tokens. The construction paper may be folded into quarters to speed up the process of cutting or punching. The tokens can also be made by cutting construction paper into ½ in. squares, or simply use a hole punch to make the tokens from construction paper.
2. Put all the tokens in a container. Stir them so the colors are thoroughly mixed.
3. Make one copy of a Pollutant Information Sheet for each student. Create a matrix of 9 squares across and 13 squares high as shown on next page.

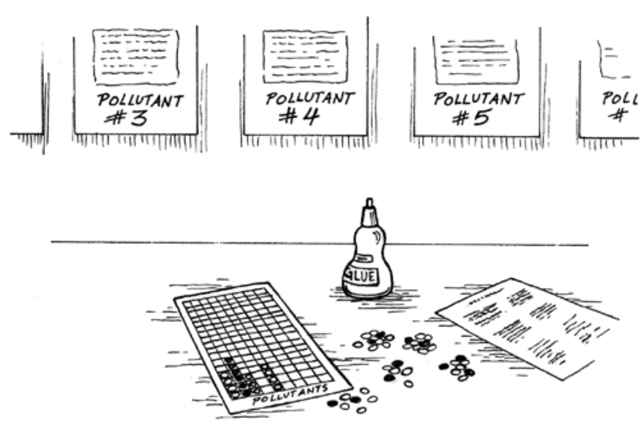
Procedure

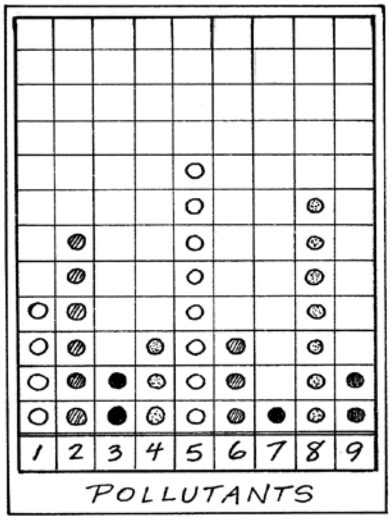
1. List the four major categories of pollution (toxic, thermal, organic, and ecological) on the chalkboard and discuss each. Refer to the background for a description of each. NOTE: Humans primarily cause the first three types of pollution, although there are cases in which natural processes can cause them. Ecological pollution is typically natural, although there are cases in which humans cause it.

2. Pass out the Pollutant Information Sheets. Review each kind of pollution with the students. Discuss how some pollutants can fit into more than one of the four categories. Assign each of the nine pollution types a color. Then write a short description of the pollution and glue it to construction paper making sure it's the assigned color. (IDEA: You can simply copy the Pollutant Information Sheets, cut the descriptions apart, and paste the appropriate paragraphs on construction paper.) Post each sheet of colored paper with its corresponding description of the kind of pollution it represents in a row in a convenient place.

3. Once all the kinds of pollution have been discussed and the students understand that each kind of pollution will be represented in this activity by one color of paper, have them divide into research teams of three students. Each team will analyze the pollution content of a hypothetical river. Supply each team with a piece of graph paper. Pass the container of colored paper tokens to each research team to measure out their share (1/4 teaspoon of the paper-punched tokens or 1 tablespoon of the ½" square tokens).

4. The teams first must separate the colored tokens into piles. Then, using the color key, they should identify each type of





pollutant. Once this step is done, have students count the number of each kind of pollutant they identified and then use graph paper to construct a simple bar graph showing the whole array of pollutants. They should arrange the pollutants in the same order as displayed in the color key posted in the classroom. This step makes it easy to compare each team's findings. Remind teams that each has a different river. Their results are not likely to be the same.

5. When students have completed the bar graphs and compared results, tell them that any quantity above two units of each kind of pollutant is considered damaging to wildlife habitat. In their hypothetical rivers, what pollutants would likely cause the most damage to wildlife and wildlife habitat? Give examples and discuss kinds of damage that could be caused.

   OPTIONAL: Invite the students to match the pollutants with the four categories of pollution listed at the beginning of the activity. Some seem to fit rather easily; others could fit in more than one category, depending on the source of the pollution. For example, is the thermal pollution human or naturally caused (power plant water effluent or thermal hot springs)?

Extensions

1. List five things you can do to reduce the number of pollutants you add to the environment.
2. Conduct a field trip to a local waterway; attempt to identify what, if any, kinds of pollution are affecting it.
3. Get information about current national and state laws protecting water quality in the United States. Write a short history of the U.S. Clean Water Act.
4. Is DDT still being used and where? Find out the current status of this pesticide's use in the United States and other parts of the world.

Original Resource

Adapted with permission from Project WILD, ***Project WILD Aquatic K-12 Curriculum and Activity Guide*** © Copyright 2005, 2004, 2003, 2002, 2001, 2000, 1992, 1985 and 1983 by the **Council for Environmental Education.** The complete Activity Guide can be obtained by attending a Project WILD workshop.

California Project WILD
CA Department of Fish and Wildlife
1416 Ninth Street, Room 1280
Sacramento, CA 95814
Phone: 916. 322.8933

or

Project WILD
Association of Fish and Wildlife Agencies
1100 First Street NE, Suite 825
Washington, DC 20002
Phone: 713.520.1936
www.projectwild.org

Pollutant Information Sheet

Sediments
Particles of soils, sand, silt, clay, and minerals wash from land and paved areas into creeks and tributaries. In large quantities, these natural materials can be considered pollutants. Construction projects often contribute large amounts of sediment. Sediments may fill stream channels covering gravel beds, making them less able to support fish spawning and egg survival.

Petroleum Products
Oil and other petroleum products such as gasoline and kerosene can find their way into water from ships, oil-drilling rigs, oil refineries, automobile service stations, and streets. Oil spills kill aquatic life (fish, birds, shellfish, and vegetation). Fuel oil, gasoline, and kerosene may also leak into ground water through damaged underground storage tanks.

Human and Animal Waste
Human waste that is not properly treated at a waste treatment plant and then released into water may contain harmful bacteria and viruses. Typhoid fever, polio, cholera, dysentery, hepatitis, flu, and common cold germs are examples of diseases caused by bacteria and viruses in contaminated water. The main source of this problem is sewage getting into the water. Animal waste an also act as a fertilizer and create damage by increasing nutrients. (See Detergents and Fertilizers.)

Organic Waste
Domestic sewage treatment plants, food processing plants, paper mill plants, and leather tanning factories release organic wastes that bacteria consume. If too much waste is released, the bacterial populations increase and use up the oxygen in the water. Fish die if too much oxygen is consumed by decomposing organic matter.

Inorganic Chemicals
Inorganic chemicals and mineral substances, solid matter, and metal salts commonly dissolve in water. They often come from mining and manufacturing industries, oil field operations, agriculture, and natural sources. Those chemicals interfere with natural stream cycles; they destroy fish and other aquatic life. They also corrode expensive water treatment equipment and increase the cost of boat maintenance.

Detergents and Fertilizers
The major source of pollution from agriculture comes from surplus fertilizers in the runoff. Fertilizers contain nitrogen and phosphorous that can cause large amounts of algae to grow. The large algae blooms cover the water's surface. The algae die after they have used all of the nutrients. Once dead, they sink to the bottom where bacteria feed on them. The bacterial populations increase and use up most of the oxygen in the water. This process is called "eutrophication."

Heated Water
Heat reduces the ability of water to dissolve oxygen. Electric power plants use large quantities of water in their steam turbines. The heated water is often returned to streams, lagoons, or reservoirs. Heated water does not hold a high level of dissolved oxygen. With less oxygen in the water, fish and other aquatic life can be harmed.

Acid Pollution
Aquatic animals and plants are adjusted to a rather narrow range of pH levels. When water becomes too acidic because of inorganic chemical pollution such as battery acid or from acidic rain, fish and other organisms die.

Pesticides, Herbicides, and Fungicides
Chemicals that are designed to limit the growth of or to kill life forms are a common form of pollution. This pollution results from human attempts to limit the negative effects of undesirable species on agricultural crop production. Irrigation, ground water flow, and natural runoff bring such toxic substances to rivers, streams, lakes, and oceans.

Assessment

Name:

1. ________________ pollution is when water temperatures are caused to go above or below normal conditions.

2. Fish can die off when too much __________________ is consumed by decomposing matter - such as sewage - that may leak into a river, stream or lake.

3. A natural element composed of small particles of rock is called ____________________.

4. Heat reduces the ability of water to hold dissolved ______________________.

5. Oil pollutants can find their way into water from:
   a. ships
   b. oil rigs
   c. refineries
   d. streets
   e. all of the above

6. Inorganic chemicals such as metal salts from mining may dissolve in water and interrupt:
   a. thermal changes
   b. sedimentation of channels
   c. sewage treatment
   d. stream depth
   e. biochemical cycles

7. Point-source pollution come from defined, localized inputs such as pipes, spills, etc. When water runs over general land areas and picks up pollution it is called:
   a. land scrub
   b. nonpoint-source pollution
   c. sheeting action
   d. toxic wash
   e. general cleanse

8. Common pollutants include:
   a. pesticides
   b. herbicides
   c. all above and below
   d. toxic chemicals
   e. oil
   f. heavy metals

9. How can human waste be harmful in a watershed?

____

____

10. How is riparian vegetation valuable in reducing erosion?

____

____

11. Tell how streamside vegetation affects temperatures necessary for fish survival.

____

____

12. Can fertilizers cause fish to die? How?

____

____

Name:

1. A rain event in a highly developed area will result in a faster _________________ of water toward streams.

2. A salmon carcass releases nutrients into the __________________, which supports the growth of plants.

3. The presence of aquatic life in a stream near a farm may be reduced by a farmer's use of ________________________.

4. Plants provide ______________________ that cools stream water in which the salmon rest.

5. Humans can reduce the amount of sediment in a stream by:
   (Circle one)
   (A) restoring vegetation
   (B) clear cutting
   (C) building roads
   (D) constructing houses

6. If there were fewer insects in the water, it would most affect the:
   (Circle one)
   (A) alevin
   (B) egg
   (C) fry
   (D) spawner

7. As the number of aquatic insects increases, the number of aquatic plants will:
   (Circle one)
   (A) stay the same
   (B) increase
   (C) decrease
   (D) increase, then decrease

8. Too little dissolved oxygen in streams will harm salmon the most at what stage of their life?:
   (Circle one)
   (A) egg
   (B) fry
   (C) smolt
   (D) adult

9. Why would an increased stream velocity benefit salmon eggs and alevins?

____

____

10. Imagine you are a bear catching spawning salmon. Why would you be eating nutrients from the ocean?

____

____

11. Imagine all the spawning salmon were suddenly carried downstream to the ocean by an extremely high stream velocity. Would the river otter population go up or down? Why?

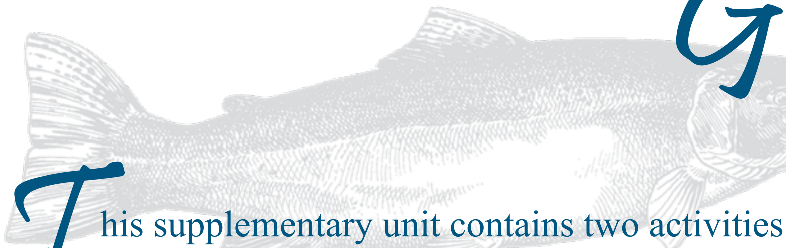
____

____

12. Why would too many nutrients in the soil eventually cause a decrease in stream temperature?

____

____



Grade 7 Supplement

Overview

This supplementary unit contains two activities without student assessments. The supplement is included for those interested in advanced salmonid lessons. Activities teach students about the effects that various substances can have on water quality. Through an experiment with actual substances, students will see exactly how these substances affect the water. Students learn about different types of pollution and use their results from the activities to make inferences about how changes to physical or biological components of an ecosystem affect populations. They discover the importance of maintaining clean water for ensuring healthy wildlife and wildlife habitats.

Activity	Time (mins)		Setting	CA Content Standards	Topic
	Prep	Activity			
Fish Fertilizer	30	120	Indoor/ Outdoor	MS-LS1-7, MS-LS2-1, MS-LS2-2, MS-LS2-3, MS-LS2-4, MS-LS2-5, MS-ESS2-1, MS-ESS3-3, MS-ESS3-4, MS-ETS1-1	Life Cycle
Water Quality Testing	25	90	Indoor	MS-LS1-7, MS-LS2-1, MS-LS2-2, MS-LS2-3, MS-LS2-4, MS-LS2-5, MS-ESS2-1, MS-ESS3-3, MS-ESS3-4, MS-ETS1-1	Water Quality

Original Curriculum Provided By:

Fish Fertilizer
***Salmonids in the Classroom*: Intermediate.**
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Water Quality Testing
***Salmonids in the Classroom*: Intermediate.**
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7

Fish Fertilizer

Original Curriculum Provided by: Fisheries and Oceans Canada

Overview

In this activity students see the effects that salmon bodies have on stream habitat. Students will realize the importance of salmon bodies by predicting, observing and discussing an experiment with fast-growing plants.

Time Required

One fifty minute session, plus periodic observations

Setting

Indoor or Outdoor

Topic

Life Cycle

Objectives

(1) Understand the importance of salmon carcasses in ecosystems. (2) Identify the role of salmon carcasses in healthy streams.

California Standards

NGSS:MS-LS1-7, MS-LS2-1,
MS-LS2-2, MS-LS2-3, MS-LS2-4,
MS-LS2-5, MS-ESS2-1,
MS-ESS3-3, MS-ESS3-4,
MS-ETS1-1

Common Core English:
RI 7-4, 7-10
W 7-1, 7-4
L 7-1, 7-3, 7-4, 7-6
RST 6-12-2

Skills

Hypothesizing, observation, patience

Key Vocabulary

Fertilizer, nitrogen, carcass

Materials

- Fast growing seeds (alfalfa, radish)
- Soil
- Fish fertilizer
- Small growing pots
- Science Experiment sheet

Background Information

The salmon's return to ***freshwater*** streams to ***spawn*** provides sustenance for other ***species***. After the salmon's death, the remains fertilize the forest environment. West Coast watersheds are often low in nutrients essential for plant growth, especially nitrogen. Recent studies have shown that nutrients from the ocean make an important contribution to plants and animals along spawning salmon streams. Spawners bring these nutrients from the ocean and leave them in their carcasses when they die.

Some animals take up marine nutrients by eating the salmon carcasses. A single dead spawner can feed thousands of insect larvae, which in turn will form a food source for fry. Algae, fungi, and bacteria, which live in the water, also take up marine nutrients before dying and providing food for small invertebrates. Forest streams provide little nutrition compared to the richness of the estuary and ocean, and many species might not survive without the nutrients released by decaying spawners.

Salmon carcasses may also become part of the forest ecosystem. Birds, bears and smaller mammals drag some carcasses ashore, carrying marine nutrients through the forest. The remains of salmon fertilize the forest soil in regions where heavy rainfalls quickly leach out nutrients that are essential for strong tree growth.

Preparation

1. Make copies of student reading and experiment sheet.

2. Gather other materials.

Procedure

1. Have students read "The Salmon Spawners" student reading.

2. Ask students what happens to the bodies of salmon spawners after they die.
   They are eaten by birds, bears and other wildlife or their bodies decompose, fertilizing the spawning lakes and rivers. Plants and micro-organisms grow in the rich and productive environment, providing a habitat and food source for salmon fry when they are growing.

3. Ask students to describe their experience at home using fertilizer to encourage the growth of plants and gardens. Explain that fish fertilizer is made from fish scraps from processing plants. The scraps are composted in a way that resembles what happens to fish bodies when they decompose in nature.

4. The class now acts as scientists who want to test how the bodies of dead salmon affect plants growing in the environment. Have them form a hypothesis and develop a procedure, similar to the one below, which they can use to test their hypothesis.

5. Have students plant fast-growing seeds (e.g., alfalfa or radish) approximately one inch deep in soil, in two identical pots. Have them label one pot, "Control", and the other, "Fish Fertilizer", before placing the pots in a warm,

Pacific Salmon Bring It All Back Home

Like other species of Pacific salmon, coho hatch out of eggs laid in streambed gravel; migrate out to sea, where they spend most of their adult life; and return to natal streams to spawn and die. "Salmon are the only animals that return nutrients to the land from the sea," says Jeff Cederholm, a salmon biologist for the Washington Department of Natural Resources.

"The healthiest salmon streams," he points out, "are loaded with salmon carcasses." Cederholm and his coworkers observed a surprising array of species feasting on dead coho, including otters, black bears, raccoons, and skunks. These larger animals often pulled carcasses onto streambanks, where leftovers were scavenged by wrens, shrews, mice, and other small creatures. Coho spawn in the fall, and their carcasses remain through the winter, the hungriest time of year for wildlife in the Pacific Northwest forests. Perhaps most, if not all, woodland animals rely on salmon to help sustain them until spring. Even white-tailed deer sometimes feed on salmon carcasses.

Bioscience, Vol. 27 No. 10, 1997

Salmon Feed Forests; Forests Shelter Salmon

"Salmon benefit from the plants that line the banks of their spawning grounds. These trees and bushes, known as riparian vegetation for their proximity to rivers' natural banks, provide many of the conditions that salmon need for successful spawning.

"The riparian plants provide shade, which helps to regulate the temperature of the spawning grounds. Trees and large bushes provide snags and other debris that create sheltered areas along the river in which young salmon can find refuge. Their roots also keep river sediments in place, reducing erosion."

Cat Lazaroff, *Environment News Service*, September 2001

bright location in the class. Plant at least three "Control" and three "Fish Fertilizer" pots containing one plant each.

6. Have students water the pot labeled "Control" with water and the pot labeled "Fish Fertilizer" with a solution of commercial fish fertilizer. Read the instructions on the fish fertilizer label to determine when and how much to fertilize young plants (often fertilizing occurs when the plants have developed their second set of leaves). Make sure the seeds receive about one inch of water per week and a little more when they are first developing. Don't overwater, though, too much water causes more damage than too little.

   Note: Some fish fertilizers claim to have low or no odor, but we encourage you not to use these so the students will experience a rich opportunity that enhances their direct experience with nature.

7. Have students observe and record the growth of the plants over one to two weeks, or more as appropriate. Measure the height of the plants and count the leaves for quantitative comparison.

8. Have students use the data from their experiments to form a conclusion about their hypothesis. Have them create a written description of the experiment in their notebooks, or use the blank form in "Science Experiment Sheet".

9. Discuss what the results show about the significance of salmon bodies in the environment. If necessary, prompt the students with questions, such as:

   "How did the growth of the plants with the fertilizer compare with the growth of the other plants?"
   The plants with the fertilizer should be bigger.

   "What could explain the results?"
   Nutrients, especially nitrogen, in the fertilizer gave the plants food to grow bigger.

   "How is the experiment similar to what happens in nature? How is it different?"
   In both cases, the fish remains provide nutrients for plant growth. However, in nature, salmon bodies decay slowly and release their nutrients over a longer period of time. Unless the salmon bodies are carried onto the land by animals, they fertilize aquatic plants and micro-organisms.

10. With the class, discuss how the bodies of dead salmon contribute to the forest and stream environment. Have students describe in writing what would happen if there were no salmon bodies in a lake or stream.
    The aquatic growth would be reduced, and salmon fry and other animals would not find as much to eat. The forest might lose ocean nutrients that are not otherwise available.

Original Resource

Salmonids in the Classroom: Intermediate. Reprinted with the permission of **Fisheries and Oceans Canada.**

Stewardship and Community Involvement Unit
Habitat and Enhancement Branch
Fisheries and Oceans Canada
555 West Hastings Street
Vancouver, B.C. V6B 5G3 Canada
Phone: 604-666-6614

The Salmon Spawner

In the final stage of their life cycle, salmon re-enter their home river and swim back to the stream or lakeshore from which they emerged as fry. Some travel many hundreds or even thousands of kilometers, swimming from 30 to 50 km a day against the current. They follow the scent of the water to their home stream. Fishers and predators such as bears, otters, raccoons and eagles catch many salmon on their trip upstream.

When they enter freshwater, salmon usually stop eating and live only on stored body fat. To save energy, they lose the slimy coating that helps protect them, their skin becomes thick and leathery, and they start to absorb their scales. Some internal organs may fail on the journey.

The salmon's appearance changes dramatically, with males and females developing distinct differences. They lose their silvery color and take on deep red, green, purple, brown and gray colors. Their teeth become long, and they develop a hooked jaw, which is particularly pronounced in males. Their body shape can change, with some species developing a distinct hump on their back. Eggs develop in the ovaries of females, while males develop sperm.

When she reaches her home stream or lake, the female uses her fins and tail to find a spot with the right gravel size and water conditions. With her tail, she rearranges the stones in the gravel bed to form a redd, the nest-like depression in the stream or lakebed where she will lay her eggs.

The female deposits her eggs in the redd, then the male deposits his sperm to fertilize them. Some species deposit up to 6,000 eggs, but the average is about 2,500. The female covers the eggs with gravel to protect them, often moving on to build a second or third redd which may be fertilized by other males.

Both males and females die within a few days of spawning. (Steelhead and cutthroat may survive to spawn more than once, although once is most common. If they survive, they go back out to sea as kelts, spawned-out salmon, then return to the spawning area in another year or two. Altogether, they may spawn three or four more times.) The salmons' bodies decompose, releasing valuable nutrients, including minerals from the sea. The nutrients from the salmon carcasses form a rich food source for other wildlife, as well as fertilizing the stream and lake along the shore.

When salmon carcasses are carried onto the riverbank, they also fertilize the forest and bushes. The ocean compounds in the salmons' bodies can be very scarce in the upstream environment. If few adult salmon return to spawn, the lack of nutrients can make the forest and the water a poor environment, with few nutrients for growing salmon fry and other species.

Marine-derived nitrogen can be detected in the riparian vegetation of salmon-producing streams hundreds of miles from the ocean.

Science Experiment Sheet

Name: ____

Date: ____

Experiment Title: __________________________________

Hypothesis:

Procedures:

Observations:

Conclusions:

Water Quality Testing 7

Overview

Students test and observe the effects of certain pollutants on water quality. They determine the sources of pollution and analyze the potential effects of the substances on salmonids.

Time Required

Two forty five minute sessions

Setting

Indoor

Topic

Water Quality

Objectives

(1) Determine how pollutants affect water quality. (2) Discover sources of pollution. (3) Analyze how substances affect salmonids.

California Standards

NGSS:MS-LS1-7, MS-LS2-1,
MS-LS2-2, MS-LS2-3, MS-LS2-4,
MS-LS2-5, MS-ESS2-1,
MS-ESS3-3, MS-ESS3-4,
MS-ETS1-1

Common Core English:
RI 7-4, 7-10
W 7-1, 7-4
L 7-1, 7-3, 7-4, 7-6
RST 6-12-2

Skills

Observation, analyzing

Key Vocabulary

Turbidity, acidity, pH, leachate

Materials

- Wire coat hanger
- Six sections of cheesecloth
- Six elastic bands or string
- Six one liter jars
- One pollutant for each of six stations
- Six containers for substances
- Ruler
- Litmus paper
- Copies of student handout

Preparation

1. Place one liter samples of tap water at each of six stations around the room. Label the samples and stations from 1 to 6. To have smaller student groups, double the number of stations. Place substance in water sample for each station as shown on the Substances and Effects Chart.

2. Place a ruler at Station 1 and litmus paper at Station 3.

3. Bend the wire coat hanger to form a small square and place it at Station 6, with the sections of cheesecloth and elastic bands.

4. Refer to the Substances and Effects Chart as needed when discussing the experiment.

Procedure

1. Have the class describe water in a liquid state and list as many of its characteristics as they can. *It is clear, neutral in taste and scent, inactive.*

2. Have the class suggest ways to compare water from different sources to see if it is all the same.

3. Have the class list substances that they think might affect the characteristics of water, and hypothesize about their effect on salmon living in the water.

4. Divide the class into six groups, and have each group work at one of the six stations. (With more advanced students, you may prefer to have the groups rotate through all six stations.)

5. Give students copies of the handout and have them work in small groups to conduct each of the tests in Part A, noting their observations on the sheet. Give them about five minutes at each station. (Tell them not to put any of the water samples in their mouth or eyes.)

6. Have students report their observations to the class, while you record them on a large chart or chalkboard. Have the students compare their observations before and after adding the substances (sand, bleach, lemon juice, plant food, wood chips, motor oil). Discuss the conclusions the students drew after completing Part A of the procedure. If necessary, prompt students with questions, such as:

   "What characteristics did the water have before adding the pollutant?"
   Clear, neutral in scent, inactive, etc.

   "What happened to the water after each pollutant was added?"
   Tests should give different results on each sample.

7. Have students, in small groups, use Part B of the handout to list the six polluting substances from Part A, then use their knowledge about the environment and salmon to hypothesize about the sources from which each enters the environment and their effects on salmon.

8. Have the groups report to the class on the information they added to Part B. Prompt them, as needed, with information from the Substances and Effects Chart.

9. Have the students write a short paragraph or draw a picture in the space provided, illustrating things people could do to prevent substances from entering salmon habitat and harming salmon.

Extensions

1. Have students add their lists and any additional comments to a salmon science notebook or portfolio.

Original Resource

Salmonids in the Classroom: Intermediate. Reprinted with the permission of **Fisheries and Oceans Canada.**

Stewardship and Community Involvement Unit
Habitat and Enhancement Branch
Fisheries and Oceans Canada
555 West Hastings Street
Vancouver, B.C. V6B 5G3
Canada
Phone: 604-666-6614

Water Quality Issue	Experimental and Similar Substances	Source of Substances in Environment	Effect on Salmonids
1. **Turbidity**- cloudiness due to suspended particles	Experimental substance: sand Similar substances: silt, soil, gravel, dust, crushed concrete	• logging near stream • road construction • concrete plant • dredging activity • flooding/ erosion	- reduced light for plants, impacts food web - less clean gravel, reduces spawning habitat - large volume of suspended sediments, clogs fish gills
2. **Vapors**- smell	Experimental substance: bleach Similar substances: chlorine, soap, herbicides, pesticides	• home & garden chemicals • runoff water from lawn or driveway • pools, hot tubs • industrial waste	- harsh chemicals can sicken and kill fish - toxins accumulate in food chain including fish - diseased/weakened fish less capable of healthy reproduction
3. **Acidity**- pH	Experimental substance: lemon juice Similar substances: carbonated drinks, coffee, discarded batteries	• industrial effluent • emissions from automobiles • negligent disposal of old batteries	- acid burns sensitive tissues, can damage eyes, skins, and gills - can have negative impact on populations of organisms on which salmon feed
4. **Nitrogen and phosphorus**- chemical content	Experimental substance: plant food Similar substances: agricultural fertilizers	• excess use of fertilizers on crops • waste from livestock • runoff from land in agricultural use	- fertilizers may cause algal blooms which rob oxygen from the water when algae die - fish can suffocate when oxygen is low
5. **Color**- discoloration due to leachate	Experimental substance: wood chips (soak for 24 hours) Similar substances: many items in landfill, water soluble paints	• wood waste • construction sites, lumber yards • leachates from city & county refuse landfills	- effects will vary by substance and level of concentration - introduction of new substances to stream has unknown impacts
6. **Residue**- insoluble substances that adhere to surfaces	Experimental substance: motor oil Similar substances: gasoline, oil-based paint/ stain, petroleum products	• washing boats & cars • careless cleaning of painting tools • non-point source pollution (runoff from streets & highways)	- oils spread on water surface reducing gas exchange - petroleum products can coat skins or be ingested causing death of many organisms

Name: ______________________________

The physical and chemical properties of water affect organisms that live in it. Salmon and other organisms need some substances in water, such as dissolved oxygen. However, some substances found in water can be fatal. Pollution is a source of harmful substances. These tests let you compare the effect of certain pollutants on water quality.

Part A
Describe as many characteristics of the plain water sample as you can. ____________________________

____

____

Station	Test	Observations after adding substance
1	*Appearance: Turbidity (suspended v. deposited sediments)* Add the substance to the water sample. With a ruler, measure how much sediment settles on the bottom of the jar.	Sediment measured: __________ mm Observations:
2	*Smell* List as many words as possible to describe the scent of the water after adding the substance, (Note: Scientists do not smell unknown substances. The substances in this test are safe to smell.)	Observations:
3	*Acidity* Add the substance and use the litmus paper to test the pH of the water. (Note: Healthy water in salmon habitat ranges between 6.5 and 9 on the pH scale.)	Observations:

Station	Test	Observations after adding substance
4	*Nitrogen/ Phosphorus* Add drops of substance and use chemical indicator to test for nitrates.	Observations:
5	*Appearance: Color/ Texture* Add some wood chips. Record the color and texture of the water.	Observations:
6	*Residue* Pour the substance in the water sample and shake it. Insert the wire scoop in the water containing the substance. Describe what remains on the cheesecloth and what remains in the water.	Observations:

What conclusions can you make about the effect of the substances on the water samples?

____

____

____

Part B

In small groups, list the six substances you tested in the correct column below. Using your knowledge of the environment and salmon, fill in the other two columns, listing sources from which the substances might enter the environment and their potential effects on salmon. (Leave room to add additional information after the class discussion.)

Substance	Sources (e.g. human activity)	Effect on Salmonids

Grade 8 Supplement

Overview

This supplementary unit contains two activities without student assessments. The supplement is included for those interested in advanced salmonid lessons. Activities will introduce students to the role that genetics plays among salmonids. Students will learn about salmonid taxonomy by exploring the differences between closely related salmon and trout. Students will discover the importance of genetic diversity in fish hatcheries through a hatchery operations decision-making activity. Through an exploration of genetics, students gain an understanding of how specific traits help salmonids survive, while some salmon and steelhead runs become threatened, endangered, and extinct.

Activity	Time (mins)		Setting	CA Content Standards	Topic
	Prep	Activity			
Variations on a Theme	15	100	Indoor	MS-LS1-3, MS-LS1-4, MS-LS1-5, MS-LS3-1, MS-LS4-4, MS-LS4-5	Taxonomy
Designing Hatcheries with Genes in Mind	25	50	Indoor	MS-LS3-1, MS-LS4-4, MS-LS4-5, MS-LS4-6, MS-ETS1-1, MS-ETS1-2, MS-ETS1-3	Genetics

Original Curriculum Provided By:

Variations on a Theme
***American River Salmon* published by the California Department of Fish and Wildlife.**
Also from Some Things Fishy, A Teacher's Guide to the Feather River Fish Hatchery published by the California Department of Water Resources.

Designing Hatcheries with Genes in Mind
From *The Fish Hatchery Next Door.* This information has been provided courtesy of the Oregon Department of Fish and Wildlife. Also from American River Salmon published by the California Department of Fish and Wildlife.

8 Variations on a Theme

Original Curriculum Provided by: California Department of Fish and Wildlife

Overview

Students will use a Venn diagram as a mental organizer when comparing the two types of fish. Students use computational, graphing and measuring techniques to draw life size replicas of either a salmon or steelhead.

Time Required

Two fifty minute sessions

Setting

Indoor

Topic

Taxonomy

Objectives

(1) Understand the classification system for categorizing animals as it relates to Pacific salmon and steelhead. (2) Describe similarities and differences between Chinook (king) salmon and steelhead.

California Standards

NGSS: MS-LS1-3, MS-LS1-4

MS-LS1-5, MS-LS3-1

MS-LS4-4, MS-LS4-5

Common Core English:

RI 8-4, 8-10

SL 8-1

L 8-1, 8-4, 8-6

RST 6-12-2, -7, -10

Skills

Comparing, graphing

Key Vocabulary

Taxonomy, genus, species

Materials

- Butcher paper (about 4 feet per student)
- Crayon or marking pens
- Grid paper, rulers
- Newspaper, stapler, string
- Copies of "Fact Sheet"
- Copies of Venn diagram handout

Background

Pacific salmon such as the Chinook or king salmon, and related trout are classified in the genus Oncorhynchus. (See also Introduction, "Salmonids: Salmon, Steelhead and Rainbow Trout"). Rainbow trout, O. mykiss, are the most common trout in most of California's lakes and streams, although several other native and introduced species can be found in various waterways. Interestingly, steelhead trout and rainbow trout are the same species, but steelhead have a behavioral difference in that they have different life histories.

A rainbow trout that spends its entire life in a freshwater environment is called a rainbow trout. However, some populations migrate to the ocean for part of their life cycle, and those are called steelhead trout. Genetically, rainbow and steelhead are identical, but separate life histories lead to unique outcomes. Fish that breed in fresh water but spend part of their life in the ocean are said to be anadromous. After spending time in the ocean and due to saline conditions and broad differences in foods eaten, steelhead become physically different from landlocked rainbow trout.

The theory of natural selection, first widely promoted by Charles Darwin, can help explain the great diversity of life on Earth, including why some fish migrate to the sea. Darwin observed that nature appears to select the fittest individuals in a population, favoring those with traits that are best adapted for survival. He reasoned that, over time, traits that increased the chance of survival would appear more frequently in populations. Darwin also considered that a population of a single species could become split into two groups, with one group separated from the other by distance or some other barrier. If this happened, then each population could evolve differently. Without being able to interbreed, the populations would develop or evolve different adaptations or characteristics to survive in their respective habitats.

What is the advantage to anadromous fish such as salmon or steelhead trout to spending part of their life in the ocean? Fish that migrate to the ocean gain access to a huge supply of food including krill (also a food source for many whales), which allows great growth and vitality.

Some adaptations have obvious survival value. Examples in trout and salmon include protective coloration, teeth, strong muscles, and lateral lines. (The lateral line is a line of cells along a fish's side. These cells enable the fish to sense approaching predators and to sense one another to facilitate 'schooling' as a defensive mechanism.)

Other characteristics, such as the adipose fin, may or may not provide an evolutionary advantage – we don't know what the function of the adipose fin is. (The adipose fin is a small fleshy lobe between the dorsal fin and the tail or caudal fin. While it may play some very small role in balance and locomotion, it may have been more accentuated in the ancestral line, much prior to the current salmonid line. Today, hatchery workers have a protocol to harmlessly remove the adipose fin to identify fish that were spawned in the hatchery system so that anglers can readily separate a catchable hatchery-raised fish from the wild fish that may not be 'legal take.')

Chinook (king) salmon and rainbow trout share many characteristics, but differ in several ways. In this activity, students will learn some of these differences and similarities and use Venn diagrams to compare and contrast the species. In addition, students will learn to use a grid method to enlarge or reduce the size of a drawing.

Preparation

1. Make copies of "Salmon and Steelhead Fact Sheet" and Venn diagram handout.

2. Gather materials.

Procedure

Part 1

1. Introduce the word taxonomy and briefly review the classification of Pacific salmon and trout.

2. Ask students if they are familiar with the Venn diagram format. As a review, create one on the board and have students provide the information to compare two familiar subjects (perhaps a dog and a cat).

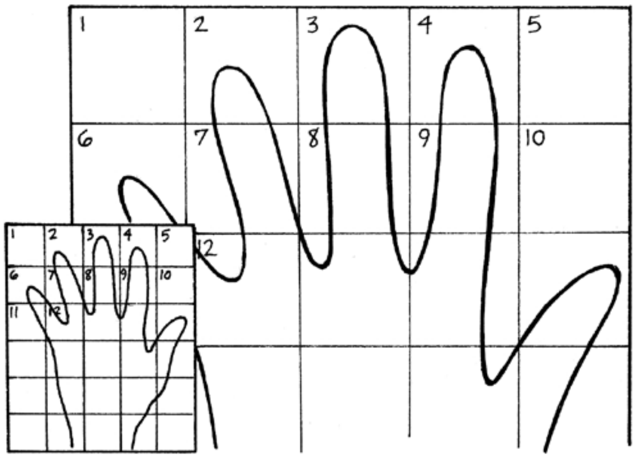
3. Provide students a copy of the "Salmon and Steelhead Fact Sheet" and a Venn diagram. Each student should complete a Venn diagram using the Fact Sheet.

4. Have the class discuss their diagrams by creating a large class Venn diagram on the board.

Part 2

5. Provide students with grid paper. Explain that they will learn how to use grids to draw a life size Chinook salmon or steelhead.

6. To learn how to use the grid, students should draw an outline of their hand on the grid paper. Once the outline of the hand is finished, have students make a grid on larger paper (flip chart paper or butcher paper.) The grid squares on the large paper



should be three to four times bigger than the squares on the smaller grid paper. Once the students have a larger grid made, have students transfer the small drawing of their hand to the larger paper. Number the squares on both pieces of paper and transfer the drawing by matching the number of squares.

7. Students will use the same method to draw the fish. First, have students copy the picture of either the salmon or steelhead from page 122 onto grid paper. Alternate salmonid images may be obtained from an Internet search. Using this picture, determine the scale of the copy to create a two foot fish. This will determine the size for the larger grid. For example, if the four inch copy is placed on a one inch grid, each one inch square would represent six inches. Therefore, four to six inch squares could be used to transfer the fish, creating a two foot representation.

8. Create the larger grid on butcher paper to produce a two foot fish. The fish may be cut out (double the paper to create two copies) and colored using the species information page. Place the two cut-out fish together and staple the perimeter edges, leaving an opening large enough to stuff crumpled newspaper into the interior, and staple closed. Attach string to hang the fish.

Extensions

1. Have students write a brief report on how Chinook and steelhead use their habitat differently. (They have different spawning sites, steelhead need streams that have cool, freshwater throughout the year.)

2. Discuss with students the question of who would need to know the difference between Chinook and steelhead. (An angler would need to know because of different fishing regulations for each. Also, a scientist would need to know in order to study the fish or their environment. Finally, a planner should know in order to make appropriate land use decisions that may affect habitat.)

Original Resource

American River Salmon published by the **California Department of Fish and Wildlife.**
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and

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Salmon and Trout Fact Sheet

CHINOOK SALMON
Oncorhynchus tshawytscha

Chinook salmon (also called king salmon) are anadromous fish that live in the cold water of the Pacific Ocean north from California and the streams flowing into it. When they are in the ocean, Chinook are silvery in color with a bluish or gray back and larger, blotchy, black spots.

Commercial salmon fishing provides jobs for many people, from catching fish to processing it for retail sales. The salmon from the American River watershed swim to the ocean through the San Francisco Bay and stay within seventy miles of the coast of California.

After two to four years in the ocean, adult salmon return to their home streams to spawn (the process of reproduction.) In California, most are three or four years old. Returning Chinook turn dark in color. The males often become red and develop a hooked jaw. They spawn in river gravels containing rocks up to six inches across. Chinook salmon die after spawning and their carcasses deliver a host of ocean-derived nutrients to freshwater systems.

Most young Chinook start migrating to the ocean shortly after hatching. Salmon migrate to the ocean unless they are landlocked, that is, trapped in water that does not flow to the ocean. While in the ocean, young salmon feed on plankton, crab larvae, and other small organisms, while adults feed on shrimp, squid, and a multitude of small (and not-so-small!) fishes.

Although mature Chinook salmon in California waters can weigh up to 40 pounds, the average weight is 12 to 17 pounds, and the average length is 24” – 30” (2 – 2.5 feet). The largest Chinook caught was 135 pounds!

RAINBOW TROUT
Oncorhynchus mykiss

Rainbow trout are native to freshwater systems in western North America, including northern California. The upper portion of their body is olive colored with black spots, shading to a silver white on the lower part of the body, with a pink-ish or red-ish stripe along the side.

While ‘rainbows’ can get to over eight pounds, a more typical weight is one to five pounds. A typical adult rainbow is 7-16 inches in length, but they may reach 22 inches long. They will eat almost anything, feeding on zooplankton when young and fish eggs, insects, worms, crustaceans, small fish and mollusks.

Fishing for rainbow trout is a popular sport, and supports many businesses, including sales of equipment and guide services. Rainbows are not fished commercially, but they are raised on fish “farms” for commercial sale and also for people to catch at the farm. Most anglers seek to catch them in fishable freshwater habitat, and the revenue raised by California Department of Fish and Wildlife through sales of sport fishing licenses helps the Department protect many species of fish and wildlife in the State.

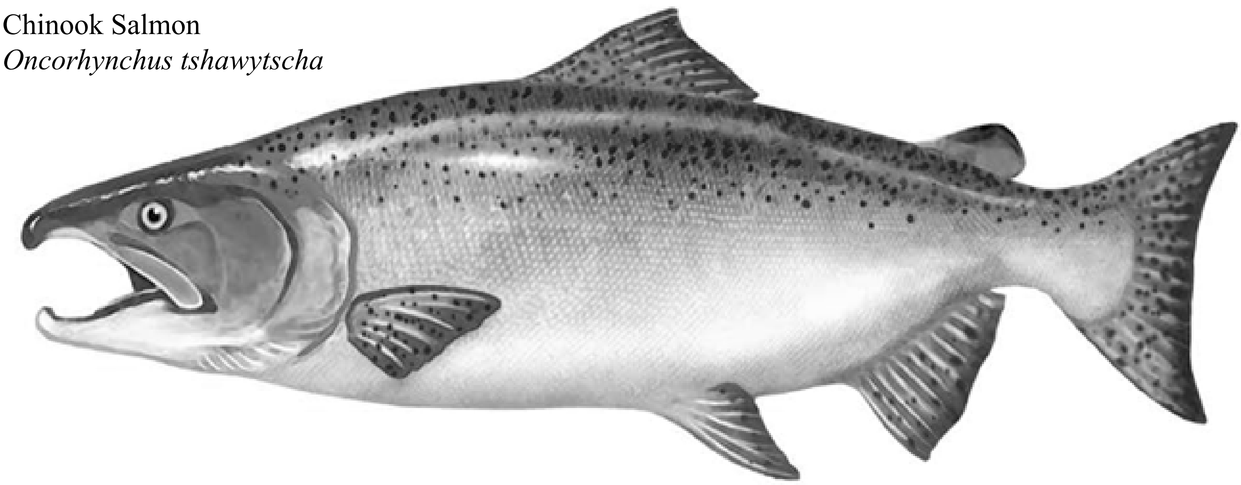
Unlike Chinook salmon, rainbow trout spend their whole lives in freshwater lakes and streams. Male trout do not develop the hooked jaw common in Chinook males. Female rainbow trout, like salmon, use their tails to create a depression in the gravel (a redd) and release their eggs into it, covering the eggs with gravel after fertilization by the male. Rainbows may live to spawn (reproduce) several times during a life that may last as many as eight years.

California’s state fish, the golden trout (*Oncorhynchus mykiss aguabonita*), is a subspecies of the rainbow trout.

Enlarge a Drawing by Using a Grid

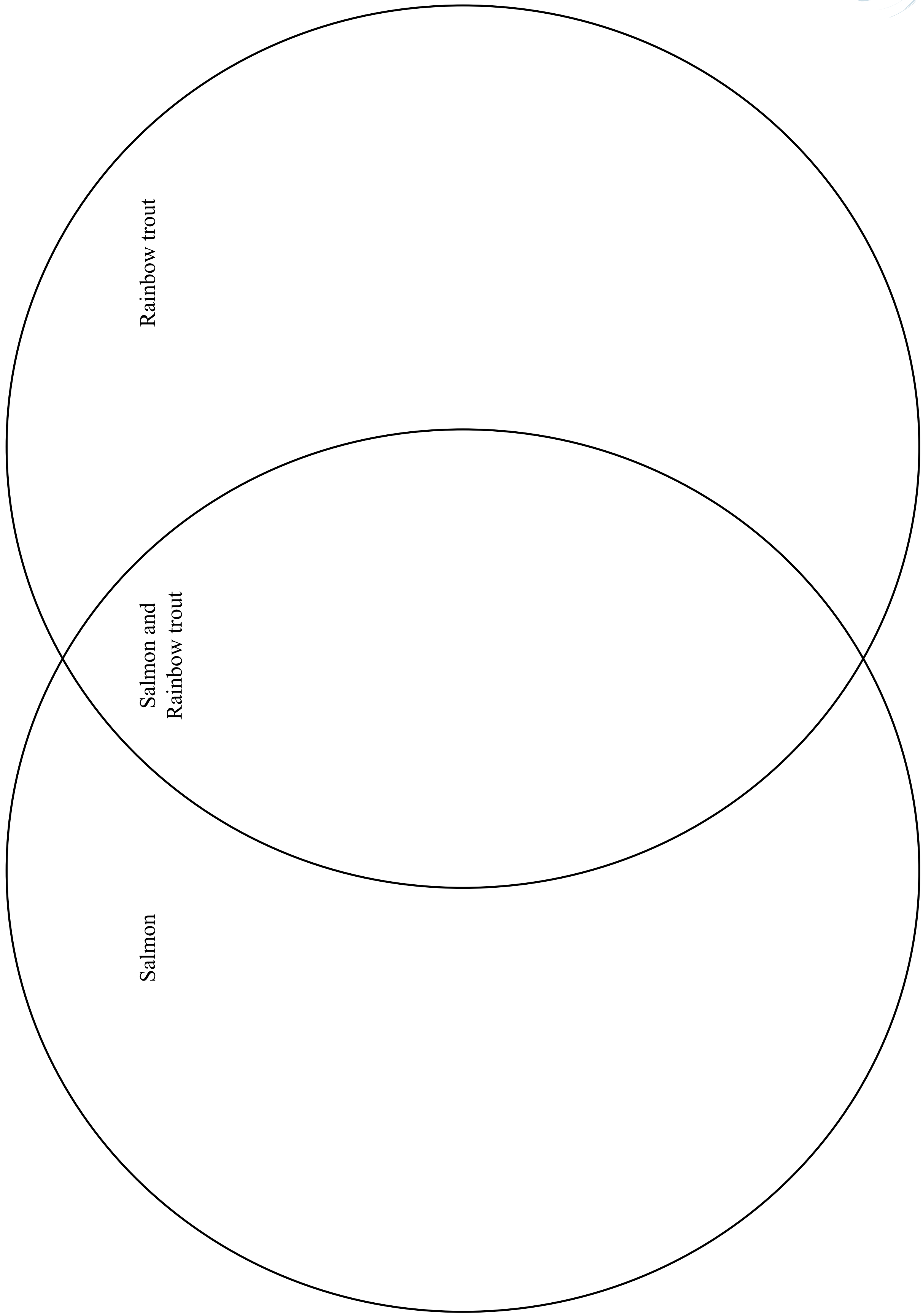
Original Artwork by Elissa Pfost

Chinook Salmon
Oncorhynchus tshawytscha



Rainbow trout
Oncorhynchus mykiss

Venn Diagram



8

Designing Hatcheries with Genes in Mind

Original Curriculum Provided by: California Department of Fish and Wildlife

Overview

Students will analyze the simulated genetic make-up of a salmon population and discuss hatchery operations and decisions as they relate to genetic diversity.

Time Required

two 50 minute sessions

Setting

Indoor

Topic

Genetics

Objectives

(1) Understand how genetic traits affect survival and reproduction of fish and other animals. (2) Understand that hatcheries must implement practices to sustain genetic diversity. (3) Consider why salmon and steelhead runs may become threatened, endangered, or extinct.

California Content Standards

(8th grade)

MS-LS3-1, MS-LS4-4, MS-LS4-5, MS-LS4-6 MS-ETS1-1, MS-ETS1-2, MS-ETS1-3

Common Core English:

RI 7.1, RI 7.4, RI 7.10

SL 7.1, SL 7.2, SL 7.4, SL 7.5, SL 7.6

RST 6-8.1, RST 6-8.2, RST 688.7, RST 6-8.8, RST 6-8.10

Skills

Decision making, speaking

Key Vocabulary

DNA, gene, allele, phenotype, genotype, extirpation, anadromous, imprinting

Materials

- 35 beads for each of 8 different colors
- 4 jars (each able to hold 70 beads)
- 35 small containers (i.e., plastic cups)
- 1 class set "Student Reader"
- 8 "Surviving and Thriving" activity/ Q&A
- 8 each of four "Hatchery Mgt" questions

Background

This exercise is intended to offer enriched perspective on the role of genetics in natural systems. The objective of these activities is to demonstrate the role that genetic diversity plays with endangered and threatened salmonid populations. These fish are an extremely important part of our ecosystem not only by importing nutrients from the sea to inland habitats but also as a virtual 'canary in the coal mine' as indicators of system health.

Students will become acquainted with conservation efforts implemented in CDFW hatcheries to maintain a broad genetic pool for a local salmon population through enlightened hatchery practices in artificial spawning of salmonids. Through the two activities presented in this lesson, students will get a visual representation of how genes are randomly distributed throughout wild populations, and then they will be challenged to act as hatchery managers and face tough decisions regarding the salmon run.

In order to introduce background about the need for fish hatcheries as mitigation for dam construction on rivers having a native salmon run, students are to be provided a copy of the Student Reader page included here and allowed time to complete individual reading. Following up with a group discussion on the importance of genetic diversity, the students are divided up to work in small groups on a first activity ("Surviving and Thriving"). Using colored beads they will chart data simulating distribution of alleles for specific traits in a limited gene pool.

Diversity within a population means that there are enough different forms of a given gene, called alleles, among the individuals to continue producing a variety of genetic combinations within the group. Alleles inherited from male and female parent may be identical or slightly different, but they always work together to determine the final expression of a particular trait, such as body color, body size, tail strength, aggressiveness to defend feeding territory, or resistance to disease.

Genotypes expressing certain combinations of alleles may be better suited for survival of an individual fish in specific environmental conditions. Those individuals with genes that support survival in a particular environment are more likely to successfully reproduce than those without those genes. This process of natural selection is what allows populations to adapt to changes in their environment.

As an example, if the entire salmon population in a given area experienced a warm water, low-oxygen environment, many would die. A population that does not have the genes to withstand these conditions could become locally extinct. But some of the fish in the stream may survive if the individuals inherited the ability to tolerate those particular environmental conditions. These fish would be the basis of rebuilding a fish population in the stream and more of those fish would likely have the genes enabling survival in such an environment.

In a second session activity ("Hatchery Management: Options and Choices") students are presented with specific, 'real-world' resource management challenges via a series of hatchery management questions provided here and asked to consider and promote solutions for them. Hatchery practices are crucial in maintaining the genetic diversity of a salmonid run. In California, the California Department of Fish and Wildlife operates eight salmon and steelhead hatcheries. These generally serve as mitigation effort for lost spawning habitat.

The fish come to the hatchery. Each pan taken for propagation contains eggs from at least two females and milt from two males. The pairs are also taken for spawning at different times of the run. These practices are done to encourage preservation of diversity in the gene pool.

Each hatchery has production outputs or quotas of salmonids that they must return to the river in either smolt or yearling size. Due to the variations in each river system, the hatcheries are operated according to their unique fish populations. This ensures the success of each salmon run.

It is recommended that teachers begin with reproducing and disseminating copies of the Student Reader for each student followed by reviewing the concept of alleles and the role they play in providing genetic diversity. Follow with "Striving and Thriving" activity. As stated below: This exercise does not involve dominant and recessive alleles. For a simple approach here, all alleles are assumed to have equal influence (i.e. to be co-dominant). As such, a mix of low/high alleles for a given trait could be interpreted as medium expression of the characteristic.

The "Hatchery Management: Options and Choices" activity is included to engage further critical thinking/problem solving. A final guided discussion about how genetic diversity connects to critical physical traits of fish, fish survival, and the relative impacts of hatchery practices in maintaining diversity is encouraged.

Designing Hatcheries - Student Reader:

Northern and Central California are home to three species of anadromous salmonids. The Chinook, sometimes called Pacific salmon or king salmon, is popular with anglers and has a relatively stable population, while the coho, or silver salmon, is considered endangered in California. The third species of salmonid that we will learn about is actually an ocean-going trout called "steelhead trout," and it is a threatened species across much of California.

Up until about 150 years ago these fish occurred in vast numbers. It is said that in the late 1800's a person "could cross a river on the backs of the spawning salmon." Currently however, due to loss of suitable freshwater habitat, changing climate, and pressure from over-fishing, populations of these species have all been greatly reduced. These fish are an extremely important part of their ecosystems, as well as being culturally significant to native peoples and the natural heritage of every Californian. Chinook salmon are economically important for both sport and commercial fisheries.

Today, many organizations watch over these fish in order to protect them from suffering further losses. Conserving fish can be challenging since they encounter, and must adapt to, many different habitats during their life span. As anadromous species they spawn in freshwater streams, and as they grow they make their way to the estuary where fresh and salt water mix near the coastline, and then move out to the ocean. After several years of ocean maturation they return to their home stream and build redds (gravel nests for their eggs).

In California, the need for flood control, along with regulation of water for urban, agricultural and fish population support has brought about large changes in the landscape. Dams have been constructed across rivers as necessary interventions but have also resulted in habitat loss for salmonids. When a river is blocked by a dam it prevents salmon from reaching their spawning grounds. In some cases, fish ladders enable some fish to get past the dams. Fish hatcheries have also been created to artificially spawn and rear fish in order to conserve and maintain salmonid populations.

In numerous river systems, hatcheries have now taken a major responsibility in maintaining genetic diversity within specific salmonid populations. This is accomplished by understanding and applying nature's process of selection in reproduction. The greater the genetic diversity among members of the population, the greater the chances are that some of the fish, and thus the species, can survive environmental changes.

Having a good variety of traits in the population can mean the difference between survival and extinction of a population. The goal of the hatchery manager is to have populations of native salmon retain a wide range of traits within each local run. As a result of this approach, if a population were to face severe habitat change or introduction of an invasive competitor, new pathogen, etc., it is more likely that some members of the population will have the alleles necessary to help them survive the unexpected change.

Hatchery managers employ practices that protect genetic diversity when they randomly select individuals for spawning from throughout the salmonid run. In this manner, the greatest variety of traits is conserved for passing on to the next generation. For example, we know that certain alleles dictate when in the migratory run (early, middle or late) an individual fish will arrive upstream to spawn. An individual that spawns early in the fall run may be the most likely to contend with extended summer drought conditions. Alternatively, an individual programmed for late run return may confront high flooding and wash-out conditions.

Many river mouths are blocked by sand bars until enough rain falls to swell the river sufficiently to break through the barrier. If rains come late, or are light, "early run" fish may not be able to spawn. But by actively taking in spawners from each part of the run and introducing offspring from each time of run into the system, hatchery managers can ensure that successive years will allow for the best possibility of a genetically diverse field of returning adults (including 'early run' spawners) regardless of environmental conditions.

Activity 1: Surviving and Thriving

Procedure

1. Set up the activity by separating paired colors of beads into four separate jars or bowls (e.g., 70 combined light blue (35 count) and dark blue (35 count) beads in one jar, etc.) so that each of the four jars contains the mix of color tones or shape (equal numbers of each allele/bead color) representing possible allele make-up for a single gene. Some possible color pairings – may be changed per bead availability – include Orange/yellow, Red/pink, Dark blue/light blue, Green/white.

The genetic makeup of each fish will be represented by a pair of beads. The color of the beads indicates the alleles for genes that govern specific traits in an individual salmon (refer to the 'bead color - key to trait' line on the provided Population Trait Diversity activity sheet). This exercise does not involve dominant and recessive alleles. All alleles are assumed to have equal influence (i.e. to be co-dominant).

2. Divide the class into seven groups (roughly four students each). Explain that each group will take a random "sample" of the Steelhead population in a river. All the samples together will represent the genetic diversity of the entire population (based on scientific sampling / projection from sample size).

3. Provide each student group with four small plastic cups numbered 1 – 4 and one Surviving and Thriving activity sheet. Each member of the group takes two beads from each of the four large jars (randomly, without looking) and places their total of 8 beads into one of the numbered cups. Each student fills a different cup. These represent four fish from their sample population.

5. Have students fill out the Surviving and Thriving activity sheet by charting the occurrence of alleles for each of their fish. Ask groups to discuss the question: Are any trends or patterns observable in distribution of alleles (e.g., three or more fish in sample population with similar combinations)?

6. Ask them to remember: The key to survival of a population of a given species is to have genetic diversity (a variety of allele combinations for a given trait) in that population. The population can only survive if some of its members have the genes (alleles) which produce the physical or behavioral attributes that allow at least some of the individuals to adapt to changing environmental conditions, surviving to reproduce and thereby passing on genes to their offspring. Provide each student team with a copy of the Surviving and Thriving – Question and Answer sheet.

7. Working in groups, have students discuss and designate a recorder for the group to fill out their Surviving and Thriving - Question and Answer sheet together. Have a spokesperson from each group then share the genetic make-up of their population of salmon. Are all the fish genetically identical? How might each fish's genetic make-up affect its chances of survival in different situations? Assuming that all the salmon represented in the room belong to one greater population of salmon in the larger watershed, is there genetic diversity within this population?

8. The discussion portion of this activity is a great opportunity to reinforce the important role of critical thinking in scientific research. All reasonably justified answers to the Genes for Surviving and Thriving activity sheet are acceptable. This is not a fact finding mission but instead an exercise to think creatively as scientists must.

Enrichment option: If time allows, consider the opportunity to pen a star on two of the red beads (prior to distributing them into the jar with red and pink beads) to indicate a rare allele (i.e., only 1 may be found in 100,000 fish!). When student groups have completed and shared their determinations for fish 1 – 4 about the circumstances outlined in the activity sheet, ask the class if anyone has an individual fish with a star shown on the red allele. If so, tell them this is a very rare allele but has unique properties as some rare alleles in nature do.

Describe for the class a situation in which a meteor hits the earth and drops the summer temperature in a given region from 80 degrees Fahrenheit down to 29 degrees Fahrenheit. The fish having this unique gene is the only one that has the temperature tolerance capability to survive that wide a temperature variation. Having this allele in the population, rare as it is, makes the population prepared for catastrophic environmental conditions because it allows a few fish to survive freezing circumstances and to keep a population from dying out completely. Having unusual genes reside in a population gene pool also makes possible great adaptive change over time, known as evolution.

Genes for Surviving and Thriving activity sheet

TRAIT	TAIL STRENGTH	TEMPERATURE TOLERANCE	AGGRESSIVE/ TERRITORAL	BODY SIZE
Bead Color Key to Trait	**Orange:** high **Yellow:** low	**Red:** high **Pink:** low	**Dark Blue:** high **Light Blue:** low	**Green:** large **White:** small
FISH 1				
FISH 2				
FISH 3				
FISH 4				

Surviving and Thriving – Question and Answer sheet

Group members: ____

Circle the fish (one or more) in your population that would have the best chance of success in the following situations and explain why:

1) As juvenile fish living in small streams with limited food resources –

Fish 1 Fish 2 Fish 3 Fish 4

Why? ____

____

2) As adult fish living in the ocean and swimming in schools to stay safe from predators –

Fish 1 Fish 2 Fish 3 Fish 4

Why? ____

____

3) As spawning age fish swimming back upstream against the strong river current, fish encounter many blockages in the river, some of which may be squeezed through, some of which must be jumped over –

Fish 1 Fish 2 Fish 3 Fish 4

Why? ____

____

4) As spawning age males compete with one another for a female and a place to make a redd –

Fish 1 Fish 2 Fish 3 Fish 4

Why? ____

____

5) During the time that salmonid smolts were attempting to migrate downriver a major reservoir failed to release the water necessary to keep a cool temperature in the river. In some places the water temperature reached 80 degrees Fahrenheit –

Fish 1 Fish 2 Fish 3 Fish 4

Why? ____

____

Activity 2: Hatchery Management: Options and Choices

Procedure

1. This activity presents students with several challenges regarding operating a hatchery which happens to manage returns of both coho salmon and steelhead trout. As an introduction, recall the information about different species of salmonids from the first paragraph of the Student Reader and one way to know how populous the species is (Is it listed under Endangered Species Act?). Remind students that as hatchery managers it is their responsibility to maintain genetic diversity in their local population of salmon to the best of their ability.

Remind students also that hatcheries collect eggs and milt from returning fish and raise the young for a period of time in captivity before release. Why is this done? Mitigation hatcheries are the mandated response to establishment of a dam which has cut off migrating fish from accessing their former spawning habitat above the dam. It is a resource manager's tool to keep the numbers of fish up at sustainable levels.

Ask the students what differences it might make for a resource manager of returning salmonids if the steelhead were considered a State and Federally threatened species as opposed to a non-listed species.

[Note: Counting and marking hatchery fish as distinct from the rarer 'wild/unmarked' is important. Extra care and caution is required by anglers who cannot legally keep a wild steelhead from this watershed. They must release them back into the wild. However, because of successful artificial propagation at the hatchery (and marking of 'hatchery steelhead' by clipping its adipose fin) anglers are able to keep up to two marked hatchery steelhead.]

Ask the student hatchery managers if they would take any special approach if the challenges involved State and Federally endangered coho salmon that are nearly extirpated (locally extinct) in California?

[Did you know that so few fish of this species return annually to the hatchery on the Russian River in California that each spawner that does come back undergoes a DNA analysis of its genetic code? In this way, eggs and milt can be most effectively paired through cues provided by a detailed matrix of specific traits of individual fish. This makes it achievable to keep the small gene pool as genetically diverse as possible for producing the hardiest, most viable offspring. Also, it is not legal for anglers to take any coho salmon from this river.]

2. Divide class into small groups of three to four students and distribute one of the four Hatchery Manager Challenge questions to each group. For a class of 32 students you will need to have 2 copies of each challenge questions.

3. Ask for volunteers from each group to be:
   - a) A card reader
   - b) A recorder to record a list of issues brought up by the team
   - c) A timekeeper – the group has five minutes to discuss and list the issues then should be provided three minutes to formulate a decision
   - d) A group spokesperson to share the hatchery manager's decision to the larger class and be able to logically justify the group's decision.

Hatchery Management Options and Choices Questions

Challenge 1 – Steelhead Trout

The time of the season when a steelhead spawns is dependent on its genetic make-up. Alleles govern whether a fish will begin the travel up the river as early as October or as late as March.

Question: As a hatchery manager, is it important to consider at what time during the steelhead run you collect eggs and milt from spawning fish?

Tell:

1. What you would recommend
2. Why you would make that recommendation

Challenge 2 – Coho Salmon

Coho salmon are in danger of extirpation (local extinction) in California. There are very few coho spawners returning to the hatchery each year. For this reason, your hatchery has developed a captive breeding program. Some of these fish are kept at the hatchery year round through adulthood to ensure their survival and spawning success.

Question: The ocean conditions of their adult life phase are not a part of the habitat changes these 'brood stock fish' go through. However, the hatchery must ensure survival and reproduction by maintaining a healthy population even if it cannot mimic ocean conditions.

Tell what you might recommend to help ensure that the local coho salmon population survives.

Challenge 3 – Steelhead Trout

Now you have to think about what will happen when your hatchery fish return to spawn. One tributary in your river watershed has no steelhead in it. Would you release your new, hatchery-raised juvenile steelhead into that barren stream?

What information would you want to have in order to make a decision?

Challenge 4 – Coho Salmon v. Steelhead Trout

When taking eggs and milt from salmonids to expand your hatchery production, you must determine how to go about choosing the individual fish from which to collect eggs/milt.

In recent years only 20 endangered coho salmon returned to the hatchery compared with thousands of adult steelhead. You have an option to pair male and female spawners for each separate population on the basis of their observable phenotype (i.e., body size; the time in the seasonal run they appear, etc.) or you could pair on the basis of their genotype (i.e., capacity for tolerance to very specific environmental conditions; capacity for high kidney function, etc.) by getting a DNA test for each individual fish.

The DNA testing is available but at a cost of millions of dollars. Tell what you would do for each different population of salmonids (coho salmon and steelhead trout) and why you would make that choice.

For the Teacher - Possible responses to Hatchery Management Options and Choices Questions

To a biologist who is constantly assessing a changing set of circumstances there are few black and white answers to questions. Often, options must be tried in order to get the data required to better understand all the factors involved in nature's dynamic. Adaptive management, the ability to remain as flexible as possible within strategic or policy guidelines, is one of the hallmarks of a professional resource manager.

Challenge 1 – Steelhead Trout

It is a basic consideration to take in spawners from early, middle, and late parts of the run. That results in fish progeny that contain genes for continued returns at differing times. If a catastrophic event were to occur in a given year to decimate or impede migration and spawning of fish during that segment of the run, spawners in other times of the run would ensure survival of the population.

Alternatively, if eggs and milt were only taken from one segment of the run, the genetic diversity for this trait would be greatly reduced. Imagine if only the mid-run spawners were propagated (artificially spawned) – if nearly all of future returning adults came in during same period, and if a catastrophic event occurred during that window – then the population could face total elimination.

Challenge 2 – Coho Salmon

While it is not possible for a hatchery to mimic ocean conditions, these are endangered fish; they must be protected, and they must be maintained to prosper from the kinds of physical activity and nourishment that has allowed the species to prosper for thousands of years.

Consider that in raising fish for a number of years, through adulthood, the goal must be healthy growth of fish to enable successful reproduction. You might think of it as creating a kind of 'health club for salmon.' One possible solution for building body strength could be the movement of water in large tanks (as an alternative to ocean currents). As an example, a circular tank with water in constant motion clockwise/counterclockwise would produce resistance to movement providing vital exercise for health and growth.

Fish at sea eat different foods than they do as freshwater juvenile fish and this may contribute to tissue development that is vital to successful reproduction. One ocean source of nutrients is krill (small shrimp-like organisms also enjoyed by baleen whales, such as gray, humpback and blue whales). Fish foods inclusive of krill and other marine organisms (or other high-nutrient value foods) might be fed to captive brood stock in order to achieve desired results.

Challenge 3 – Steelhead

Hatcheries are in the business of stocking (introducing or releasing) the fish they raise into appropriate receiving waters. Typically, some research is required to assess a potential tributary, for example, as to its past history – is there evidence that it once harbored a steelhead population? It would be important to know what habitat conditions exist there such as water quality, flow rate, temperature levels and so forth to determine whether the fish released could survive and prosper there. Also, you would want to find out what other aquatic life is found in the stream. For example, if a different species of salmonid such as salmon may be found there it would not be an ideal steelhead release location so to avoid interspecies competition.

Challenge 4 – Coho Salmon v. Steelhead Trout

Because coho salmon are an endangered species in California it would be important to use any resources or tools that may be at hand to ensure the population can be effectively sustained. Although DNA testing of individuals involves high additional costs – testing for the genotype of males and females at spawning with this technology allows hatchery managers to select for precise pairing in order to determine exact progeny that will maximize genetic diversity and the chance of survival.

For spawning selection of species that are not endangered, it would likely not be cost efficient to do DNA analysis of individual fish but rather rely on observable phenotypes (large bodied, small bodied, early run returner, late run, etc.) to select for pairings. The important strategy would be to do a random selection to enhance genetic diversity rather than select on the basis of one feature (i.e., all large bodied fish, all early returners, etc.). There may be circumstances in which smaller bodied individuals may have survival advantage, etc., and so having a variety of traits in the gene pool is advantageous. Maintaining a genetically diverse population is the prime objective.

adaptation
an adjustment made over time in structure or behavior that allows the species to be better suited to its environment

alevin
the stage of a salmonid's life after hatching until the yolk sac has been absorbed

anadromous
fish that hatch in freshwater, spend some of their lives in the ocean, and then return to freshwater to spawn

aquatic
living in or pertaining to water

camouflage
the coloration or behavior that allows something to blend in with its surroundings

coloration
a genetically controlled combination of color and pattern

condensation
the process by which a substance changes from a gas to a liquid

decomposer
a plant or organism that feeds on and breaks down dead organic material

dissolved oxygen
amount of oxygen gas present in water

ecosystem
an interacting collection of living creatures and their non-living environmental conditions

environment
all of the external conditions that influence the existence of a species

erosion
the removal of land surface by water or wind

estuary
the area where a river meets the ocean, where freshwater and saltwater mix

evaporation
the process by which a substance changes from a liquid to a gas

evapo-transpiration
the process by which ground moisture is transferred to the atmosphere through both evaporation and movement of water through plants to the atmosphere

fish ladder
a series of steps with flowing water and pools built by humans so that fish can swim upstream around an obstruction

freshwater
water with a low level of salinity (e.g. most rivers, lakes)

fry
the stage of a salmonid's life after the yolk sac has been absorbed

groundwater
water stored underground in spaces between soil and rocks

habitat
a living space providing food, water, and shelter to meet the needs of a plant or animal

hatchery
a place where fish eggs are hatched and the young are raised for release into the wild

imprint
the process by which fry memorize the characteristics of their home stream so that they can return to it to spawn as adults

lateral line
a sensory organ extending from head to tail along the side of the body which detects water movements and vibrations

life cycle
the continuous series of phases undergone by an organism during its lifetime

limiting factor
a primary need necessary to sustain life that is in short supply

migration
the movement of animals from one location to another

non-point source pollution
pollution that did not originate from a single particular location

parr marks
dark stripes or blotches found on the sides of salmonid fry

pH
a measure of the acidity or alkalinity of a substance on a scale of 0 to 14 (0=most acidic, 7=neutral, 14=most basic). Stands for “potential of hydrogen”

plankton
microscopic plants and organisms that float or drift in an aquatic habitat

point-source pollution
pollution discharged from a specific, identifiable location

pollution
harmful substances released into air, water, or land

precipitation
water falling from the air to the ground as rain or snow

predator
an animal that hunts and eats other animals

prey
animals that are killed by other animals for food

redd
a salmonid nest made by creating a space in stream gravel where eggs are laid, fertilized, covered with gravel and left to hatch

resource management
policies based on scientific understanding of living resources and actions that may be taken to regulate and protect fish and wildlife populations

riparian
pertaining to or located on a stream or riverbank

runoff
water that flows along the ground surface toward nearby bodies of water

salmonids
any fish species classified within the taxonomic family Salmonidae which includes salmon and trout

saltwater
water that contains a high concentration of salt (e.g. ocean)

sediment
material eroded from the land surface and transported to streams where it settles

silt
fine particles of earth carried by water

smolt
a young salmonid that is adapting to saltwater and migrating to the ocean

smoltification
the process of transforming into a smolt- gills and kidneys must now be able to process saltwater

spawning
release of eggs (female fish) or sperm (male fish) during reproduction

species
a population of similar individuals able to breed among themselves and produce fertile offspring

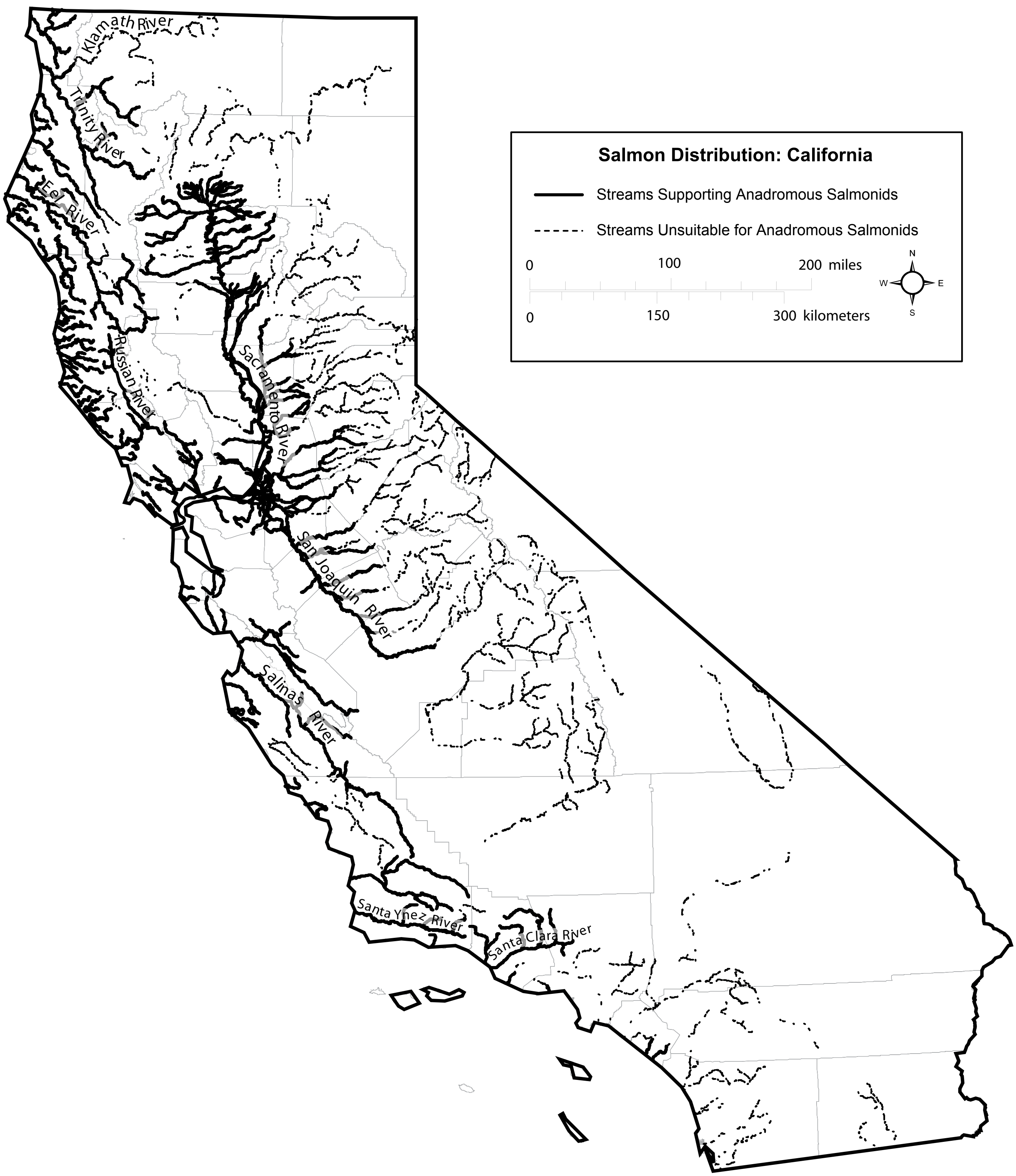
turbidity
loss of clarity of water due to presence of suspended matter

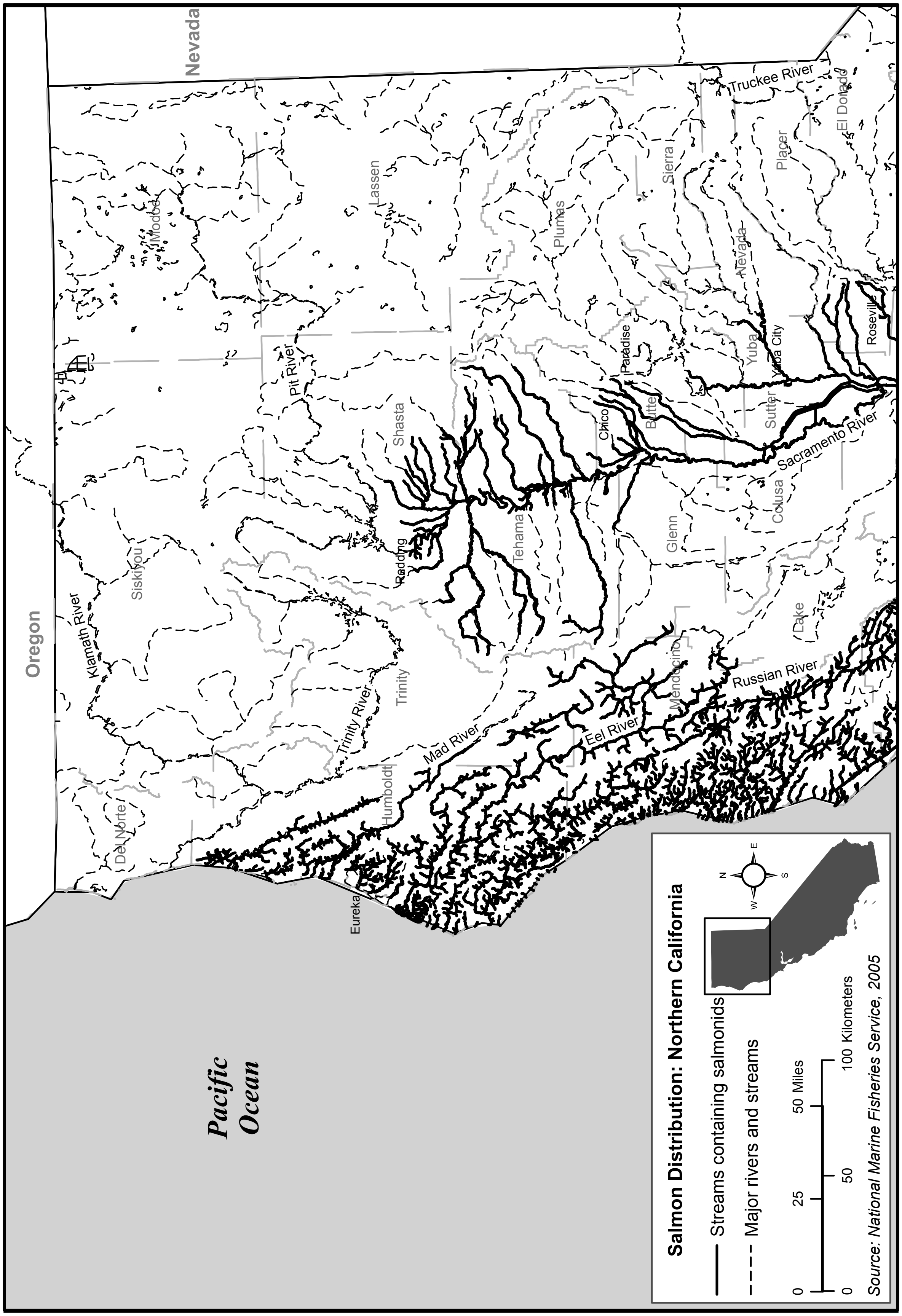
vegetation
plants covering a given area

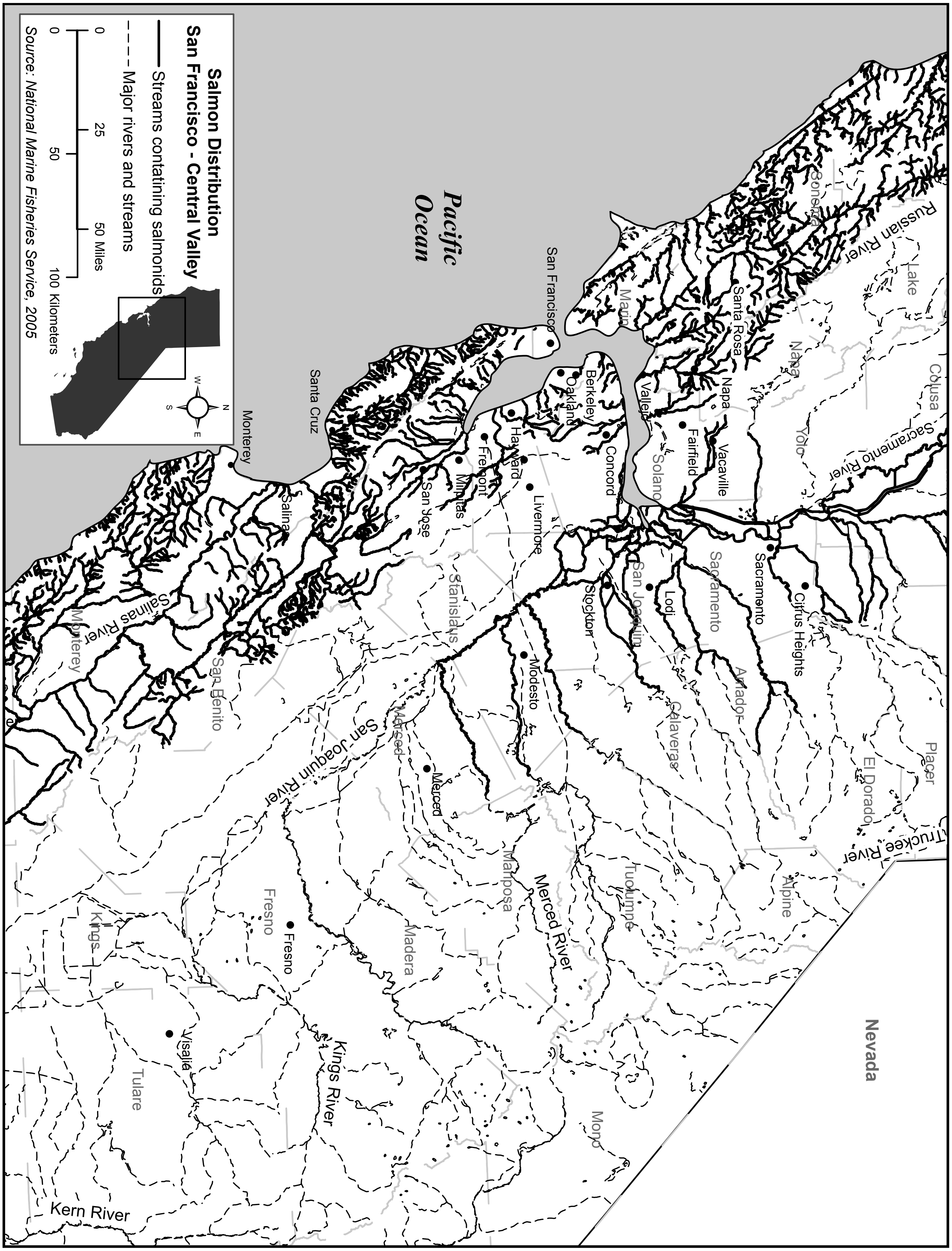
water cycle
the continuous circulation of water through its various states- gas, liquid, solid

watershed
the land area which collects water runoff into a stream or river system from its surrounding ridges

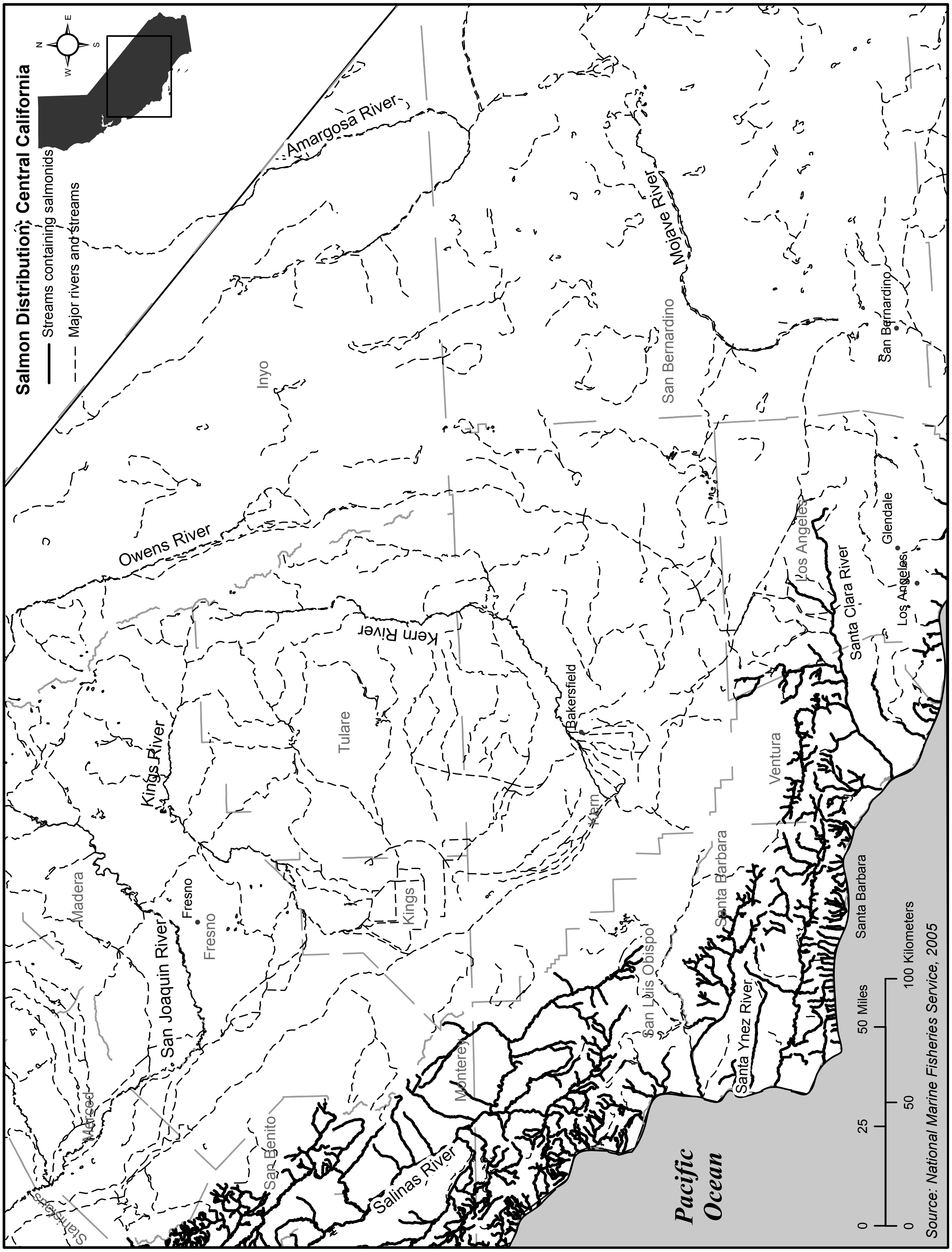
yolk sac
a structure containing nutrients for salmonid alevins to absorb as nourishment

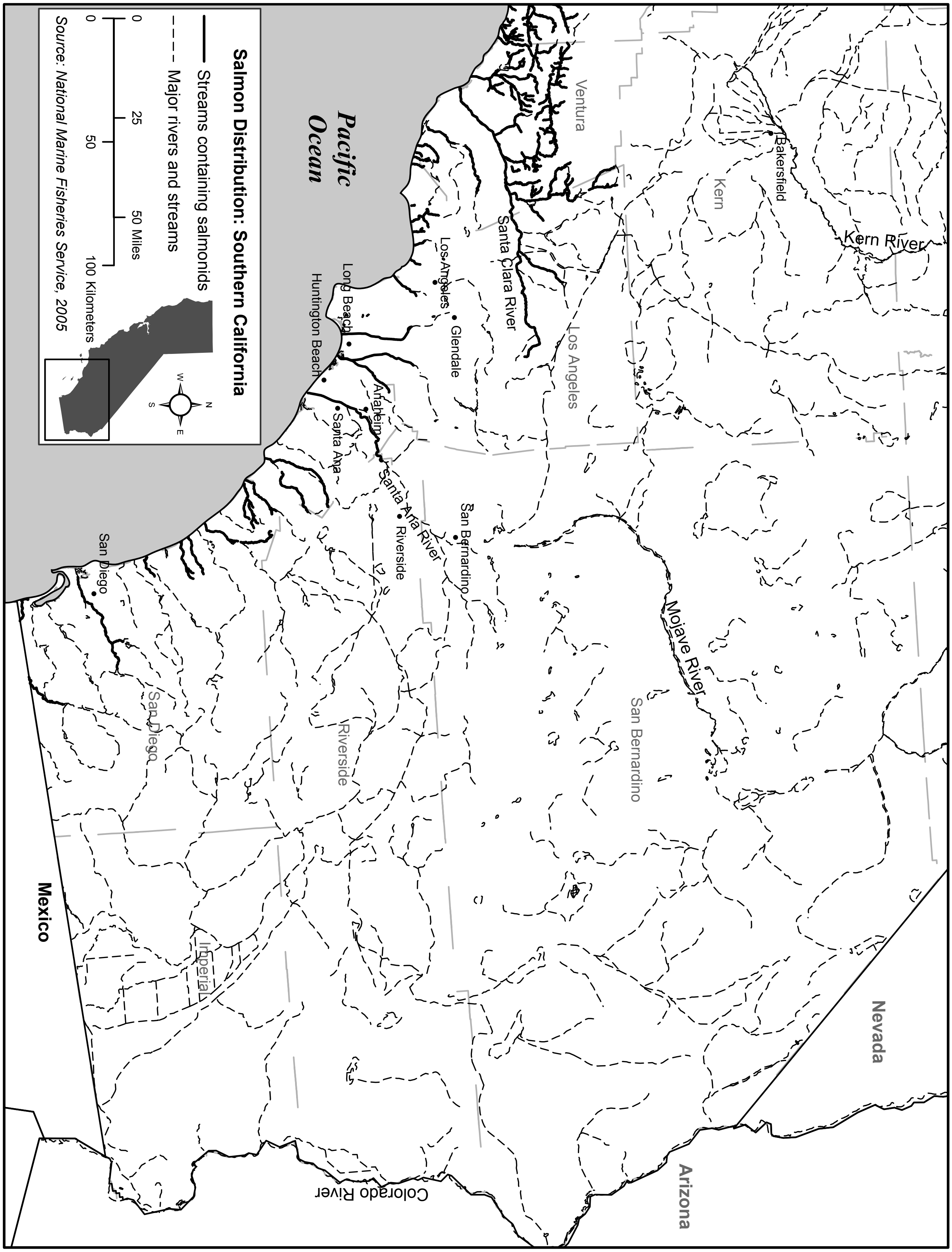

Klamath River
Trinity River
Eel River
Russian River
Sacramento River
San Joaquin River
Salinas River
Santa Ynez River
Santa Clara River
Salmon Distribution: California
Streams Supporting Anadromous Salmonids
Streams Unsuitable for Anadromous Salmonids
0
100
200 miles
0
150
300 kilometers
N
S
E
W


Salmon Distribution: Northern California
Streams containing salmonids
Major rivers and streams
0
25
50 Miles
0
50
100 Kilometers
N
E
S
W
Source: National Marine Fisheries Service, 2005
Nevada
Oregon
Pacific Ocean
Truckee River
El Dorado
Placer
Sierra
Lassen
Modoc
Plumas
Nevada
Roseville
Paradise
Yuba
Yuba City
Pit River
Shasta
Chico
Butte
Sutter
Sacramento River
Colusa
Glenn
Tehama
Redding
Siskiyou
Klamath River
Lake
Mendocino
Russian River
Trinity
Trinity River
Mad River
Eel River
Humboldt
Del Norte
Eureka



Salmon Distribution
San Francisco - Central Valley
Streams containing salmonids
Major rivers and streams
0 25 50 Miles
0 50 100 Kilometers
Source: National Marine Fisheries Service, 2005
Pacific Ocean
San Francisco
Santa Cruz
Monterey
Oakland
Berkeley
Hayward
Fremont
Milpitas
San Jose
Livermore
Concord
Vallejo
Napa
Santa Rosa
Fairfield
Vacaville
Sacramento
Citrus Heights
Lodi
Stockton
Modesto
Merced
Fresno
Visalia
Russian River
Sacramento River
San Joaquin River
Salinas River
Merced River
Kings River
Kern River
Truckee River
Nevada
Sonoma
Lake
Marin
Colusa
Yolo
Solano
Amador
Calaveras
Placer
El Dorado
Alpine
Tuolumne
Mariposa
Madera
Mono
Tulare
Kings
San Benito
Monterey
Stanislaus
San Joaquin


Salmon Distribution: Central California
Streams containing salmonids
Major rivers and streams
N
E
S
W
Amargosa River
Owens River
Mojave River
Kern River
Kings River
San Joaquin River
Salinas River
Santa Ynez River
Santa Clara River
Inyo
San Bernardino
San Bernardino
Tulare
Bakersfield
Kern
Kings
Fresno
Fresno
Madera
Merced
Stanislaus
San Benito
Monterey
San Luis Obispo
Santa Barbara
Santa Barbara
Ventura
Los Angeles
Los Angeles
Glendale
Pacific Ocean
0 25 50 Miles
0 50 100 Kilometers
Source: National Marine Fisheries Service, 2005



Salmon Distribution: Southern California
Streams containing salmonids
Major rivers and streams
0 25 50 Miles
0 50 100 Kilometers
Source: National Marine Fisheries Service, 2005
N
E
S
W
Pacific Ocean
Ventura
Bakersfield
Kern
Kern River
Santa Clara River
Los Angeles
Glendale
Long Beach
Huntington Beach
Anaheim
Santa Ana
Santa Ana River
Riverside
San Bernardino
Mojave River
San Diego
Imperial
Mexico
Nevada
Arizona
Colorado River

Universal Correlation Chart

Activity	Page	Grade Level	Duration (minutes)	Setting (I=in, O=out)	Adaptations	Anatomy	Biology	Ecosystem	Genetics	Habitat Conservation	Human Impacts	Life Cycle	Limiting Factors	Taxonomy	Water Quality	Watershed
The Salmon Story	2	3	65	I/O								X				
Hooks and Ladders	7	3	60	O									X			
Water Wings	15	3	100	O						X						
Parts of a Fish	25	4	65	I	X	X										
Smelling the Way Home	31	4	80	I/O	X											
Inside Out	37	4	130	I		X										
Team Salmon	52	5	60	I			X					X				
Aquatic Connections	64	5	60	I/O				X								
Finding Your Ecological Address	82	5	65	I												X
When It Rains It Pours	96	6	80	I							X					
Coming Home	102	6	150	I						X						
What's in the Water?	108	6	75	I											X	
Fish Fertilizer	118	7	150	I/O								X				
Water Quality Testing	123	7	115	I											X	
Variations on a Theme	130	8	115	I										X		
Designing Hatcheries With Genes in Mind	136	8	75	I					X							

Grade 3:

The Salmon Story-

1. yolk sac
2. predator
3. imprinting
4. migration
5. C
6. D
7. C
8. B
9. Their bodies need to adapt to saltwater
10. Salmon are food for sharks.
11. No. Salmon need to be able to recognize the scent of their home stream.
12. Upstream. They are at the end of their life cycle and fully grown.

Hooks and Ladders-

1. predators
2. migration
3. limiting
4. shade
5. B
6. C
7. D
8. B
9. Down. Orcas are predators of salmon.
10. Because it can find many things to eat in the ocean.
11. Negative. Resources such as food and space for other living things would be gone.
12. Salmon need the plants to provide shade and protection.

Water Wings-

1. one
2. transpiration
3. moved
4. water
5. B
6. C
7. A
8. C
9. Plants and trees absorb water.
10. Most of the earth's water is contained in the oceans.
11. A moves water from one place to another.
12. Less likely, because there would be not as much water, and less stream flow.

Grade 3 Unit Assessment-

1. yolk sac
2. imprinting
3. predator
4. one
5. C
6. B
7. A
8. B
9. Because it can find many things to eat in the ocean.
10. Upstream. They are at the end of their life cycle and fully grown.
11. Less likely, because there is not as much water and less stream flow.
12. Salmon are food for sharks.

Grade 4:

Parts of a Fish-

1. oxygen
2. nostrils
3. gills
4. fins
5. B
6. C
7. D
8. A
9. It helps the swimming salmon turn to change direction.
10. More. Salmon have eyes on the side of their head and people have eyes facing forward.
11. Scales provide the salmon with protection.
12. The body shape helps the salmon swim faster.

Smelling the Way Home-
1. spawn
2. smell
3. more
4. memory
5. C
6. C
7. D
8. B
9. So it can find its home stream to spawn in.
10. The salmon can't smell the water.
11. Salmon. It has a much better sense of smell.
12. To remember a scent for many years.

Inside Out-
1. gills
2. esophagus
3. caudal
4. pump
5. A
6. C
7. B
8. B
9. Harder. Salmon eyes have one fixed focus. Humans can change their focus.
10. More energy. It would have to keep swimming to stay afloat.
11. The lateral line can sense food, predators, and other salmonids.
12. Because it just passes blood to the other heart chamber

Grade 4 Unit Assessment-
1. migration
2. predator
3. plants, trees
4. hide
5. A
6. B
7. C
8. A
9. An alevin feeds off its yolk sac.
10. Increase. There is more food for salmon to eat.
11. Everything in an ecosystem is connected.
12. You would have less food because fewer salmon live to migrate to the ocean.

Grade 5:

Team Salmon-
1. fry
2. cool
3. plankton
4. spawn
5. B
6. C
7. B
8. D
9. To adjust to the saltwater.
10. Smolts hide from predators in eelgrass.
11. No. Spawning salmon do not eat anything.
12. People could step on eggs and alevins in the gravel.

Aquatic Connections-
1. plants
2. connected
3. gravel
4. nutrients
5. A
6. B
7. D
8. A
9. Plants act as the primary food source.
10. Everything in the ecosystem is connected.
11. Improper logging creates sediment that smothers eggs.
12. Decrease. Crawdads get food from decomposing salmon.

Finding Your Ecological Address-
1. watershed
2. people
3. ecological
4. runoff
5. A
6. D
7. D
8. A
9. Larger watersheds are made up of smaller watersheds.
10. Yes. All land is part of a watershed.
11. Lots of erosion. The steep slope creates rapid runoff.
12. The channels have to carry more water from all the watersheds.

Grade 5 Unit Assessment-
1. spawn
2. connected
3. nutrients
4. watershed
5. D.
6. A
7. B
8. B
9. It creates sediment that smothers salmon eggs.
10. Yes. All land is part of a watershed.
11. No, because spawning salmon stop eating when they enter their home stream.
12. Because everything is connected and we all live in a watershed.

Grade 6:

When It Rains It Pours-
1. sediment
2. impermeable
3. velocity
4. flood
5. D
6. C
7. C
8. A
9. Plant roots hold the soil in place on the banks.
10. Increased sediment could clog their gill filaments or bury their food.
11. It scours and cleans the gravel beds for salmonids to lay their eggs in.
12. Eggs in the gravel would not be able to get enough oxygen.

Coming Home-
1. sponge
2. current
3. plants
4. dissolved
5. B
6. C
7. A
8. C
9. Sediment is transported downstream and smothers eggs.
10. So they can hide from predators and rest in the shade
11. Less. Pesticides would kill aquatic insects, which is what salmon eat.
12. It prevents small streams from drying up in the summer.

What's in the Water?
1. thermal
2. oxygen
3. sediment or silt
4. oxygen
5. E
6. E
7. B
8. C
9. Human waste can carry dangerous bacteria and viruses. Also, it provides fertilizer that can cause an algal bloom, resulting in reduced oxygen levels.
10. The roots of streamside vegetation

can hold the soil in place, reducing sedimentation.

11. Streamside vegetation can provide shade which results in cooler water. Cool water can hold more oxygen.
12. Fertilizers can cause an algal bloom. When the algae die, they decompose, which results in reduced oxygen.

Grade 6 Unit Assessment-

1. velovity
2. aquatic ecosystem
3. pesticides or other pollutants
4. shade
5. A
6. C
7. C
8. A
9. It brings oxygen and eliminates waste and silt.
10. Because salmon are returning from the ocean where they feed and grow to maturity.
11. Down. River otters depend on spawning salmon carcasses for food.
12. Too many nutrients would create too many plants that would reduce stream temperature.