Illustration by Zach Mandell, Hidden Valley High

UNIT 4. SALMON

INTRODUCTION:

This unit introduces the student to the star of our program, the Pacific Northwest Salmon. In order to understand the plight of the salmon, and to conceive possible solutions to their declining populations, it is necessary to understand what and who they are. This means learning their anatomy and taxonomy (the “what”), and how salmon change during their lives (the “who”), as well as how they use their senses to cope with a difficult, migratory life. In this unit, we hope to give the student an opportunity to swim for a while with a salmon’s fins. Focus on making the salmon come alive as a living organism in the student's mind. This awareness plays an important part in establishing an ethic, which incorporates the conservation of our wild fish heritage into the student's view of Pacific Northwest watersheds. Another important aspect to this unit is to provide you with a host of information about the salmon to use to compliment the lessons and activities and/or to use in any manner you see fit to facilitate learning about salmon.

OBJECTIVES:

Students will:

- know and understand the general anatomy and physiology of salmonids.
- be able to identify the similarities and differences among the five salmonid species.
- further understand the life cycle of the salmon.
- know and understand the habitat requirements of salmonids.

SECTIONS:

A. The Journey of Wild Pacific Salmon
B. External Characteristics of Salmonids
C. Goin’ Fishin’ - Identifying Salmon Species
D. Sniffin’ Salmon - Salmonid Life Cycles
E. Salmon Supplemental Information

UNIT 4. SALMON

Student Handouts

Teacher Pages

4A-1	*The Journey of Wild Pacific Salmon*
4A-2	*The Life Cycle of Wild Salmon*
4A-2 (Answers)	*TEACHER PAGE: The Life Cycle of Wild Salmon*
4A-3	*Potential Challenges to Salmon*
4A-3 (Answers)	*TEACHER PAGES: Challenges to Salmon*
4A-4	*My Life Cycle Compared to a Salmon's*
4B-1	*External Characteristics of Salmonids*
4B-1 (Answers)	*TEACHER PAGE: External Characteristics of Salmonids*
4C-1	*Goin' Fishin'*
4C-2	*Fish and Fish Facts #1-#5*
4C-3	*Sample Dichotomous Key*
4D-1	*Sniffin' Salmon*
4D-2	*Sniffin' Salmon Diagram*

UNIT 4A. THE JOURNEY OF PACIFIC WILD SALMON

ACTIVITY	TIME	LEVEL
The Journey of Wild Pacific Salmon	30 minutes	Introductory
The Life Cycle of Wild Salmon	20-30 minutes	Introductory
Challenges to Salmon	30-45 minutes	Advanced
My Life Cycle	60 minutes	Introductory

BENCHMARKS	
Next Generation Science Standards	MS-LS2-4, HS-LS2-8 LS1.B, LS2.A, L2.A, LS2.C
NGSS Science & Engineering Practices	-Developing & using models -Constructing explanations & designing solutions
Common Core State Standards–ELA/Literacy	CCRA.R.1, CCRA.R.4, CCRA.W.9
OR Social Sciences Academic Content Standards	HS.63

OBJECTIVES:

Students will:

- gain an understanding of the life cycle of the salmon and the many challenges faced in their migratory journey.

MATERIALS:

- STUDENT HANDOUT 4A-1: The Journey of Wild Pacific Salmon
- STUDENT HANDOUT 4A-2: The Life Cycle of Wild Salmon
- TEACHER PAGE 4A-2: The Life Cycle of Wild Salmon
- STUDENT HANDOUT 4A-3: Challenges to Salmon
- TEACHER PAGE 4A-3: Potential Challenges to Salmon
- STUDENT HANDOUT 4A-4: My Life Cycle Compared to a Salmon’s
- Dictionary and/or biology textbook

PROCEDURE:

1. Give students STUDENT HANDOUT 4A: The Journey of Wild Pacific Salmon and STUDENT HANDOUT 4B: The Life Cycle of Wild Salmon. As students read The Journey, have them fill in the blanks for each of the ten stages in the chart. Refer to the TEACHER PAGE 4B when reviewing the Life Cycle Chart. Also, words in bold are important to understanding salmon and may be unfamiliar to students. Encourage students to use reference materials to look up and define these words.

2. Have students refer again to STUDENT HANDOUT 4A as they brainstorm and/or conduct research about the challenges at each stage of a salmon's migratory journey. Use the chart in STUDENT HANDOUT 4C: Challenges to Salmon to organize their thoughts. Refer to TEACHER PAGE 4C to review this activity.

3. After the Challenges to Salmon chart is complete, facilitate a discussion about solutions to the problems. Ask students to think about the difficulties in the management of a natural resource.

4. After learning about the life cycle of the salmon and the challenges they face in their journey, use STUDENT HANDOUT 4D: My Life Cycle Compared to a Salmon's. Have students follow the directions to develop a timeline with a narrative about their life cycle compared to a salmon's.

EXTENSION QUESTIONS:

What other animal species migrate in the Pacific Northwest? Compare and contrast the different migration patterns of animal species with that of the salmon.
What is the difference between the life cycle of wild salmon and that of a hatchery salmon?

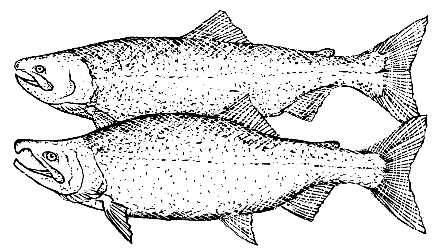
STUDENT HANDOUT 4A-1
The Journey of Pacific Wild Salmon

ACTIVITIES:

- As you read, complete the chart in Student Handout 4A-2: *The Life Cycle of Wild Salmon*.
- As you read about each stage of a salmon's life, think about all the possible human and natural challenges a salmon might encounter. Use Student Handout 4A-3: *Challenges to Salmon*, to organize your thoughts and to develop a list of potential problems and challenges to salmon on their journey.
- Use Student Handout 4A-4: *My Life Cycle*, to compare the similar stages of your life with those of the salmon's.
- Use a dictionary or biology textbook to look up the definitions of words that are unclear. Words that are in **bold** are of particular importance to understanding salmon and are defined in the glossary.

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

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



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

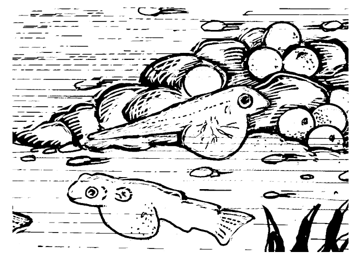
The salmon have evolved with incredibly strong instinctive patterns. Born in freshwater streams, anadromous or sea-run species like salmon are uniquely compelled to travel to the ocean. The vast ocean food chain supports a growth rate that freshwater members of the same species could never hope to achieve.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

STUDENT HANDOUT 4A-1

1. EGG STAGE

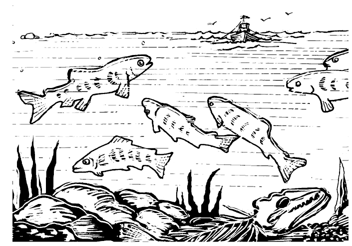
Salmon begin their lives in shallow gravel beds within the substrate of the freshwater streams and rivers in which their parents were born. The fertile, reddish-orange eggs develop in the safety of the gravel. Cold, clean sediment-free water must wash the eggs and bring them oxygen. Eggs lie in the gravel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

2. ALEVIN STAGE



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

3. JUVENILE STAGE



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

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

4. SMOLT STAGE

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

Estuaries occur where coastal rivers enter the ocean, creating a mix of fresh- and saltwater habitats. For salmon, the estuary represents the drastic transition from the river to the sea. Nutrient-rich sediment in estuaries produces nurseries for thousands of tiny organisms, upon which salmon feed. The inner waters of eelgrass beds and salt marshes provide habitat for the fish as they transition from fresh to salt water.

This transformation involves amazingly complex body-chemistry changes. In addition, other physical changes occur during smolting: scales become larger, color turns silvery, and tails lengthen and become more deeply forked. Depending upon the species, salmon spend from a few days to a few months in an estuary.

STUDENT HANDOUT 4A-1

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

5. OCEAN-FARING ADULT STAGE

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

6. UPSTREAM MIGRATION STAGE

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

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

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

7. COURTSHIP STAGE

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

STUDENT HANDOUT 4A-1

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

8. SPAWNING STAGE

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

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

9. KELT STAGE

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

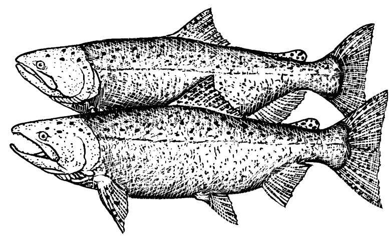
10. CARCASS STAGE

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

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

STUDENT HANDOUT 4A-2

The Life Cycle of Wild Salmon



DIRECTIONS: As you read *The Journey of Pacific Wild Salmon* (Student Handout 4A-1), complete the chart with the following information.

1. Stage
   a. Location
   b. Time at stage (approx.)
   c. Distinct characteristics

1. Egg
a.
b.
c.

2.
a. freshwater gravel
b.
c.

3.
a.
b. 4 months to 3 years
c.

4.
a.
b.
c.

5.
a.
b.
c. two-tone coloring; grow rapidly

6. Adult upstream
a.
b.
c.

7.
a.
b.
c.

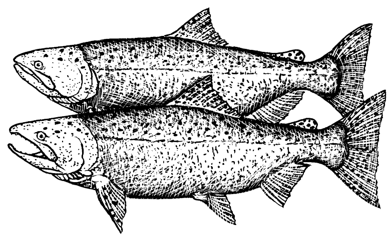
8.
a.
b. several days
c.

9.
a. freshwater
b.
c.

10.
a.
b. varies
c.

Answers to STUDENT HANDOUT 4A-2

The Life Cycle of Wild Salmon



DIRECTIONS: As you read *The Journey of Pacific Wild Salmon* (Student Handout 4A-1), complete the chart with the following information.

1. Stage
a. Location
b. Time at stage (approx.)
c. Distinct characteristics

1. Egg
a. freshwater gravel
b. 2 months +
c. eggs are reddish orange

2. Alevin
a. freshwater gravel
b. 1-2 months
c. orange yolk-sac on bellies provides food

3. Juvenile
a. freshwater shallow pools
b. 4 months to 3 years
c. length up to 2 inches; parr have dark bars on sides called parr marks

4. Smolt
a. estuaries
b. days to months
c. about 4-6 inches in length; transform into ocean-looking fish

5. Adult
a. ocean
b. 1-5 years
c. two-tone coloring; grow rapidly

6. Adult upstream
a. freshwater
b. hours to several months
c. stops eating

7. Courtship
a. freshwater
b. days to months
c. males – humped backs, hooked jaws, sharp teeth; both – white fungus and frayed fins

8. Spawning
a. freshwater
b. several days
c. female digs redd, male defends

9. Kelt
a. freshwater
b. hours to days
c. females defend redds; males can spawn again

2. Carcass
a. freshwater
b. varies
c. decomposing bodies add nutrients to stream and feed wildlife

STUDENT HANDOUT 4A-3

Potential Challenges to Salmon

According to the Pacific States Marine Fisheries Commission, there are six major factors, six potentially important factors, and two minor factors that could possibly challenge a salmon's migratory journey and contribute to their overall decline. For each factor, describe at least two potential problems created that might threaten salmon health, migration and/or habitat. In addition, try to determine at what life cycle stage or stages salmon would be challenged.

	FACTORS	PROBLEM CREATED	PROBLEM CREATED	LIFE CYCLE STAGE(S)
MAJOR	Agriculture			
	Dams			
	Drought			
	Fishing			
	Forestry			
	Urbanization			

IMPORTANT	Gravel Harvest			
	Irrigation			
	Bycatch Mortality*			
	Hatchery Fish Interference			
	Poor Ocean Conditions			
	Illegal Fishing			

MINOR	Bird Predation			
	Marine Mammal Predation			

*Salmon killed during fishing for other species

Answers to STUDENT HANDOUT 4A-3:
Potential Problems and Challenges Contributing to Salmon Decline

The following list will assist you in completing the chart on page 4.19. (Information provided by Pacific States Marine Fisheries Commission):

AGRICULTURE
Loss of streamside vegetation and functions
Pesticide exposure
Increased amount of sediment entering streams
Stream straightening and channelization
Habitat destruction
Filling of the side channels of streams
Reduced freshwater flow in rivers and streams
Exposure to abnormal temperatures
Barriers preventing salmon migration
Forest fragmentation
Estuary degradation

DAMS
Reduced freshwater flow in rivers and streams
Habitat area loss
Barriers preventing salmon migration
Water supersaturation

DROUGHT
Reduced freshwater flow in rivers and streams
Exposure to abnormal temperatures

FISHING
Reduced numbers reaching spawning grounds
Loss of genetic integrity and diversity

FORESTRY (if not adhering to rules and regulation set by the Oregon Forest Practices Act)
Loss of streamside vegetation and functions
Pesticide exposure
Increased amount of sediment entering streams
Habitat destruction
Decreased amount of large logs in streams and loss of deep pools and channel forms
Exposure to abnormal temperatures
Forest fragmentation
Estuary degradation

URBANIZATION
Loss of streamside vegetation and functions
Industrial pollutants exposure
Stream straightening and channelization
Habitat destruction
Decreased amount of large logs in streams and loss of deep pools and channel form
Filing of the side channels of streams
Reduced freshwater flow in rivers and streams
Exposure to abnormal temperatures
Habitat area loss
Forest fragmentation
Estuary degradation

GRAVEL HARVEST
Habitat destruction
Loss of eggs & juvenile fish
Sediment downstream

IRRIGATION
Reduced fresh water flow in rivers and streams
Lack of screening of water diversion canals

BYCATCH MORTALITY
Reduced numbers reaching their spawning grounds
Loss of genetic integrity and diversity
Loss of stream nutrients due to fewer carcasses

HATCHERY FISH INTERFERENCE
Loss of genetic integrity and diversity
Competition between hatchery and wild fish
Elevated numbers of predators

POOR OCEAN CONDITIONS
Reduced upwelling
Altered ocean currents and flow
Decreased food abundance
Reduced numbers reaching their spawning grounds
Smaller fish
Confused migration & more strays

ILLEGAL FISHING
Reduced numbers of adults reaching their spawning grounds
Loss of genetic integrity and diversity

BIRD PREDATION
Reduced numbers of adults making it to the sea
Loss of genetic integrity and diversity

MARINE MAMMAL PREDATION
Reduced numbers reaching their spawning grounds
Reduced numbers of adults making it to the sea

Answers to STUDENT HANDOUT 4A-3 (Information is from USFWS, BLM and the U.S. Forest Service)

EGG/ALEVIN STAGE

- Eggs suffocate when silt clogs spaces in gravel.
- Chemical pollutants can weaken and kill fish.
- Water diversions and natural drought dry up creeks and strand fry in pools, making them easy prey for birds and other predators.
- Removal of streamside vegetation through poor grazing management of livestock can remove shade and raise water temperatures—sometimes to lethal levels.
- Drought and water diversions lower water levels, making nests vulnerable to freezing in winter.
- Erosion, following clearcutting or fires, can smother nests with silt if logging operation are not following good management practices..
- Floods can sweep eggs out of gravel.
- Fish and birds eat salmon eggs.
- If good spawning habitat is scarce, females may dig up each others' nests.
- Clearcutting along streams can raise water temperature and reduce oxygen in water if adequate buffers are not present, this could result in eggs being suffocated.

JUVENILE STAGE

- Riverbank clearing and rip-rap bank protection structures remove streamside vegetation that provides shade and keeps the water cool
- Altering of riparian vegetative instream characteristics and water quality impacts habitat conditions for fry.
- Insects and other food sources are reduced.
- Clearing woody debris or dredging gravel can ruin habitat.
- Agricultural, urban, and industrial pollution kills salmon fry.
- Excessive removal of trees in riparian areas could reduce insect food available to young salmon.
- Floods, either natural or caused by human activity, can sweep fry from streams before they are ready to migrate.

SMOLT STAGE

- Changes in the natural river flow such as dams, diversions, and turbulence can confuse and delay migrating salmon.
- Migration delays increase losses from predation.
- If delayed, smolts may lose the urge to migrate.
- Estuaries are valuable nurseries that can be lost when coastal wetlands and estuaries are filled, dredged, or developed.
- Anglers who mistake them for trout take coho and spring Chinook smolts.
- Anglers who catch & release can fatally injure fish.
- Migration is slowed as smolts swim through slackwater pools above dams.
- Slackwater pools are ideal habitat for pike minnow that eat young salmon.
- Many smolts are killed and injured going through hydroelectric turbines or over spillways.
- Smolts are preyed on by birds, mammals, and larger fish.
- Pollution kills or weakens smolts.
- Pollution of estuaries reduces food available to smolts at a critical time.

OCEAN FARING ADULT STAGE

- Overfishing results in inadequate numbers of fish returning to spawn.
- Poor ocean conditions can result in altered ocean currents and flow, decrease food abundance and reduce upwelling.

UPSTREAM MIGRATION STAGE

- Dams, gill nets, siltation, natural predators, and low water levels can all prevent fish from reaching the spawning grounds.
- Adult salmon are confused and slowed by slackwater pools above dams and tailwater turbulence below dams, using up precious energy reserves.
- By raising water temperatures, slackwater pools contribute to "warmwater disease," a major killer of adult salmon.
- Adult salmon run the gauntlet of predators: humans, sea lions, bears, and others.
- Poorly constructed dams and natural rockslides block adult migration.
- Pollution can weaken or kill adult salmon.

COURTSHIP/SPAWNING STAGE

- People can disrupt courtship behavior or frighten spawning salmon from their nests if they approach too closely.
- By controlling and diverting water, humans interfere with natural cycles of flushing and gravel deposition that create spawning habitat.

STUDENT HANDOUT 4A-4

My Life Cycle Compared to a Salmon

From birth to death, we progress through a cycle that contains specific stages such as infant, toddler, child, teenager, young adult, mature adult and senior. As you have learned, salmon also go through cycles in their lives. Salmon start out as an egg, and grow through a series of stages to become an adult salmon. This activity is designed to help you think about your own life cycle stages and how they compare to the salmon's life cycle.

Below is a timeline with some of the major life stages of the salmon. In examining your own life determine the stages that are equivalent, either in age or event importance. From that comparison, draw your own life cycle, including ages and important events that occur at each stage.

Your assignment is to compare the similar stages of your life with those of salmon. For each stage, explain two important events that occur in your life cycle, as well as the salmon.

EGG

ALEVIN

JUVENILE

SMOLT

OCEAN ADULT

MIGRATION UPSTREAM

COURTSHIP

UNIT 4B. EXTERNAL CHARACTERISTICS OF SALMONIDS

TIME	LEVEL
45-60 minutes	Introductory

BENCHMARKS	
Common Core State Standards–ELA/Literacy	CCRA.SL.2
OR Social Sciences Academic Content Standards	HS.63

OBJECTIVES:

Students will know and understand:

- the external characteristics of salmonids in terms of form and function.

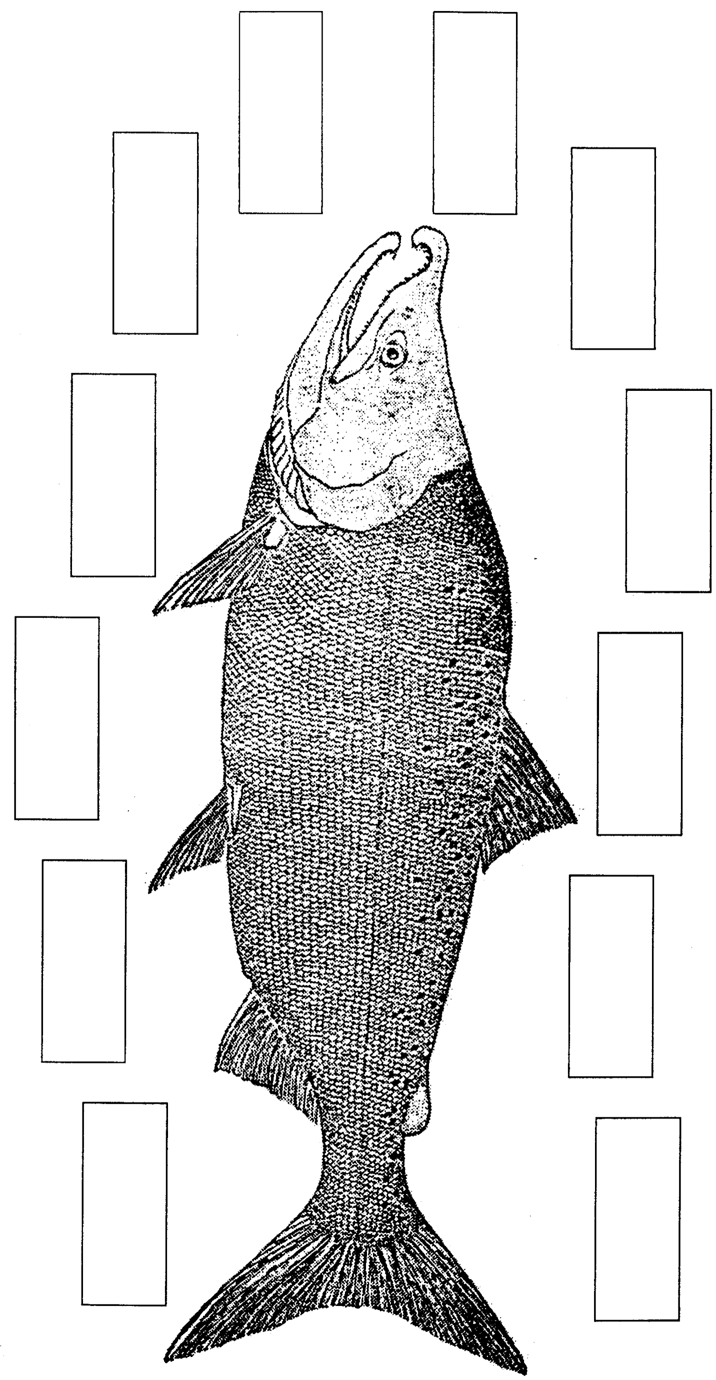
MATERIALS:

- STUDENT HANDOUT 4B: *External Characteristics of Salmonids*
- TEACHER PAGE 4B: *External Characteristics of Salmonids*

PROCEDURE:

1. Make an overhead transparency of STUDENT HANDOUT 4B: *External Characteristics of Salmonids* and use the TEACHER PAGE 4B as a guide. Have the students fill in the blanks with you as you facilitate a discussion about the external characteristics of salmonids. Challenge them to hypothesize why a salmon has developed into their design and the function of each of their external parts. Have students also define and explain the characteristics of the salmon like the fin structure, body shape, mucus covering, etc.

STUDENT HANDOUT 4B



EXTERNAL CHARACTERISTICS OF SALMONIDS

STUDENT HANDOUT 4B

FINS

DORSAL & ANAL

PECTORAL & PELVIC FINS

CAUDAL OR TAIL FINS

ADIPOSE FIN

BODY SHAPE

MUCOUS COVERING

STUDENT HANDOUT 4B

EYES

NOSTRILS

HEARING

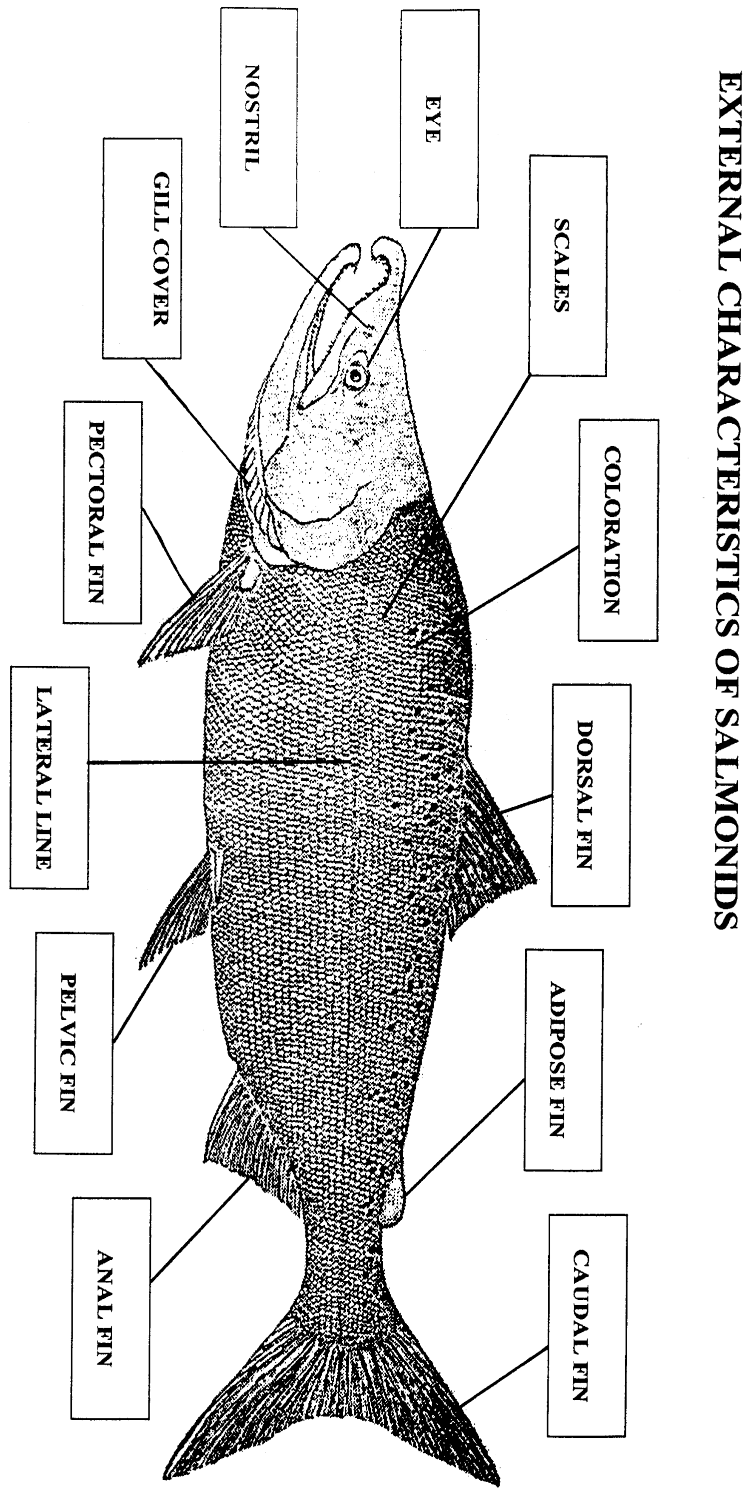
GILLS

COLORATION

LATERAL LINE

SCALES

Answers to STUDENT HANDOUT 4B



Answers to STUDENT HANDOUT 4B

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

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

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

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

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

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

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

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

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

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

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

Answers to STUDENT HANDOUT 4B

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

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

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

UNIT 4C. GOIN' FISHIN' – IDENTIFYING SALMON SPECIES

TIME	LEVEL
60 minutes	Introductory

BENCHMARKS	
Next Generation Science Standards	LS1.A
NGSS Science & Engineering Practices	-Developing & using models
Common Core State Standards–ELA/Literacy	CCRA.R.1.
Common Core State Standards–Writing	CCRA.W.7.
Common Core State Standards–Speaking & Listening	CCRA.SL.1.
OR Social Sciences Academic Content Standards	HS.63.

INTRODUCTION

Have you ever picked out the face of a friend in a crowd? We recognize someone by discovering the details, which make him or her different from others; pulling them into relief from the "faceless" masses. In Goin' Fishin', students learn the major anatomical parts of a salmon, how these parts vary from one species of salmon to another, and how to recognize a coho or sockeye from other salmon (similar to picking someone out of a crowd).

In this section, students develop the skills and understanding necessary to identify five of the salmon species found in the Columbia River watershed. This activity introduces salmonid external anatomy and species characteristics through a simulation in which the student is going fishing, but has a very specific license: there are stiff penalties for catching the wrong fish. During the activity, "Goin' Fishin'..," students get to know the salmonid species by studying their similarities and differences, then devising an identification key to sort them out.

Don't forget to use your Adopt-a-Stream-Foundation's Field Guide to the Pacific Salmon as an excellent reference in this unit. Keep it with you and refer to it first when you have questions.

OBJECTIVE:

Students will become familiar with the anatomy of salmonids and identify similarities and differences among the five salmonid species

MATERIALS:

- Reference materials about salmonid species provided in this Unit
- Adopt-A-Stream Foundation's Field Guide to the Pacific Salmon
- STUDENT HANDOUT 4C-1: Goin' Fishin
- (5) STUDENT HANDOUTS 4C-2: Fish and Fish Facts
- STUDENT HANDOUT 4C-3: Sample dichotomous key

KEY QUESTIONS

- What are the parts of a salmon? Do these parts change as salmon migrate? Will I be able to recognize a salmon in the stream?
- How are salmon anatomically distinct from other fish in Northwest streams? How many kinds of salmon are there? How do I tell them apart?

VOCABULARY: (Brief definitions of vocabulary terms are found in the Glossary.):

dichotomous key	anadromous
salmonids	life cycle
Coho	Sockeye
Chinook	Pink
Chum	Steelhead
Cutthroat	physiological adaptations

PROCEDURE:

1. Before you begin this activity, review the bibliography to select reference materials for your students. Organize the reference materials that you have available, and ask your students to review the reference materials about salmonid species. Have them note the differences between the species including timing of life cycles, habitat requirements and physical features. Consider assigning one species to each group of students, who will produce an annotated poster describing the anatomy of a representative of their species. You might even ask them to write a poem or story about their species, and then present this to the class.

2. Let's go fishing...

3. Say to your students, "You are going on a most excellent fishing trip, but there are things you have to do to get ready. You've got your pole, you've got your license, and you've got your snacks and drinks. However, you have to know what kind of fish you plan to catch. Your license is very specific-- if you take home the wrong kind of fish, you could be fined lots of money!"

"Unfortunately you left this part of your preparation until last and your friends are ready to go. You have ten minutes to devise a chart or tool you can use to identify the fish that you might catch. Make your tool an instrument of identification for all the possible fish you might run into. After all, if fishing is bad, you and your friends may go somewhere else."

HELPFUL HINTS

• You might want to include information about: age, color, size/weight, sex differences, and habitat, along with anything else you find helpful. Remember: too much information is just as bad as too little!

• You might ask your students to make their own fishing licenses. These licenses can have spaces for species identifications, rules and fines, and a title section. Organize the spaces for writing so that the licenses can be folded, like a brochure.

• Organize students into groups, then pass out the STUDENT HANDOUTS, and ask them to follow the directions therein.

• After your students have created their tool for identifying the fish (their key), break them into small groups. Provide each group with several pictures with STUDENT HANDOUTS 4C-2: Fish and 'Fish Facts' on the reverse. Have them take turns 'fishing' from the selection of pictures, and identifying the species that they have caught. (An alternative is to exchange tools and evaluate their ease of use in sorting and identifying pictures of salmon.)

4. Share the sample dichotomous key (STUDENT HANDOUT 4C-3) or a key from a published field guide with your students. Compare this sample key with their tools for identification. Do this in groups, or as a class discussion.

5. Identify which salmonids live in your river basin. Have students discuss the status of these fish populations. Are they listed as threatened or endangered? Students can do research through local media articles and agency publications to determine the status of salmonids in local watersheds.

EVALUATION

6. Set out "unknowns" (pictures of salmon that students haven't seen) for students to identify with their keys. You might bring in fresh fish, and have students use their keys to identify them. A good way to do this is to have groups exchange their keys, and then evaluate the facility with which they are able to use these tools to identify the fish.

Remind students that these are just examples of some individual adult fish and that there is great variation even within species. The descriptions below are contained in STUDENT HANDOUTS 4C-2, except that the student pages do not have names appended.

COHO:
Vital Statistics:
1. 27 inches, 11 lbs, gray mouth with white gums. Caught in shallow water.
2. 20 inches, 6 lbs, gray mouth with white gums. Caught in slower moving stream with small gravels.
3. 23 inches, 8 lbs, you've seen these fish (younger ones) in the same stream for over a year.

CHINOOK:
Vital Statistics:
1. 36 inches, 28 lbs, this is a husky looking fish. You caught this one in a very large stream.
2. 42 inches, 43 lbs, a monster!! You pull out a scale and count the rings... it is 7 years old!
3. 36 inches, 30 lbs, gray/black mouth. You caught this fish in a fast moving, deep stream.

SOCKEYE:
Vital Statistics:
1. 20 inches, 7 lbs, your fish is very red.
2. 18 inches, 5 lbs, you caught this fish very close to a lake.
3. 21 inches, 8 lbs, your fish has a dull green head and the body is turning a reddish color.

PINK:
Vital Statistics:
1. 18 inches, 5 lbs, you caught your fish down by the coast.
2. 15 inches, 4.5 lbs, your fish has a reddish cast to it.
3. 20 inches, 6 lbs, your fish was hanging out with some very odd-looking humpbacked fish.

CHUM:
Vital Statistics:
1. 24 inches, 7.5 lbs, you caught your fish where water was flowing pretty well and there was medium sized gravel in the stream.
2. 28 inches, 9 lbs, you caught your fish close to the ocean.
3. 30 inches, 10 lbs, your fish is greenish blue with white tips on its pelvic and anal fins.

NAME: ____________________

STUDENT HANDOUT 4C-1

Goin' Fishin'

LET'S GO FISHING...

You are going on a most excellent fishing trip, but there are things you have to do to get ready. You've got your pole; you've got your license; you've got your snacks and drinks. However, you have to know what kind of fish you plan to catch. Your license is very specific and if you take home the wrong kind of fish you could be fined lots of money!

Unfortunately you left this part of your preparation until last and your friends are ready to go. You have ten (10) minutes to devise a chart or tool you can use to identify the fish that you might catch. Make your chart or tool an instrument of identification for all the possible fish you might run into; after all, if fishing is bad, you and your friends will go somewhere else.

HELPFUL STUDENT HINTS: You might want to include information about: age, color, size/weight, sex differences, and habitat, along with anything else you find helpful.

After your have created your tool for identifying the fish, break up into small groups. Each group has several pictures of fish with "fish facts" on the reverse. Take turns 'fishing' from the selection of pictures, and identifying the species that you have caught.

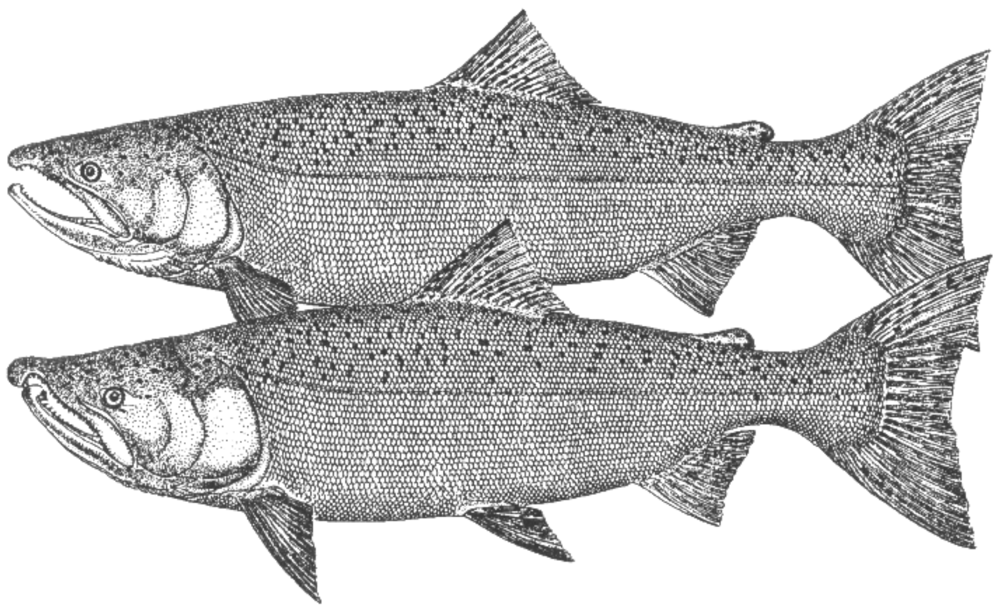
Finally, look at the sample dichotomous key that your teacher will make available. Compare the sample with your tools for identification.

STUDENT HANDOUT 4C-2 – FISH #1

Fish and Fish Facts

FISH #1:

Vital Statistics:
1. 27 inches, 11 lbs, gray mouth with white gums. Caught in shallow water.
2. 20 inches, 6 lbs, gray mouth with white gums. Caught in slower moving stream with small gravels.
3. 23 inches, 8 lbs, you've seen these fish (younger ones) in the same stream for over a year.



Artwork courtesy of NOAA

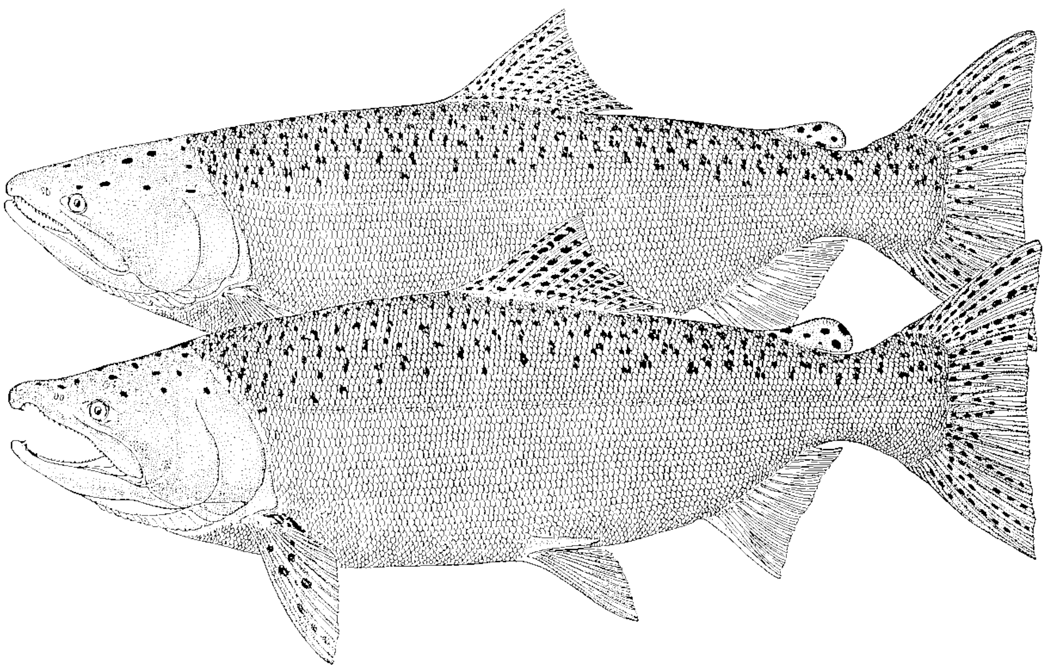
STUDENT HANDOUT 4C-2 – FISH #2

Fish and Fish Facts

FISH #2:

Vital Statistics:

1. 36 inches, 28 lbs, this is a husky looking fish. You caught this one in a very large stream.
2. 42 inches, 43 lbs, a monster!! You pull out a scale and count the rings... it is 7 years old!
3. 36 inches, 30 lbs, gray/black mouth. You caught this fish in a fast-moving, deep stream.



Artwork courtesy of NOAA

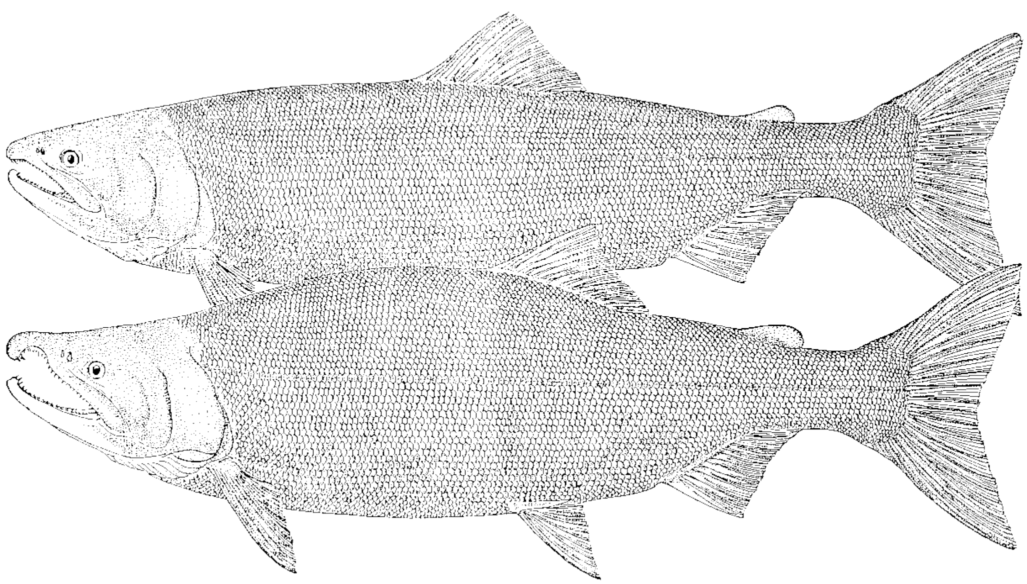
STUDENT HANDOUT 4C-2 – FISH #3

Fish and Fish Facts

FISH #3:

Vital Statistics:

1. 20 inches, 7 lbs, your fish is very red.
2. 18 inches, 5 lbs, you caught this fish very close to a lake.
3. 21 inches, 8 lbs, your fish has a dull green head and the body is turning a reddish color.



Artwork courtesy of NOAA

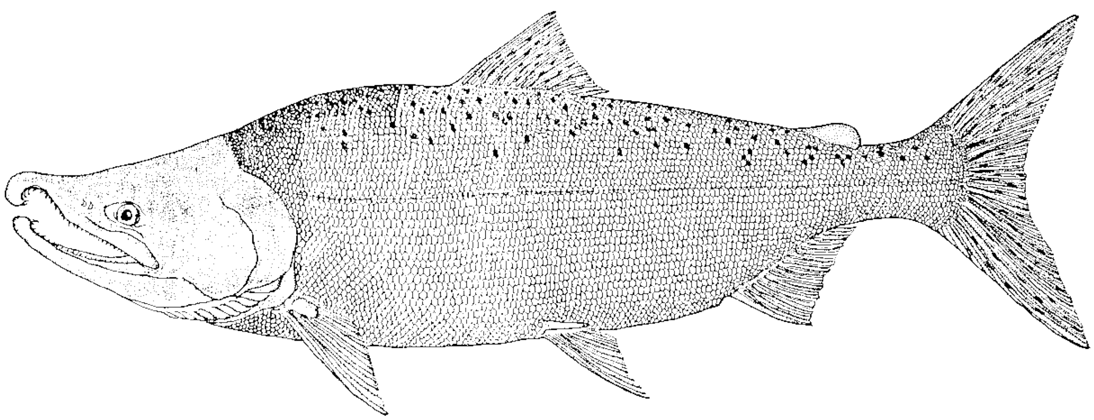
STUDENT HANDOUT 4C-2 – FISH #4

Fish and Fish Facts

FISH #4:

Vital Statistics:

1. 18 inches, 5 lbs, you caught your fish down by the coast.
2. 15 inches, 4.5 lbs, your fish has a reddish cast to it.
3. 20 inches, 6 lbs, your fish was hanging out with some very odd-looking humpbacked fish.



Artwork courtesy of NOAA

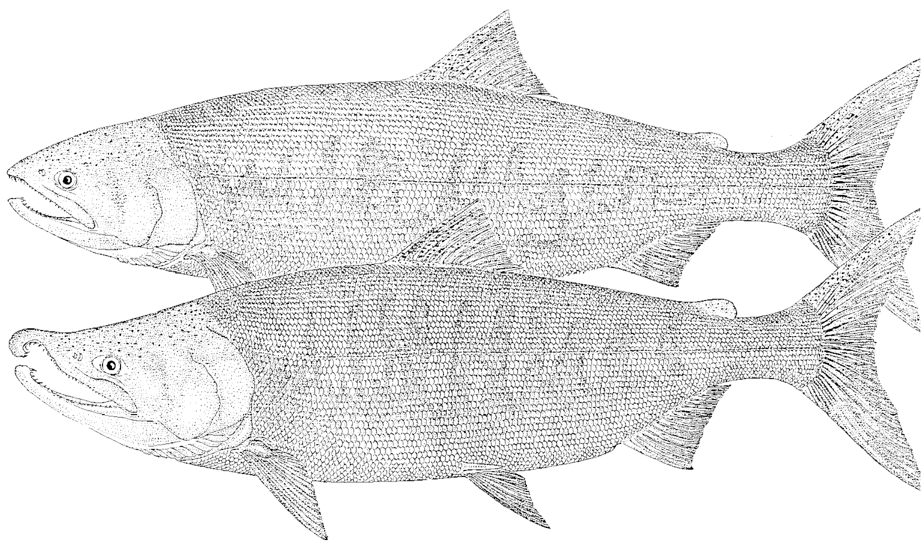
STUDENT HANDOUT 4C-2 – FISH #5

Fish and Fish Facts

FISH #5:

Vital Statistics:

1. 24 inches, 7.5 lbs, you caught your fish where water was flowing pretty well and there was medium sized gravel in the stream.
2. 28 inches, 9 lbs, you caught your fish close to the ocean.
3. 30 inches, 10 lbs, your fish is greenish blue with white tips on its pelvic and anal fins.



Artwork courtesy of NOAA

STUDENT HANDOUT 4C-3

Dichotomous Key for Five Salmon Species

1.
a. Dorsal, adipose and caudal fins spotted..Go to #2
b. Dorsal, adipose and caudal fins not spotted...Go to #3

2.
a. Caudal fin is speckled on the upper half only...**Coho**
b. Caudal, dorsal and adipose fins are heavily spotted...Go to #4

3.
a. Caudal fin is divided into distinct lobes; Pectoral, anal and pelvic fins have a dark band on the trailing edges..**Chum**
b. Caudal fin is lobed, but less distinctly; no dark band on the edges of the pectoral, anal and caudal fins..**Sockeye**

4.
a. Head has distinct spots; spots extend to the tip of the dorsal fin and are arranged in rows on dorsal and caudal fins..**Chinook**
b. Male has pronounced hump..**Pink**

Note: Male salmon have a hooked upper jaw and large, bony gill covers. Some are humpbacked.

UNIT 4D. SNIFFIN' SALMON: SALMONID LIFE CYCLES

TIME	LEVEL
60 minutes	Introductory

BENCHMARKS	
Next Generation Science Standards	LS1.B
NGSS Science & Engineering Practices	- Developing & using models - Planning & carrying out investigations
Common Core State Standards–Writing	CCRA.W.7
OR Social Sciences Academic Content Standards	HS.63

INTRODUCTION

Can you remember when you were born? How about your first birthday? What is your earliest memory? How old were you then? How do you appear now, compared with when you were two? Twelve? Twenty? We all change in appearance from the time when we were a single fertilized egg. What is the nature of these changes? Are humans the only organisms which experience this?

Have you ever been "turned around" in the city, then found your way? What markers did you use? Could you describe the process to someone else? Do salmon experience the same thing? How do they know when they're "home?" How many of us are living in the same place where we were born? Would your friends recognize you in your baby picture? Did our growth, development and travels dictate our needs, or visa versa?

This section uses the activity, Sniffin' Salmon to simulate a salmon's journey back to their home stream, using their keen sense of smell.

OBJECTIVES:

• Students will simulate and discuss the life cycle of salmon, identify habitat requirements of salmon during stages of its life cycle, and understand how a salmon finds its way back to its native stream.

MATERIALS:

- paper cups
- masking tape
- pencil
- paper towels
- cards with different salmon names on them
- several to many "smells" (cloves, garlic, vanilla, rum flavoring, peppermint, etc.)
- STUDENT HANDOUT 4D-1: Sniffin' Salmon!
- STUDENT HANDOUT 4D-2: Sniffin' Salmon Diagram
- FILM: *Life of the Sockeye Salmon* (Optional. See Supplementary Curriculum for source.)

KEY QUESTIONS:

- What are the 'stages' of a salmon's life?
- What happens during each stage of their lives? Where do they go?
- Which stages will I observe at my site?
- What are salmon's needs during the part of their life cycle that I will observe?
- How does a salmon know when it is home?

VOCABULARY (Brief definitions of vocabulary terms are found in the Glossary.):

egg	alevin
fry	smolt
life cycle	fingerling
home stream	adult
migrate	parr smoltification

PROCEDURE

This activity is adapted from *The Comings and Goings of Coho*, *Water Water Everywhere....*, Oregon State University Sea Grant College Program and Oregon Department of Education.

1. You will need to gather the materials first. (You might have the students bring in some of the "smells." It is best to use smells that they can't recognize by brand name, so that they really have to remember the smell and not the name of the smell.)

2. Make the Field Guide to the Pacific Salmon and other reference materials available to the class. If you show the Life of the Sockeye Salmon video, they can use it as a reference also. Ask for student volunteers to read the first two paragraphs of Part I: Sniffin' Salmon. Facilitate any ensuing discussion. Have the students read the third paragraph. They should ask clarifying questions after reading.

3. Students then construct their "home streams" using the materials provided and following the directions on the handout. Basically, they crumple a paper towel, sprinkle or pour a "smell" on it, and stuff it into a paper cup. They then invert another cup over that cup, and tape them together. Place the cups so that the paper towel is in the upper half. Write the name of the hypothetical stream on the bottom of the bottom cup. Try to avoid visual differences amongst cups so that students won't have visual clues as they attempt to find their "home stream." (See diagram on STUDENT HANDOUT 4D-2.)

4. Using the reference materials at your disposal, explain the life cycle stages of the salmon. A prepared transparency with one stage of the cycle on successive overlays would enhance the study. As you discuss each stage, list on the transparency what the salmon needs to survive that stage.

5. After constructing their "home stream," students memorize its smell. They then leave the room, simulating the passage of salmon to the ocean. While they are out of the room, you might have them work on something, attempt to travel through a set of hazards, or watch the film, *Life of the Sockeye Salmon*. The idea is that the salmon are away from their home stream for some time. (This might be an opportunity to play Hooks and Ladders see Project Wild Aquatic.)

6. In the meantime, you or a cohort carefully move each "home stream" to another place. As long as containers are similar, students may not have an easy time recalling their "home stream" from visual memory. When it is time for the students to return to their "home streams," call them into the classroom, and ask them to find their "home stream" using their sense of smell.

EVALUATION

7. After students are "home," encourage discussion of their experiences. An appropriate evaluation of this activity is a journal entry in which students describe their feelings upon returning to the classroom and searching for their home stream.

STUDENT HANDOUT 4D-1

(This activity was written by Marvin Pemberton and Lynn Wilson for Salmon Watch in 1993.)

Sniffin' Salmon!

WHAT THIS IS ALL ABOUT:

This is a story about a salmon.

The Salmon's name is ________________________. (Write in YOUR name)

After a long period at sea, salmon return to spawn in the stream in which they were hatched. Just how they find their "home stream" was a mystery to us for many years. Now that many scientists have conducted research in this area, it seems probable that anadromous fishes (fish that migrate from their home streams to the sea and return to their fresh water stream to spawn) use the smell of the water to find their home streams. Other research has shown that salmon may use solar clues (the sun) at sea, but when they enter rivers, the sense of smell takes over in guiding them home. This seems to make sense because the sun would not be a very practical "landmark" to a fish traveling up a winding stream. Smell would be much more reliable.

The most remarkable thing about this method of navigation is the fact that the fish can "remember" the smell of their home stream after such long periods in the ocean. It is also surprising that similar streams would differ much in smell.

WHAT WE'RE GOING TO DO:

In this activity, you will experience first-hand what it would be like to be a returning salmon attempting to identify a home stream by smell. The activity enables the entire class to participate in the salmon life cycle and the hazards of their journey. You will first select a home stream and try to memorize its smell, leave the room for a time to simulate going to the ocean to feed and grow, and then return and try to identify the stream by smell.

1. You will need the following materials:
   - Paper cups
   - Masking tape Pencil
   - Paper towels
   - Cards with different salmon names on them
   - Several "smells"

2. Construct your simulated "home stream" by crumpling up a paper towel, sprinkling or pouring a "smell" on it, and stuffing the towel into a paper cup. Invert another cup over this cup, and tape them together. The paper towel should be in the upper end. Write the name of your hypothetical or actual stream on the bottom of the cup. See the drawing on the next page to help orient yourself.

STUDENT HANDOUT 4D-1

3. Now, you are going to leave the room and do something else. This simulates the salmon smolt leaving its home and going to the ocean. When it is time, your teacher will tell you to return to the classroom.

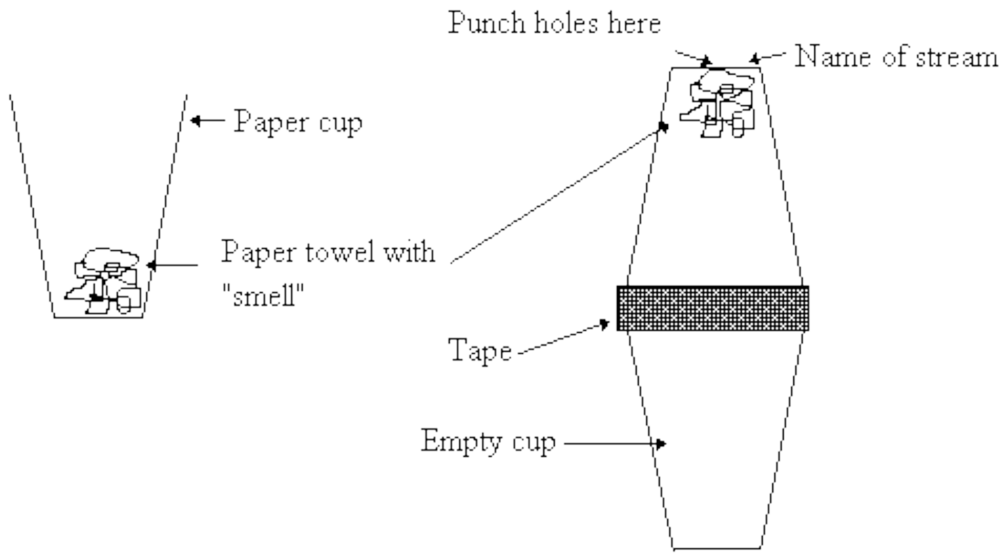
4. Using your sense of smell and memory of the smells of your "home stream," find your "home stream." Describe how you knew you were in the right place.

5. How did you feel when you finally found your "home stream?"

6. Open your journal and reflect on what you have learned today.

STUDENT HANDOUT 4D-2

Sniffin' Salmon Diagram



UNIT 4E. SALMON SUPPLEMENTAL INFORMATION

In the STUDENT HANDOUTS/TEACHER PAGES Section of this unit, we have provided you with a host of information from various sources to supplement not only this unit, but also the entire curriculum. Please read through this section and use the various articles, tables, charts and maps to enhance your teaching about salmon.

EXTENSION CURRICULUM

1. Have your students make “Salmon Cards,” which are “baseball cards” for salmonid species. Explain to your students that you are making cards for many fish, with special cards for salmon species. Use fish in an aquarium, in the classroom, a pet shop, or the zoo for the student models. If there are no living fish available, then use pictures. Like baseball cards, these Salmon Cards should have a drawing on one side and facts on the other. Facts used should be compiled from a list generated by the class and supplemented by you. When students get the idea, ask them to find out about the species of salmon, and make special cards for them.

   When students have made their cards, ask them to use them to identify pictures of fish or living fish. Consider having students exchange cards, use them for identification, and then evaluate their ease of use. Finally, ask your students to share their favorite card with the rest of the class. Then, after gathering facts about salmonid species ask them to use their cards to answer questions you ask and that they have made up. Finally, make a class poster with a place for each student’s favorite card.

   Explore salmon fry adaptations by looking at the physical appearance of salmonids at different stages in their life cycle. These stages can be compared across species as well. Ask students to identify how a salmon’s appearance helps it to survive in its changing habitat.

2. Have students write their own 'CLUE' game for the different species of salmon. Ask them to review the rules for the CLUE game, and play the game once to understand it. Then, in groups, they should design their own game based on salmonid species. When the games are completed, have pairs or groups exchange games and play them. As they play, they should evaluate the game they are playing. Evaluative criteria should cover the construction of the materials, clarity of directions, ease of play, and factual integrity of questions and protocols involving salmon.

3. Salmonids in the Classroom. Canadian Department of Fisheries and Oceans, B.C. Both the Primary and Intermediate editions of this curriculum contain similar activities; the Intermediate version contains more activities and vocabulary. Pages 298-312 cover salmonid anatomy and dissection and the functions of anatomical features. Activities suggested here are taken from the Intermediate edition. You can look up their counterparts in the Primary edition if they seem to be too difficult for your students. This curriculum is available from Lesson Aids Service, B.C. Teachers' Federation, 2235 Burrard Street, Vancouver, B.C., Canada, V6J 3H9, (800) 663-9163, FAX 737-9593.

4. Fashion a Fish, Project Wild Aquatic, pp. 56-60. This is an activity in which students learn about the evolutionary adaptations of fish, which help them to survive in their environments. Students design a particular fish whose adaptations are determined from "adaptation cards" which depict coloration, mouth type, body shape and reproductive adaptations. They fashion their fish from these adaptive characteristics, then report their fish to the class. You can then use these learning's about evolutionary adaptations to open a discussion of the anadromous life cycle of the salmon as a particular adaptation. (See the Bibliography for ordering address.)

5. Have students research various physical adaptations that salmon species exhibit throughout their life cycle which change their appearance or behavior such as: coloration, physiological adaptations, or mating behaviors. You can organize students into groups by species or adaptation. They should make posters, which communicate their assigned information, and provide written descriptions detailing the adaptation or behavior. The posters and written descriptions should be posted on the bulletin board so that students can refer to them during other Salmon Watch activities.

6. California's Salmon and Steelhead, Our Valuable Natural Heritage, pp. 18-36, contains a series of dissection and recitation activities on salmonid anatomy, finishing with a fish printing activity in which students make ink or paint prints from an actual salmon, and generate a life-sized drawing of a salmon from a smaller picture. (See the Bibliography for ordering address.)

7. Look up the World Wide Web address, http://www.streamnet.org/, for a very useful source of information about salmon. This is the StreamNet home page that contains an online database of information about salmon, the life history and ecology of species, color species of a male and female of each species listed, and extensive data on salmonids and their habitats. It might be used to organize Units 1-3 for your students.

8. Order the 25-minute film, Life of the Sockeye Salmon. Show the film, and then set out reference material on salmonid species. Introduce or review the names of all the species of Pacific Salmon (coho, sockeye, chinook, pink, chum, and the two sea-run trout: steelhead and cutthroat). Explain that their life cycles are similar to the sockeye, but differ in number of eggs deposited, length of time spent in the ocean, weight, length, and use (commercial, sport, subsistence). A detailed study of life cycle differences can be done using the Field Guide to the Pacific Salmon and other reference materials.

9. Use the film to compare the life cycle of the sockeye with other species of Pacific Salmon. The film explores the needs of the sockeye during each stage of its life cycle, the fishing industry, which is dependent on sustained fish runs, and the hazards, which may prevent salmon from living out their life cycles. It is available for rent from:

   Continuing Education Film Library 1633 SW Park Avenue
   PO Box 1383
   Portland, OR 97207
   (503) 229-4890
   (Refer to film no. 12240)

10. Salmon Life Cycle, Stream Scene, pp. 169-172. This section contains more information on the salmonid life cycle, which students can use in a class work or homework activity.

11. Hooks and Ladders, Project Wild Aquatic, pp. 43-48. This is a kinesthetic activity, which introduces the student to some of the hurdles fish must overcome during migration. Students play the roles of fish or obstacles to the migration of fish such as a dam or rapids.

12. California's Salmon and Steelhead, Our Valuable Natural Heritage, pp. 37-75, contains several interesting life cycle activities for students at all levels. Included are drawings, readings, art constructions, poetry, and mathematics vehicles for delivering information about salmonid life cycles.

UNIT 4E. SALMON SUPPLEMENTAL INFORMATION LIST

#	INFORMATION	PREPARED BY
4E-1	*A Changing Columbia Basin, 1770-Present*	Oregon State University
4E-2	*Causes of Salmon Mortality 1770 –Present*	Oregon State University
4E-3	*Table 1. WHERE ARE THE SALMON, WHEN?*	Pacific States Marine Fisheries Commission
4E-4	*Table 2. Salmonid Habitat Requirements*	Various Authors

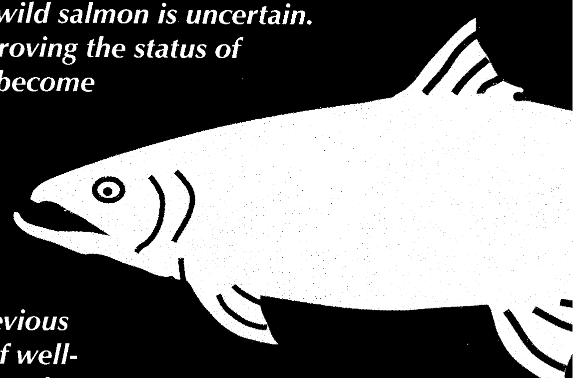
SALMON HANDOUT 4E-1

A Changing Columbia Basin, 1770-Present

Since the 1700s, when the human impact on salmon was limited to native fisheries, salmon have been increasingly affected by the Northwest's growing population and economy.

The first major European impact on the natives of the Columbia River occurred in the 1770s; by the mid-1800s, European diseases had reduced their population by 90% and the Columbia's resources were being exploited for the benefit of the European population. By the 1890s, dams were significantly affecting salmon runs; hydroelectric and flood-control projects eventually reduced the area available to salmon by half. Salmon of the Columbia are also affected by grazing, irrigation, logging, mining, overfishing, pollution, urbanization, ocean conditions, and predators.

As the Northwest's population and economy grow, the future of wild salmon is uncertain. Plans for improving the status of salmon have become increasingly common, but many projects simply undo the damage caused by previous generations of well-intentioned developers. A historical perspective is essential for understanding the current and future status of salmon and steelhead in the Columbia Basin.

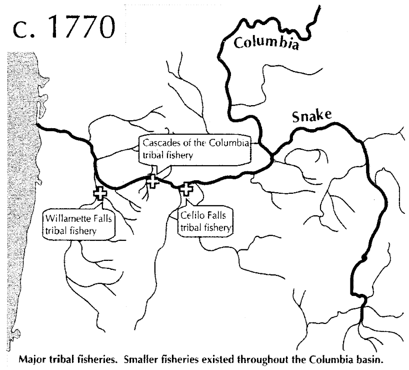


How has the Columbia changed from 1770 to the present? These maps and graphs illustrate how humans have altered the river and how these alterations have affected salmon survival.

SALMON HANDOUT 4E-1

A Changing Columbia Basin, 1770-Present

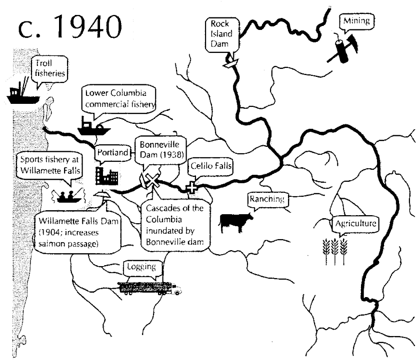
c. 1770



Major tribal fisheries. Smaller fisheries existed throughout the Columbia basin.

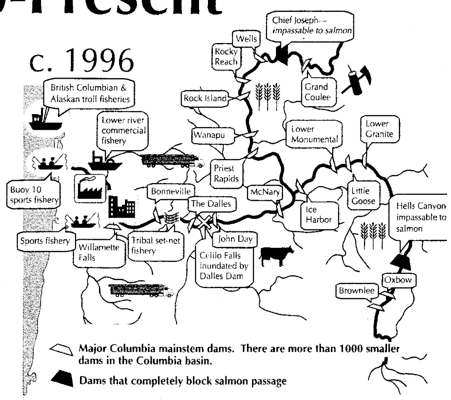
"We were but few, while the white men were many . . . we could not hold our own with them. We were like deer. They were like grizzly bears. . . . We were contented to let things remain as the Great Spirit Chief made them. They were not; and would change the rivers and mountains if they did not suit them." — Chief Joseph of the Nez Percé, c. 1879

c. 1940



"To build an industrial empire from the wasted power of the Columbia . . . They moved mountains and froze a land slide. . . . Bonneville and Grand Coulee are only the beginning. Ten million horsepower of new energy swiftly can be harnessed on America's mightiest stream. Tame the hazardous rapids. Open the Columbia waterway to navigation 500 miles inland. Provide endless water power . . . Reclaim another million acres of dry but fertile land." —BPA film "The Columbia," c. 1950

c. 1996

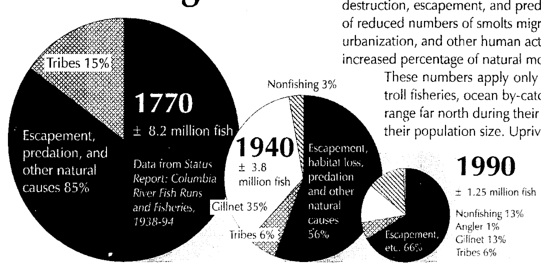


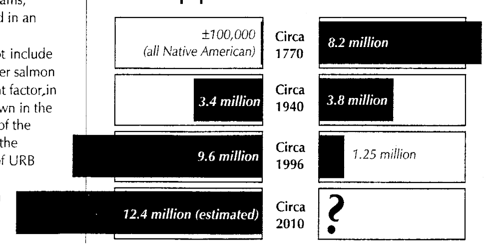
"Fish are to the northwest what wheat is to Kansas. Fish are this big integrator. They spawn 900 miles inland and they travel to the ocean all along the coast. They bind this region together." —Ed Chaney (Idaho fishery consultant). "Salmon are part of the heart and soul of the Pacific Northwest. They have defined its history, and its culture, and hopefully its future." —Will Stelle Jr. (National Marine Fisheries Service)

Diminishing Returns

These pies show the relative size of returning salmon runs from 1770 to the present. They compare in-river harvest, dam-induced mortality, and other losses caused by habitat destruction, escapement, and predation. In addition to adult mortality, run decline is a result of reduced numbers of smolts migrating to the ocean (due to habitat destruction, dams, urbanization, and other human activities). Fishing reductions in 1990 have resulted in an increased percentage of natural mortality.

These numbers apply only to returning Columbia River salmon and do not include troll fisheries, ocean by-catch, El Niño or other factors. Since Columbia River salmon range far north during their life in the ocean, ocean mortality is an important factor in their population size. Upriver bright fall Chinook salmon (URBs), which spawn in the Hanford Reach—the last undammed stretch of the Columbia—are a good example. In 1985-94 the Canadian fishery was responsible for 48.9% of URB fishing mortality, while Alaskan trollers accounted for 29.8%. (*Source*: Pacific Salmon Commission Joint Chinook Technical Committee 1994 Annual Report).





SALMON HANDOUT 4E-2

Causes of Salmon Mortality 1770 – Present

Mortality Circa 1770:

Natural mortality of salmon was due to factors like natural death after spawning; predators, including mammals, birds and other fish; and naturally occurring population fluctuations caused by ocean and river conditions. Tribal fisheries were the only human impacts at this time.

Mortality Circa 1940:

The ratio of natural mortality declines was due to human activity such as commercial fishing, trapping of beaver which reduced rearing habitat in beaver ponds; overgrazing resulted in damage to streamside vegetation; river corridors and estuaries were affected by urbanization; the use of splash dams for logging destroyed stream beds; hydroelectric facilities and irrigation dams on tributaries blocked access to spawning areas; water drawn for irrigation, industry, cities, and towns reduced river flow; and water quality was degraded by a wide variety of causes.

Mortality Circa 1996:

Mortality in the ocean increased with El Nino conditions and ocean trolling in Alaska and British Columbia. The Chief Joseph and Hells Canyon dams blocked passage to large areas of habitat. Other large dams caused 5% or more mortality (per dam) for smolts descending to the sea and adult salmon returning to spawn. Dams also changed water temperatures, reduced flow of rivers, increased nitrogen levels, and allowed more predation by Northern Pike Minnow and other predators. The destruction and filling of wetlands and estuaries reduced habitat. Forest harvest operations may have resulted in increased silt, reduced shade, and disturbed spawning beds. Urbanization, i.e. the spread of cities, roads, and other development, reduced habitat and increased pollution. Over withdrawal of water for irrigation for agriculture frequently reduced flow of rivers. Unscreened water diversions trapped fish in ditches (in 1990, less than 5% of the diversions in Oregon were screened).

Hatchery fish often increased disease rates and reduced diversity of wild stocks. Improper grazing of livestock harmed inland spawning habitat by destroying vegetation and polluting streams. Physical or natural disasters, such as landslides and floods, also influenced salmon mortality rates.
Out of approximately 1000 original wild native anadromous stocks found in Oregon, Washington, and California, 106 are now extinct and 314 are at risk of extinction. Currently, hatcheries produce two-thirds of the salmon found in the Columbia River.

SALMON HANDOUT 4E-2

Attempts to improve salmon survival include:

Improved fish passage facilities at dams; streamside or riparian buffers in logged areas (specific requirements spelled out in the Oregon Forestry Practices Act); barging or trucking of salmon smolts past dams; habitat enhancement; a Northern Pike Minnow bounty to reduce predation; regulation of commercial and recreational catches; additional spill from reservoirs to increase flow speed during smolt out-migration and to promote more natural riverbeds; improved hatchery practices; and adoption of fish friendly road construction and culvert standards.

(Adapted from: Gilden, Jennifer, Smith, Courtland, Department of Anthropology, Oregon State University. Research funded by Sea Grant Oregon through NOAA. Sea Grant Oregon, Oregon State University 1998.)

SALMON HANDOUT 4E-3

Table 1. WHERE ARE THE SALMON, WHEN?

Generalized Life History Patterns of Salmon, Steelhead, and Trout in the Pacific Northwest

	ADULTS RETURN TO STREAMS FROM OCEAN	SPAWNING LOCATION	EGGS IN GRAVEL	YOUNG IN STREAM	FRESH WATER HABITAT	YOUNG MIGRATE DOWNSTREAM	TIME IN ESTUARY	TIME IN OCEAN	ADULT WEIGHT (average) English(Metric)
COHO	Sept. –Jan	coastal streams shallow tributaries	Sept -May	1+ years	tributaries, main stem side channels, and slack water	Mar-Jul (2nd year)	few days to one month	2 years	5-20 lb (8)
CHUM	Sept. –Jan	coastal rivers and streams, lower reaches	Sept-Mar	days-weeks	little time spent in freshwater	shortly after young leave gravel	7-14 days	2.5-3 years	8-12 lb. (10)
CHINOOK **Spring run** **Summer run** **Fall run**	Jan. – July Jun-mid Aug Aug. – Nov.	main stem- large and small rivers	Jul-Jan Sept-Nov Sept-Mar	1+ years 1+ years 3-7 months	main stem- large and small rivers	Dec – Mar. (2nd year) Spring (2nd year) Dec. - Mar (2nd year)	days-months	2-5 years	10-20 lb. (15) 10-30 lb. (14) 15-40 lb.
CUTTHROAT (Coastal-Sea Run)	Jul-Dec	tiny tributaries of coastal streams	Dec-Jul	1-3 years (2 avg)	tributaries	Mar-Jun (of 2nd-4th yr)	days-months	0.5-1year	0.5-4 lb (1)
PINK	Jul-Oct	main stem of streams, tributaries, and lower reaches	Aug.-Jan	days-weeks	little time spent in freshwater	Dec-May	few days	1.5 years	3-10 lb (4)
SOCKEYE	Jul-Aug	streams, usually near lakes	Aug. –Apr	1-3 years	lakes	Apr-Jun (of 2nd-4th yr)	few days	1-4 years	3-8 lb (6)
STEELHEAD **Winter run** **Summer run**	Oct-Jun Jun-Oct (Columbia) Apr-Nov (Coastal)	tributaries and small and mid-size streams and rivers	Feb-Jul Dec-May Feb-Jun Feb-Jul	1-3 years 1-2 years 1-2 years 1-3 years	tributaries	Mar-Jun (of 2nd – 5th yr) Spring & Summer (of 3rd- 4th yr) Mar-Jun (of 3rd- 5th yr) Mar-Jun (of 2nd- 5th yr)	less than a month	1-4 years	5-28 lb (8) 5-20 lb 5-30 lb (8)

Adapted by Pacific State Marine Fisheries commission. Sources: Ocean Ecology of North Pacific Salmonids, Bill Pearcy, University of Washington Press, 1992 Fisheries Handbook of Engineering Requirements and Biological Criteria, Milo Bell, U.S. Army corps of Engineers, 1986; Adopting A Stream, A Northwest Handbook, Steve Yates, Adopt-A Stream Foundation, 1988.

SALMON HANDOUT 4E-4

Table 2. Salmonid Habitat Requirements
Oregon Coastal Streams
Spawning (including upstream migration)

	Migration	Spawn Time	Location	Substrate Size	Water Depth	Water Velocity	Dissolved Oxygen	Spawning Water Temp	Percent Fines Tolerable	Notes
Chinook – Fall	Sept-Dec	Oct- Jan	Mainstem and large tributaries	Pea to Orange (1.3-10.2 cm)	Extremely variable 0.05-7 m	0.1 – 1.5m/s; max is 2.4 m/s	> 5 mg/l	5.6-13.9°C	Fines (<6.4 mm) make up less than 25% of substrate	Large body size limits movement over barriers
Chinook-Spring	Mar-Jun	Late Aug -Oct	Upper mainstem streams	Pea to Orange (1.3-10.2 cm)	Extremely variable 0.05-7m	.21-1.5 m/s; max is 2.4m/s	>5 mg/l	5.6 – 13.9°C	Fines (<6.4 mm) make up less than 25% of substrate	Require deep water for travel-pools for summer habitat
Coho	Sept-Jan	Sept - Jan	Small tributaries	Pea to Apple (1.3-9.0 cm)	0.18 – 1 m	0.08 – 0.11 m/sec; max is 2.4 m/s	>8 mg/l	4.4-14°C	Fines (<6.4 mm) make up less than 25% of substrate	Primary target for many sport fisherman
Chum	Oct -Dec	Nov-Dec	Lower mainstem and tributaries	Pea to Orange (0.5-10.2 cm)	13-50 cm; ideal 21cm	0.21-0.83 m/s; max is 2.4 m/s	>5 mg/l; above 80% saturation best	7.2-12.8°C	Fines (<6.4 mm) make up less than 25% of substrate	Strong swimmer but doesn't jump
Steelhead-Winter	Nov-May	Dec -May	Small & mid-size tributaries with moderate gradient	Pea to Apple (0.5-9.0 cm)	> 18 cm	<2.4 m/s	>5 mg/l	3.9-9.4°C	Fines (<6.4 mm) make up less than 25% of substrate	May spawn more than once
Steelhead-Summer	May-Jul	Jan-Jun	Small & mid-size tributaries with moderate gradient	Pea to Apple (0.5-9.0 cm)	>18 cm	<2.4 m/s	>5 mg/l	3.9-9.4°C	Fines (<6.4 mm) make up less than 25% of substrate	May spawn more than once
Sea Run Cutthroat Trout	Jun-Oct	Dec-Feb	Small headwater tributaries 1st & 2nd order streams	Pea to Golf Ball (0.5-7.5 cm)	0.01 –1 m; 10-15 cm best	0.11-0.90 m/s; max is 2.4m/s	>5 mg/l	6-17°C; best is 10°C	Fines (<6.4 mm) make up less than 25% of substrate	May spawn more than once

SALMON HANDOUT 4E-4

Salmonid Habitat Requirements
Oregon Coastal Streams

	Incubation		Rearing						Status
	Incubation Temp.	**Fry Emerge**	**Fry Habitat**	**Juvenile Habitat**	**Preferred Temp.**	**Freshwater Residency Period**	**Estuary Residency Period**	**Notes**	**2004 Status**
Chinook – Fall	0.0-20°C; best 5.0-14.4° C	Mar-May	Stream; river edges	Deeper water in main river channel	7.3-14.6° C Growth stops at 20.3° C lethal at 25.2° C	Days to 2 or 3 months Fall smolt	Extensive 5-6 months April-Oct.	Estuaries play a vital role in survival of young	Healthy and stable
Chinook-Spring	0.0-20°C; best 5.0-14.4° C	Feb-Mar	Stream; river edges	Deeper water in main river channel	7.3-14.6° C Growth stops at 20.3° C lethal at 25.2° C	Days to 2 or 3 months Fall smolt	Extensive 5-6 months April – Oct	Large body size limits movement over barriers	Depressed
Coho	4.4-13.3° C	Feb-June	Backwater pools and stream edges	Pools in summer, off channel alcoves, ponds, dam pools with complex cover in winter	11.8 – 14.6° C Growth stops at 20.3° C Lethal at 25.8° C	One year Spring smolt	Move through 2-9 days, sometimes longer	Low pH (<5.01) can be lethal to alevins	Depressed
Chum	4.4 – 13.3°C	Late Mar-Apr	Move directly into estuary	High sediment levels (15.8-54.9 g/l) will kill juveniles	6.7 – 14.6°C Growth stops at 20.3°C lethal at 25.8°C	Hours to few days, leave quickly Spring smolt	2-32 days	Use estuaries immediately for food and adjustment	Depressed
Steelhead Winter	4.4- 13.3° C	May – June	Stream edges	Pools, riffles, and runs of tributary, streams, complex habitat with, large woody debris, (LWD) preferred	7.3-14.6°C Growth stops at 20.3° C Lethal at 24.1° C	2-3 years Spring smolt	Move through in days	Good habitat =small and large wood complexity	Depressed
Steelhead-Summer	4.4 – 13.3°C	May-June	Stream edges	Pools, riffles, and runs of tributary, streams, complex habitat with, large woody debris, (LWD) preferred	7.3 – 14.6°C Growth stops at 20.3° C lethal at 24.1°C	2-3 years Spring smolt	Move through in days	Summer steelhead require deep cool pools to live in before spawning	Primarily hatchery fish
Sea Run Cutthroat Trout	6.1 – 17.2°C	Mar-May	Stream edges and backwater pools, large wood, (LWD) important	Prefer pools but are often displaced by coho or steelhead, low velocity pools, and side channels	9.5-12.9°C Growth stops at 20.3°C lethal at 23.0°C	2-4 Years Spring smolt	Used extensively as adults before upstream migration	Rearing in estuary is common	Depressed

1. Emmett, R.L., S.L. Stone, S.A. Hinton, and M.C. Monaco. 1991. *Distribution and abundance of fishes and invertebrates in West Coast estuaries*, Volume 11: *Species life history summaries*. ELMR Rep. No. 8
2. Groot, C. and L. Margolis, 1991. *Pacific Salmon Life Histories*. University of British Columbia Press, Vancouver, British Columbia
3. Nickelson, T., J. Nicholas, A. McGie, R. Lindsay, D. Bottom, R. Kaiser, and S. Jacobs. 1992. *Status of Anadromous Salmonids in Oregon coastal Basins*. Oregon Dept. of Fish and Wildlife. Corvallis, OR
4. Reiser, D.W. and T.C. Bjornn, 1979 Habitat Requirements of Anadromous Salmonids. In W.R. Meehan (editor), *Influence of forest and rangeland management on anadromous fish habitat in western North America*, US Forest Service General Technical Report PNW-96 Pacific Northwest Forest Range Experiment Station, Portland, OR.