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?

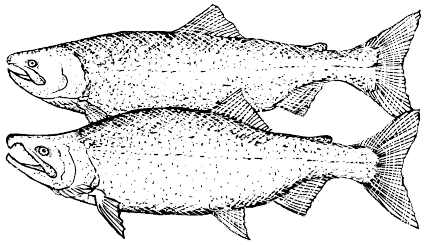
STUDENT HANDOUT 4A-1
The Journey of Pacific Wild Salmon

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.

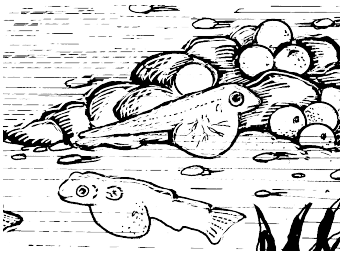
The salmon have evolved with incredibly strong instinctive patterns. Born in freshwater streams, anadromous or sea-run species like salmon are uniquely compelled to travel to the ocean. The vast ocean food chain supports a growth rate that freshwater members of the same species could never hope to achieve. 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

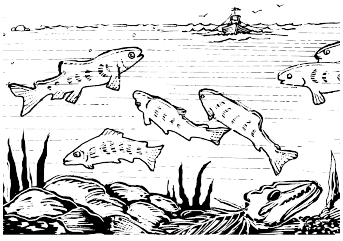
Salmon begin their lives in shallow gravel beds within the substrate of the freshwater streams and rivers in which their parents were born. The fertile, reddish-orange eggs develop in the safety of the gravel. Cold, clean sediment-free water must wash the eggs and bring them oxygen. Eggs lie in the gravel 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.

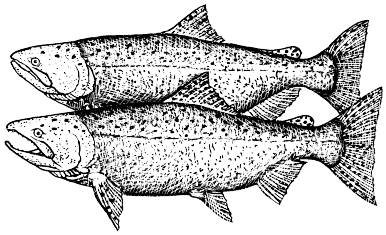
10. CARCASS STAGE

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.

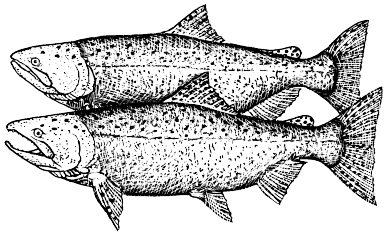
10.
a.

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