UNIT #1: Salmon Life Cycle & Food Webs

About Salmon

Salmon are **anadromous**—they spend part of their life in fresh water and part in saltwater.

Brief Life Cycle Summary:

A few months after salmon eggs are deposited in the gravel of freshwater streams, they hatch into alevins—tiny fish with yolk sacs still attached. They stay in the gravel nest, or redd, until the yolk sac is consumed and the fry have reached 1.5 to 2 inches in size. Some salmon (including Kennedy Creek chum salmon) immediately leave and migrate downstream to the estuary and the ocean. Other salmon (like coho) stay in the

Background Information

LIFE CYCLES

Pacific salmon move through several distinct stages in their lives, as all living things do. Each generation begins a new generation and another set of life stages. We refer to this process as a life cycle. In salmon, each stage of the life cycle takes place in a specific habitat, and has specific needs.

The stages in the life of Pacific salmon area as follows:

Eggs:

In late fall, adult salmon deposit thousands of eggs in a redd, a gravel depression in a flowing stream or on a lake shoreline, and cover the eggs with more gravel. The eggs, always sensitive to temperature, are particularly sensitive to movement at this stage, and need to remain undisturbed in the gravel. As cold, clean water containing oxygen flows through the gravel, an embryo develops the fertilized egg, and after about one month eyes become visible. The embryo gets the food it needs from the yolk of the egg, and oxygen from the water. Disturbances such as changing water temperature, speed of water flow and polluted water or silt deposited on the stream or lake bed can destroy the eggs. In early spring, the surviving embryos break through the membrane of the egg and hatch. They can move through the gravel, but they still face many threats: silt can still smother them, changes in water temperature or speed of water flow can be harmful, and predators catch many.

Alevin:

Alevin are mobile embryos. The yolk sac is still attached and provides food for the alevin for two to three months as they continue to develop hidden in the gravel. Alevin extract oxygen from the flowing water by using their gills.

Fry:

Once the yolk sac has been fully absorbed, the alevin leave the gravel as fry to search for food. They emerge from the stream or lake bed, usually in late spring, and swim to the surface. At the surface, they swallow air to inflate an internal swim bladder, which overcomes their natural body weight and achieves neutral buoyancy, allowing them to move easily up or down in the water. Salmon fry generally swim in a small territory and feed on whatever aquatic organisms drift through it. For protective coloring, they develop dark bars on their skin known as parr marks, which disappear in the next stage of their lives. They spend from a few months to a few years in their natal stream or lake, depending on species. At this stage, they learn to recognize their natal environment, primarily by characteristic smells created in the water by rocks, plant life, and other aquatic organisms.

Smolt:

After their time in a stream or lake, salmon migrate downstream. When they reach the estuary where the river meets the ocean, they spend some time there as smolt adapting to salt water. Smolt gradually develop the ability to swallow salt water and expel the salt in their urine and through their gills. The scales that develop when they were fry turn to a silvery color. Estuary life is rich with abundant food, so smolt can grow rapidly, but estuaries are also home to many predators, such as birds, larger fish, and also to human development.

Adults:

Salmon migrate into the ocean, where they grow to adulthood with silvery bellies and darker backs. Each species migrates to a particular part of the Pacific Coast from California to Alaska, sometimes ranging thousands of miles. They eat smaller ocean fish, krill (tiny crustaceans), and grow to their mature weight. Predators include large fish, fish-eating birds, marine mammals, and human fishers. After a time, varying from one to eight years, they return and congregate at the mouth of their river of origin. Salmon seem to use a variety of visual and magnetic clues to navigate the ocean, then rely mainly on their sense of smell to identify their natal stream or lake.

Spawners:

When they enter their river of origin in the fall and begin to travel upstream, salmon stop eating and their bodies begin to change. Using stored energy, they travel 20-30 miles upstream per day, often past waterfalls, and fallen obstacles. On the way, they become food for eagles, bears, wolves, and people. When they reach the area where they lived as fry, the female digs a redd with her tail and fins. She deposits her eggs and a male releases his milt to fertilize them. The female then covers the eggs with fresh gravel. While a single coho salmon produces about three thousand eggs, other species can produce as many as seven thousand. Both male and female die within a few days of laying and fertilizing the eggs. Their carcasses contribute essential nutrients that fertilize the rearing area for the next generation of fry.

From: Salmonids in the Classroom Primary, Fisheries and Oceans Canada

Background Information

SPAWNERS

In the final stage of a salmon’s life cycle, they reenter their natal river and swim back to the stream or lakeshore in which they grew as fry. Salmon may travel hundreds or thousands of kilometers (or miles), swimming 30 to 50 km (20-30 miles) a day against the current to get to the stream where they were born. They follow the scent of the water from their natal stream past obstacles, such as rapids, dams, rock slides, log jams, and even very low sections of river beds before reaching their destination. Fishers and predators, such as bears, otters, and eagles catch many salmon on their trip upstream.

When they enter fresh water, salmon stop eating and live only on stored body fat. Their kidneys and gills change to regulate the water and salt balance in their cells. They start to break down from lack of nutrition. They lose their slime coating, their skin becomes thick, and they start to resorb their scales.

The salmon’s appearance changes dramatically, with males and females developing distinct differences (sexual dimorphism). They lose their silvery color and take on deep red, green, purple, brown, or gray colors depending on the species. The tissue around the teeth recedes, exposing more teeth, and they develop a hooked jaw. Their body shape can change, with some species developing a pronounced hump on their back. Eggs ripen in the ovaries of females, while sperm in the male changes into liquid milt.

When they reach their natal stream or lake, the female finds a spot with the right gravel size and water conditions. With strong sweeps of her tail and fins, she rearranges the stones in the gravel bed to form a redd, the nest-like depression in the stream or lake bed where she will lay her eggs. Males fight among themselves to get close to a female. The female deposits some of her eggs in the redd, ad the male deposits his milt to fertilize them. Some species deposit up to 6,000 eggs, but the average is about 3,000 in chum and coho salmon. The female covers the eggs with gravel to protect them.

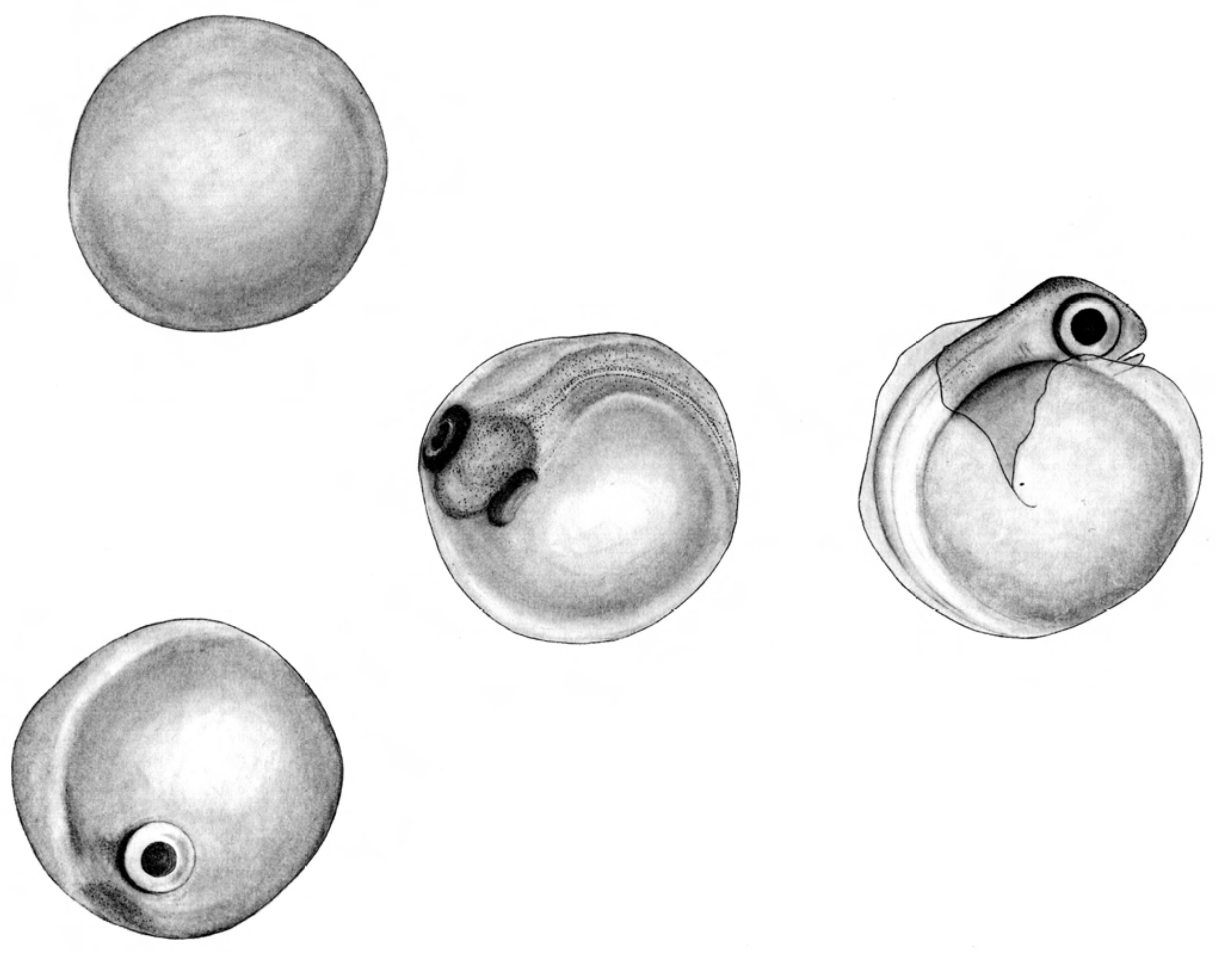
Both males and females will stay near their redd to protect the eggs from other fish trying to spawn on top of their redd and from predators trying to eat their eggs. They will both eventually die near their redd. Their bodies, battered and injured by the difficult trip upstream, decompose. Valuable nutrients from the carcasses form a rich food source for other fish and wildlife by fertilizing the forest and bushes. If most of the adult salmon are caught, the water will have few nutrients for the next generation of salmon and for the rest of the ecosystem.

Background information

THE EGG

When adult salmon return upstream to spawn, each female lays from 2,000 to 2,500 spherical, pinky-orange eggs, which are about 6 to 9 mm in diameter. Instead of a hard shell like a chicken, each egg has a soft, transparent membrane for its outside surface. This surface offers little protection against predators or other disturbances, so the female covers the eggs with gravel in a rocky stream- or lakebed nest called a redd.

The redd is a shallow depression in the gravel, about one to three metres long and one to two metres wide. The female chooses a site in a stream with a high flow of fresh water or near a lakeshore where waves keep the water fresh. Salmon prefer gravel with stones averaging 12 to 15 cm and a water depth of 15 to 30 cm.



Salmon eggs are very sensitive - only one in 10 survives to hatch. In the first days, even a slight disturbance of the stream- or lakebed can be fatal. Changes in water level or temperature can kill the eggs. Predators such as birds, bears and racoons feed on the eggs if they can find them, and flooding, pollution and disease also destroy eggs.

The salmon embryo begins to develop inside the egg, growing cells and gradually forming distinct organs. Because they are cold-blooded, the rate at which fish develop depends on the outside temperature. The ideal temperature for salmon eggs is from 5-10˚C. Eggs develop more slowly at lower temperatures. In average temperatures, the embryonic development takes place at the following rate:

- After 7 to 10 days.......head and body begin to form
- After about 1 month....eyes begin to appear
- After about 2 months....embryo begins to move inside the egg
- After about 3 months..embryo hatches from the shell

Inside the egg, the developing embryo feeds from its yolk sac and obtains oxygen through the egg membrane, through which the oxygen passes from the running water flowing through the gravel of the stream or lakebed. The eggs can smother if the gravel is covered with silt, or if the water flows too slowly and stagnates.

As development progresses, the embryo begins to move and wiggle around. Scientists believe that, when the embryo can no longer get enough oxygen through the egg wall, it releases an enzyme that weakens the membrane. The embryo then breaks through the membrane and wiggles out. It lives the next stage of its life in the gravel as an alevin.

From: Salmonids in the Classroom Primary, Fisheries and Oceans Canada

SALMON EGGS

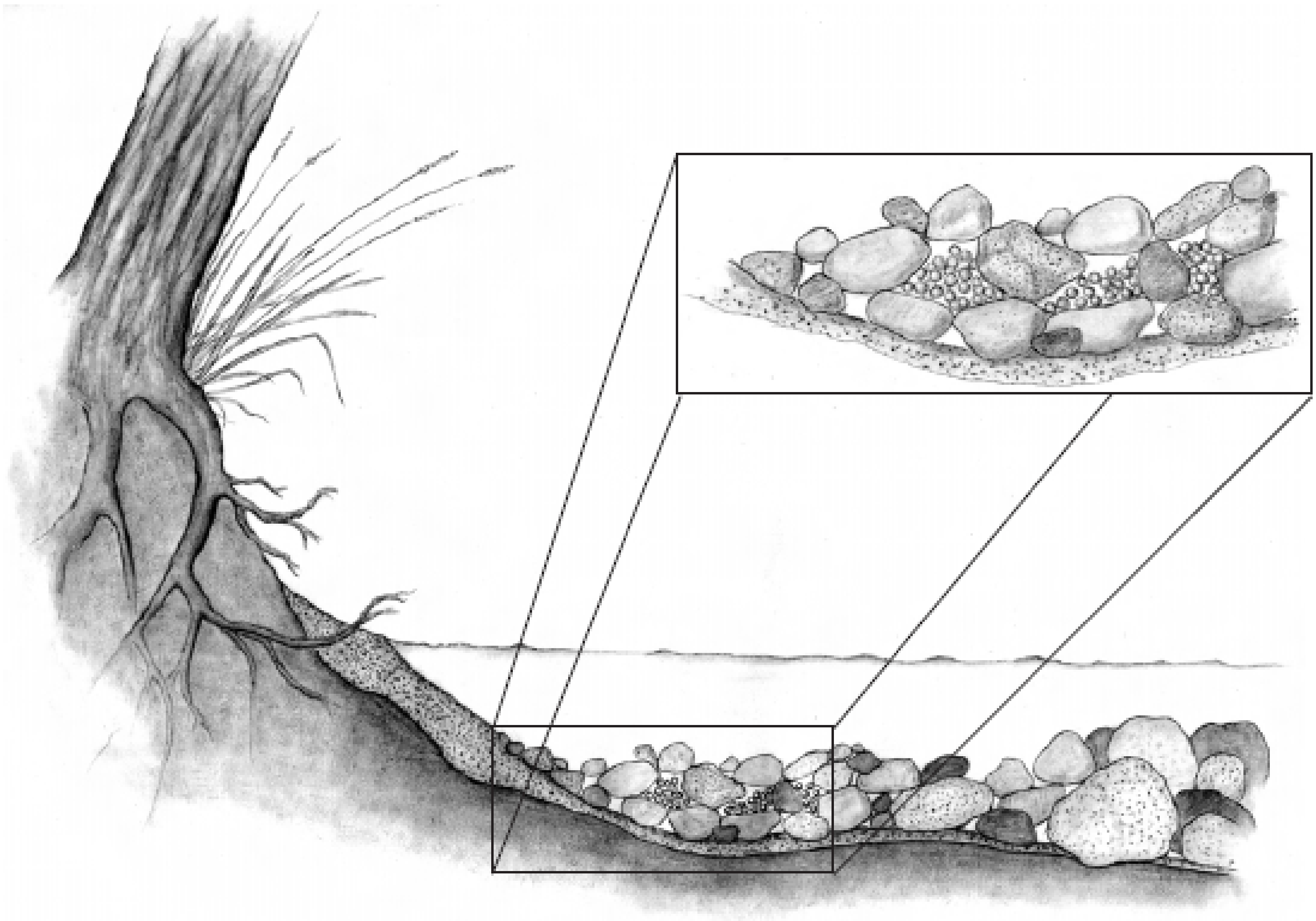


Illustration: Karen Uldall-Ekman

Salmon lay eggs in a stream or lake. They lay their eggs in a nest made of small, rounded rocks called gravel. The nest is called a redd. The salmon cover their eggs with gravel to keep them safe.

Salmon eggs are like small orange balls. They have a soft shell. Inside is a yolk and egg white.

Salmon eggs need cold water to live. If the water is too cold or too hot, the eggs will die.

A salmon begins to grow inside the egg. The yolk gives it food. The salmon gets air through the egg wall from the stream or lake water. If the water stops running, the growing salmon inside the egg will die. Dirt in the water can bury the egg and smother the salmon that is growing inside.

Salmon grow eyes, tails and other parts inside the egg. You can see a salmon's dark eye through the egg wall. After spending the winter in the water, salmon hatch from the eggs.

Background information

THE ALEVIN

The salmon embryo inside an egg hatches out to become an alevin (the A is pronounced AY as in play or AH as in cat). Wiggling energetically, the embryo breaks through the egg membrane. For the next month or two, it hides in the dark spaces in the gravel of its home stream or lake.

The yolk sac from the embryo remains attached to the alevin's belly and provides the food it needs. The sac shrinks as the alevin develops teeth, eyes and a digestive system. The alevin begins to eat some external food that floats through the water in the gravel. The alevin's respiration system also develops, allowing it to breathe through its gills.

Alevin cannot swim and their yolk sac makes movement slow, so they are an easy target for predators. To hide from predators, they avoid light and live as much as 30 cm down in the gravel. As they grow stronger and their yolk sac shrinks, the lose their bright orange colour and begin to develop a fish shape.

Alevin need cold running water that is rich in oxygen and clean gravel that has spaces where the alevin can hide. Threats include predators in the water, siltation, pollution and floods or other activities that can disturb the gravel. Human activity that disturbs the gravel can be very harmful, so people can protect the alevin by keeping dirt or other pollutants out of the water and by staying out of the gravel.

When the yolk sac is completely absorbed, or "buttoned up", the alevin grow to about 2.5 cm. Then they must emerge from the gravel and begin to search for food (at this stage they are known as fry). The alevin emerge in spring, when the water begins to warm and when algae and plankton grow in the lakes and rivers.

From: Salmonids in the Classroom Primary, Fisheries and Oceans Canada

SALMON ALEVINS

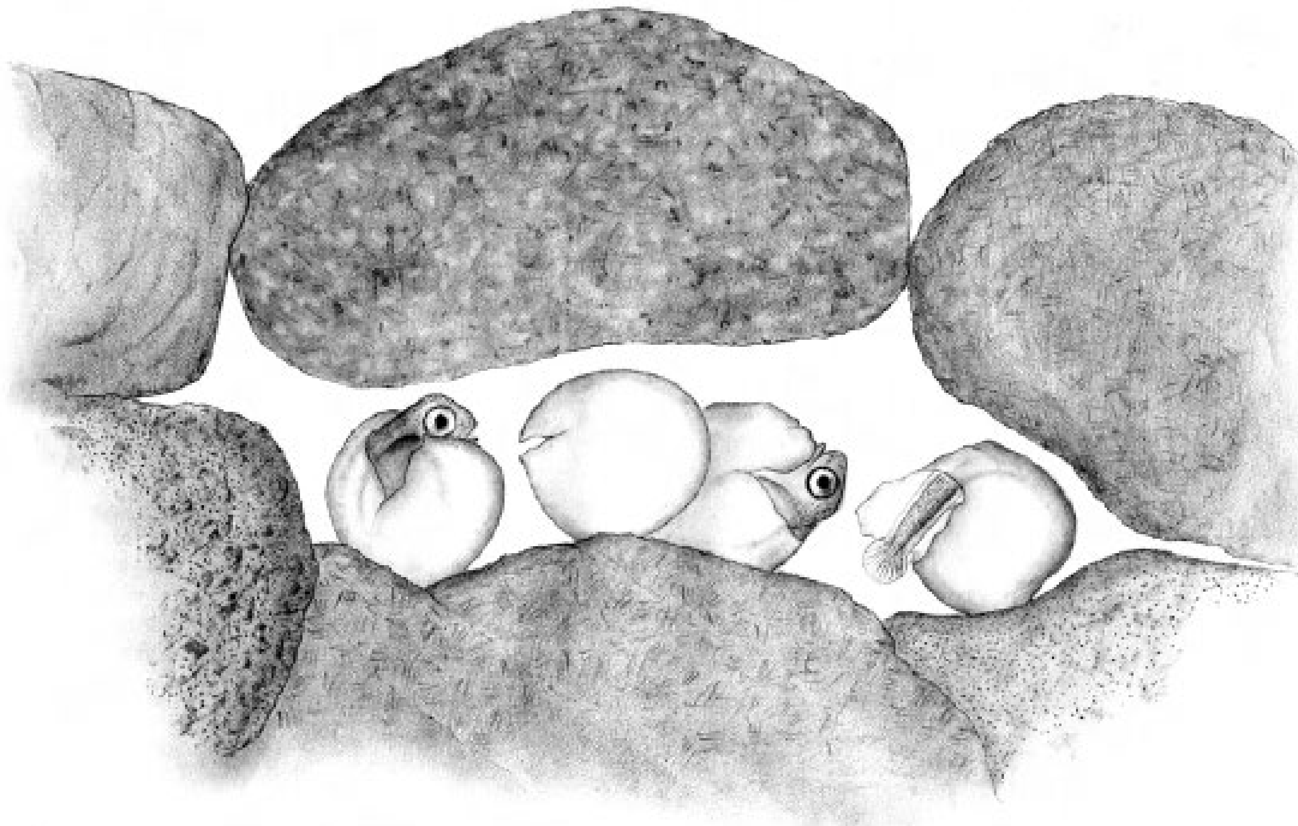


Illustration: Karen Uldall-Ekman

Alevins hatch from salmon eggs. The salmon growing inside the egg gets too big for the egg. It wiggles and wiggles. The wiggling makes the egg wall break.

The alevin pushes its head through the egg wall. It wiggles more and more. The hole gets bigger. The alevin pushes its whole body out.

The alevin has a bag on its stomach. This is the yolk sac. It is left from the yolk inside the egg.

The alevin still feeds on the yolk. The yolk is like a bag lunch. It goes where the alevin goes. Alevins start to eat bits of other food as they get older. When the yolk sac is used up, they will have to feed themselves.

The alevin is orange, like the egg. It has to hide from other animals. It lives in spaces in the gravel. It breathes oxygen dissolved in the water.

Background information

THE fry

Alevins emerge from the gravel as “swim-up” fry. Rapidly vibrating their tails, they emerge from the gravel, then push themselves vertically up to the surface of the water, usually taking several hours right after nightfall, when they will be less visible to predators. They snap their mouths into the air, hold their gills closed and force a mouthful of air into a swim bladder, a balloon-like organ in their abdomen. They may have to repeat this motion several times until they have enough air to hold their position in the water. The air in the bladder is only for buoyancy, not for breathing. It counters their body weight, giving them neutral buoyancy in water. Now, they are known as “free-swimming fry.”

Fry are not strong enough to swim upstream, so they drift downstream until they find calm pools where they can feed. There, they defend a small feeding territory from other fry. They catch land insects that fly close to the water or fall from plants hanging over the water. They also catch food in the water, mainly insect nymphs and larvae, as well as plankton. They grow from about 2.5 cm to between 4.5 and 5.5 cm.

Because they are out in open water searching for food, many salmon fry are eaten by predators, including birds and larger fish. To hide, salmon fry change their skin colour. They develop camouflage markings known as Parr marks, which are dark bars across their bodies. The mixture of light and dark helps them blend into the shadows on the stream- or lakebed so they are less visible to predators. They also dart very quickly from spot to spot.

A crucial part of the salmon’s life cycle occurs at the fry stage — imprinting. Salmon fry memorize their home stream or lake through factors such as the type of rock and soil in the bed, plant life and other aquatic organisms, all of which contribute to the quality and the unique scent of the water. Salmon learn to recognize this scent as very young fry and can identify it in the water when they return from the ocean. Changes in the stream’s environment that occur after the fry leave can confuse the returning salmon, preventing them from finding their home stream and spawning.

Imprinting continues as the fry grow and become smolts, so fry raised in an aquarium use these memories, rather than memories of tap water used in aquariums, to find their way home. Almost 90 per cent of all fry die from predators, disease or lack of food. People can help increase fry survival by protecting their environment from pollution, flooding or blockages. Fry need fresh, flowing, cold water, with plenty of oxygen and shade to keep the water from getting too warm. They also need places to hide, such as large boulders, overhanging bushes, tree stumps or fallen logs.

Depending on the species, salmon spend from a few days to three years in their home stream or lake. Then, they begin to migrate downstream to the estuary where the river meets the ocean.

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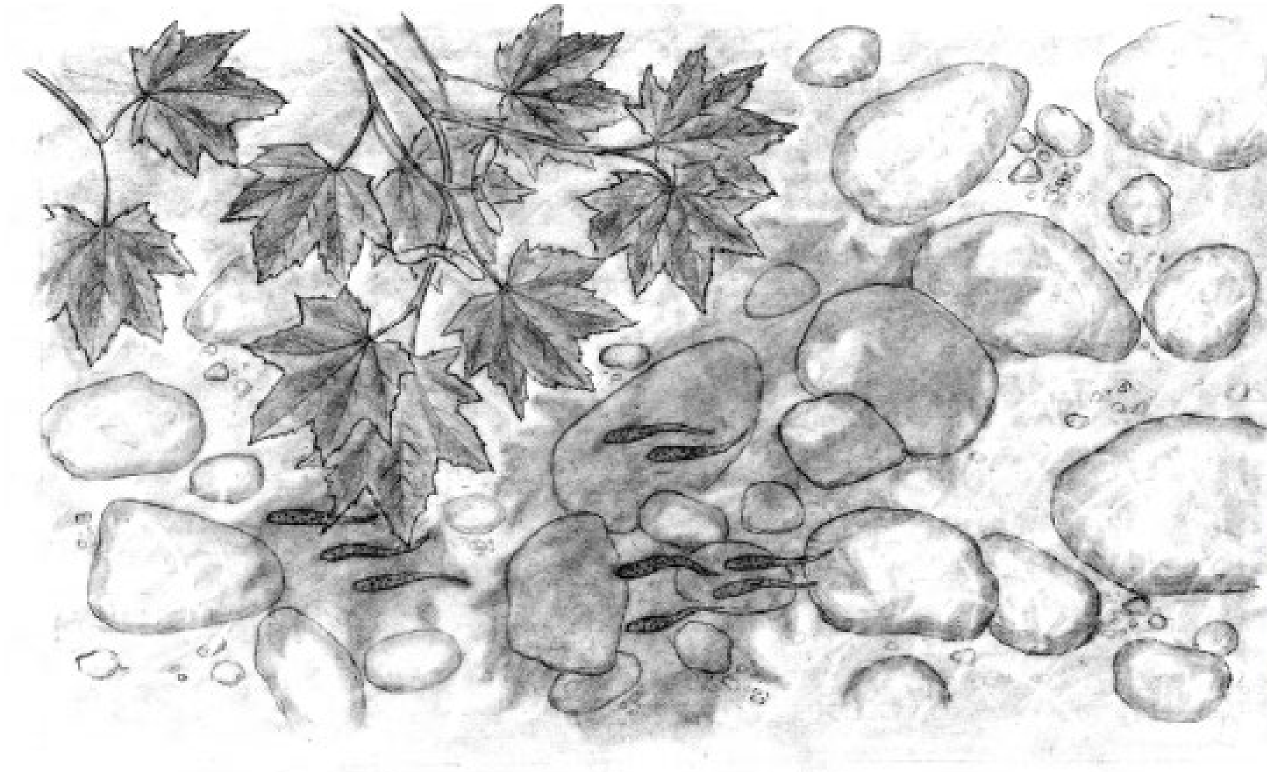
SALMON FRY



When alevins finish the food in their yolk sacs, they grow into **fry**. Fry catch their own food.

At first, fry cannot float in water. Fry sink in water. To float they must swallow air. They flutter their tail very hard to swim up. When they reach the air, they swallow large gulps. They keep air in a **swim bladder**, like a balloon in their stomach. Then they can swim up and down easily by moving their fins.

Once fry swim, they can chase food. They catch small insects. They also eat bits of animals that drift downstream.

Plants beside the stream or lake keep the water cool and shady. Fry can hide in the shadows. Their skin changes colour to help them hide. Dark lines called **Parr marks** also help them hide.

Birds and bigger fish try to eat fry. Fry dart about very quickly to avoid **predators**.

Salmon fry remember where they grew up. When they are adults, they will find their way back to the same stream or lake.

Background information

THE SMOLT

As salmon begin to mature, they adapt for life in salt water in an intermediary stage known as smolts. This process marks the beginning of their first migration from their home stream to the ocean.

Fish like salmon, that move from fresh to salt water and back again over the course of their lives, must be able to change their physiology, the way their bodies work. Most salmon species spend some time in the estuary of a river, where the fresh water mixes with the salt water. Here, they gradually get used to life in salty water in preparation for the time they will spend at sea. Very few fish have the ability to adapt from living in fresh water to salt water, and then return back to fresh water.

In a process called smoltification, salmon adapt to the changes salt water causes to their bodies. In fresh water, the salmon’s body is saltier than the water in which it swims. To work properly, the body needs salt so it tries to keep the salt in. Some escapes, but the salmon gets enough from the food it eats to make up for the loss.

In the ocean, the water is saltier than the salmon’s body needs to be, so it must try to keep the salt out and the water in. When salmon swim in the ocean, the salt water draws water out of the fish’s cells. Salmon adapt by drinking sea water to replace the water their cells lose. They excrete the excess salt through their gills and urine. Freshwater fish would die in salt water because they cannot replace the water in their cells.

As the smolts prepare for ocean life, their appearance also changes, from the dark colours of the fry to the silvery colour of adult salmon. This helps them hide in the light conditions of the surface waters of the open ocean, where there is no dark shade from overhanging trees.

In estuaries, the mineral and organic elements of a river mix with ocean nutrients brought in by tides, creating a nutrient-rich environment that supports diverse plant and animal growth. Estuaries provide salmon with a good supply of insects and crustaceans, such as tiny shrimps for food.

While in the estuary, smolts can grow from 4 or 5 cm in length to as much as 9 cm.

However, estuaries are home to many fish predators, including larger fish, birds, snakes, seals and even orcas. People build cities and industries on estuaries, as well as dyking and dredging them, or extending landfills into them for development projects. The loss of estuary habitat means that there is less room for salmon and other estuary animals to mature, feed and adapt. If smolts cannot live in an estuary, it is a sign that other plants and animals are at risk, also.

Different species of salmon spend different amounts of time in estuaries. Some leave almost immediately, while others spend several months there. While approximately 30 fry from a redd of 2000 to 2500 eggs grow into smolts, less than four survive to become adults.

From: Salmonids in the Classroom Primary, Fisheries and Oceans Canada

SALMON SMOLTS

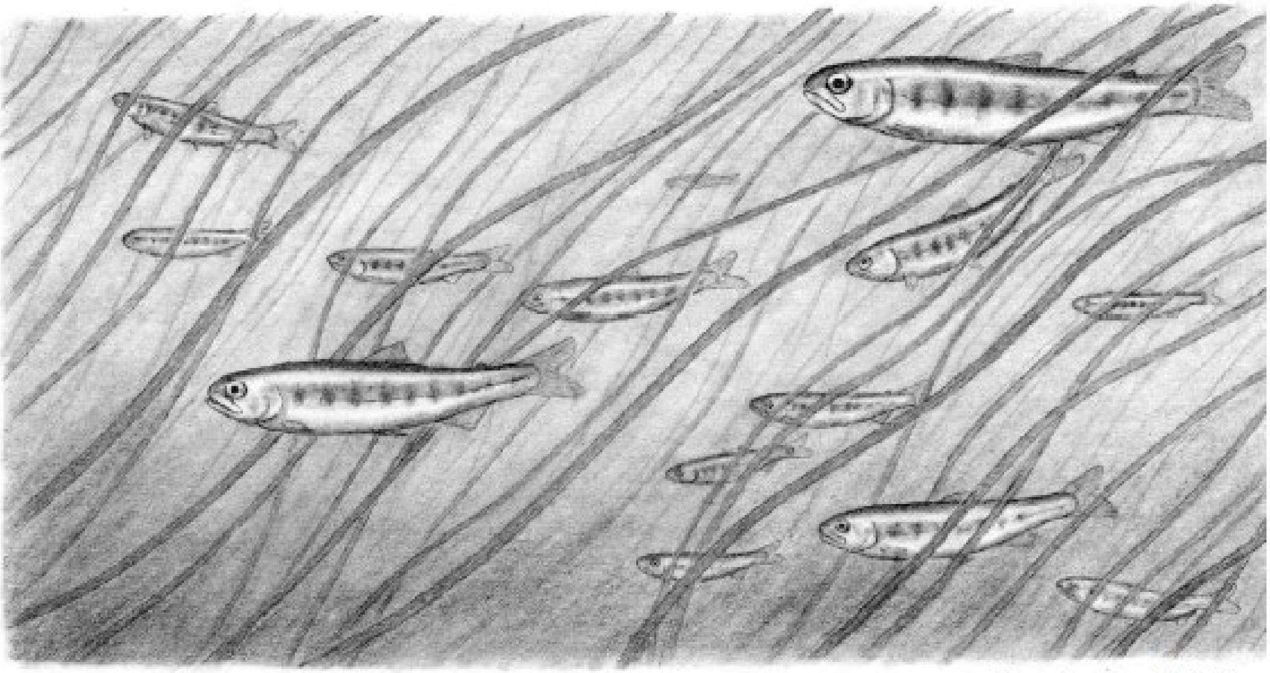


Illustration: Karen Uldall-Ekman

Salmon fry grow into smolts. They swim downstream to the ocean. Sometimes the journey takes many months.

On the way, smolts face many hazards. Predators try to catch the smolts and eat them. Logs or dams may block the way. Sometimes the water is polluted.

The end of the smolt's trip is the estuary. An estuary is a place where a river meets the sea. The fresh river water and the salty ocean water mix together. The water is salty, but not as salty as the sea. Smolts get used to the salt water in the estuary.

Smolts find a lot of food in the estuary. Smolts can eat other fish, tiny shrimp and other animals. But there are also many predators. Larger fish, birds, snakes, seals and orcas eat smolts.

People also use estuaries. People build cities, farms, factories and roads near estuaries. They fill in parts of the estuary with dirt. Building leaves little space for smolts.

People can save some of the estuary for smolts. They can build away from the estuary. They can keep polluted water out of the estuary.

Background information

THE ADULT SALMON

After gaining weight in the estuary and adapting to the salt water, salmon travel along the coastline and then to the open ocean. Here they gain the full size, shape and colour of one of the species of mature salmon: coho, sockeye, pink, chum, chinook or steelhead. (Older references describe five species, but steelhead were recently reclassified as salmon.)

Because scientists cannot easily observe salmon in the ocean, knowledge of this part of the salmon's life cycle is limited. Scientists do know that most salmon spend the first part of their life in coastal waters, then migrate farther out to sea. Each species of Pacific salmon has a characteristic migration route and spends a different length of time in the ocean before returning home.

Young salmon can travel up to 20 km a day, while mature salmon can travel as much as 50 km a day. Salmon usually travel north in summer, as far as the Gulf of Alaska, and south in winter, possibly following ocean temperature changes while searching for food.

While at sea, salmon feed on a variety of smaller fish and plankton, often following schools of herring or krill. They can gain many kilograms, with mature adults reaching weights ranging from a few kilograms to 20 kilograms or more, depending on the species. Salmon are also prey for larger salmon species, seals, orcas, and other fish, such as tuna and cod.

Canada divides the right to catch salmon among the different fishing groups. First, scientists estimate how many salmon must return to their home streams and lakes to conserve the species. First Nations people have rights to catch some of the remaining fish for food and ceremonial purposes. After meeting these needs, regulators allocate the remaining fish among commercial and recreational fishers.

The largest number of salmon is probably taken by human fishers. People catch salmon mainly in coastal waters as large schools return from their ocean travels, although some are also caught in huge ocean drift nets. Commercial fishers use three main kinds of gear to catch salmon:

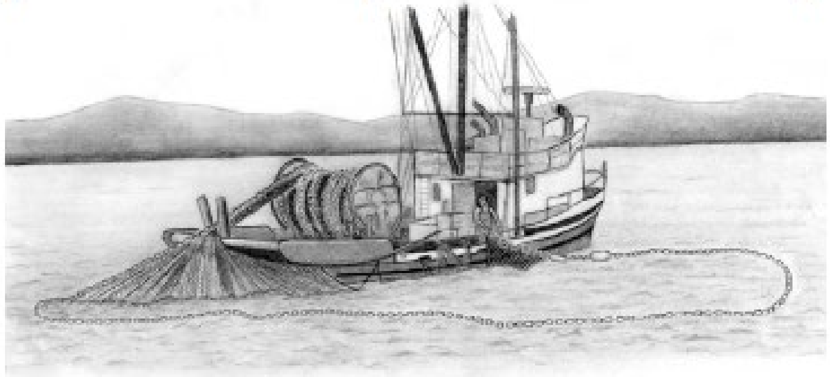
- gill nets: nets that hang like a curtain from the water's surface and entangle salmon by their gills (about 25% of the commercial catch);
- purse seine nets: nets that fishers first drag to form a circle around a school of fish, then pull in the bottom to form an enclosure from which fish cannot escape (about 50% of the commercial catch);
- troll lines: long steel fishing lines, each with several lures and hooks to catch salmon by the mouth (about 25% of the commercial catch).

Altogether, commercial fishers took about 85% of the salmon caught in 1998. Sport and native fishers also catch many salmon, both in coastal waters and as the salmon travel upstream. Recreational fishers usually catch salmon using single fishing lines with lures and hooks; they took about 3% of 1998's annual catch. Native fishers use both modern and traditional methods to catch fish; they took about 12% of 1998's annual catch.

After spending from one to seven years at sea, depending on the species, salmon return to their home stream or lake to spawn a new generation. No one knows how, but mature salmon form large schools and find their way to the mouth of their home stream. Scientists think salmon use ocean currents, the earth's magnetic field, water temperature and even the north star to find their way back. When they get near their home river, the scent of its water helps them identify the right river. The salmon congregate at the mouth of their home river before starting the difficult journey upstream.

From: Salmonids in the Classroom Primary, Fisheries and Oceans Canada

ADULT SALMON



Salmon swim to the ocean to grow into adults. Some live in the ocean for one year. Others live in the ocean for many years.

Salmon find many smaller fish to eat in the ocean. They grow very large.

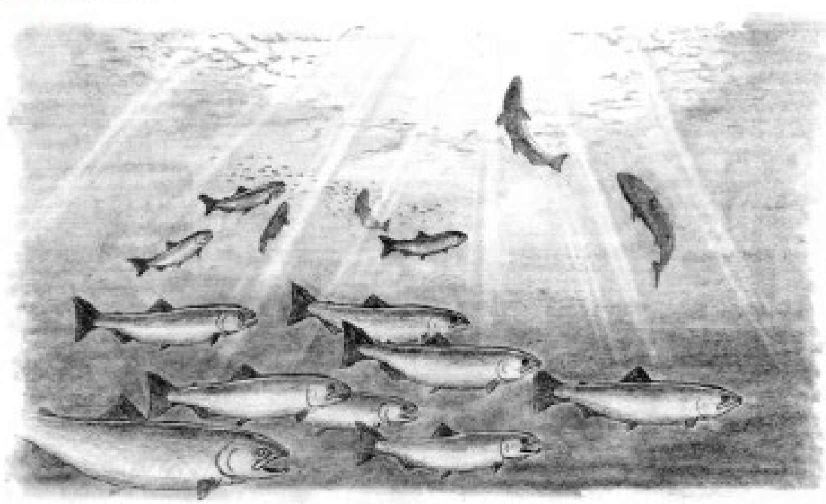
Their bodies become silver and grey. They are hard to see in the ocean.

Seals, whales and large fish catch salmon and eat them. Human fishers in fishing boats catch many salmon.

Like many birds, salmon can travel a very long way. Often they swim in big groups called schools. But they come back when their travel is finished.

No one knows how salmon find their way home. Scientists think they use all their senses to find the way.

Salmon remember the scent of the water where they were born. The scent of their home river in the ocean tells them they are almost home.



Illustrations: Karen Uddal-Ekman

Background information

SALMON SPAWNERS

In the final stage of the salmon's life cycle, the adults re-enter their home river and swim back to the stream or lakeshore in which they grew as fry. Salmon from inland rivers may travel many hundreds or thousands of kilometres, swimming from 30 to 50 km a day against the current. They follow the scent of the water from their home stream, past rapids and other obstacles, such as dams, rock slides and log jams, before reaching their destination. Fishers and predators, such as bears, otters, racoons and eagles, catch many salmon on their trip upstream.

When they enter fresh water, the salmon stop eating and live only on stored body fat. Their kidneys, gills and skin change to regulate the water and salt balance in their cells. To save energy, they lose the slime coating that helps protect them; their skin becomes thick and leathery, and they absorb their scales.

The salmon's appearance changes dramatically, with males and females developing distinct differences. Both males and females lose their silvery colour and take on deep red, green, purple, brown and grey colours. Their teeth become long and they develop a hooked jaw, which is particularly noticeable in the males. The body shape can change, with some species developing a pronounced hump on their back. Eggs ripen in the ovaries of the females, while sperm in the males changes into liquid milt.

When they reach their home stream or lake, the female uses her fins and tail to find a spot with the right gravel size and water conditions. With strong sweeps of her tail, she rearranges the stones in the gravel bed to form a redd, the nest-like depression in the stream- or lakebed where she will lay her eggs. Males fight among themselves to get close to a female. When a female chooses a male, they nudge and bump each other in an underwater courtship dance. The female deposits some of her eggs in the redd, and the male deposits his milt to fertilize them. Some species deposit up to 6,000 eggs, but the average is about 2,500. The female covers the eggs with gravel to protect them, and often moves on to build a second or third redd, which is fertilized by other males.

Both males and females die within a few days of spawning. Their bodies, battered and injured by the difficult trip upstream, decompose. Valuable nutrients from the carcasses form a rich food source for other fish and wildlife by fertilizing the stream or lake. Salmon carcasses that are carried onto riverbanks fertilize the forest and bushes. If most of the adult salmon are caught, the water will have few nutrients for the next generations of salmon and for the rest of the ecosystem.

From: Salmonids in the Classroom Primary, Fisheries and Oceans Canada

SALMON SPAWNER

Salmon **spawners** leave the ocean in the fall or early winter. They swim upstream to the stream or lake where they were born.

On the long trip upstream, spawners do not stop to eat. Their shape and colour changes. Their skin may become bright red, green or purple. Some grow a large hump. Some grow a hooked jaw.

As they swim, they face many dangers. They must jump waterfalls and rapids. Logs and rocks block the way. Human fishers try to catch them. Eagles and bears want to eat them.

Spawners smell the water to find their home stream or lake. When they reach their home stream or lake, the **female** builds a **redd**. She sweeps rocks and gravel with her tail to make a stone nest. Then she chooses a mate.

She lays her eggs in the redd. The **male** deposits his **milt** so the eggs will grow. The female covers the eggs. Often she builds another redd, finds another mate and lays more eggs.

The male and the female die soon after spawning. Other animals eat their bodies. Salmon bodies also **fertilize** the stream and forest.

Life Cycle Needs:

The stages in a salmon's life form a circle, but each stage has specific needs and is vulnerable to disruption of the stage before it. Just like every animal has a life cycle, every animal has things they need to survive.

Human Needs:

- What do people need to breathe?
  Air
- What do people need to eat and drink?
  Food and water
- What do people need to stay safe and healthy?
  Houses and clothes

Salmon Needs:

- What do salmon need to breathe?
  Air in the water
- What do salmon need to eat and drink?
  Water (absorbed through their skin and gills) and food like insects
- What do salmon need to stay safe and healthy?
  Clean streams, lakes, and oceans

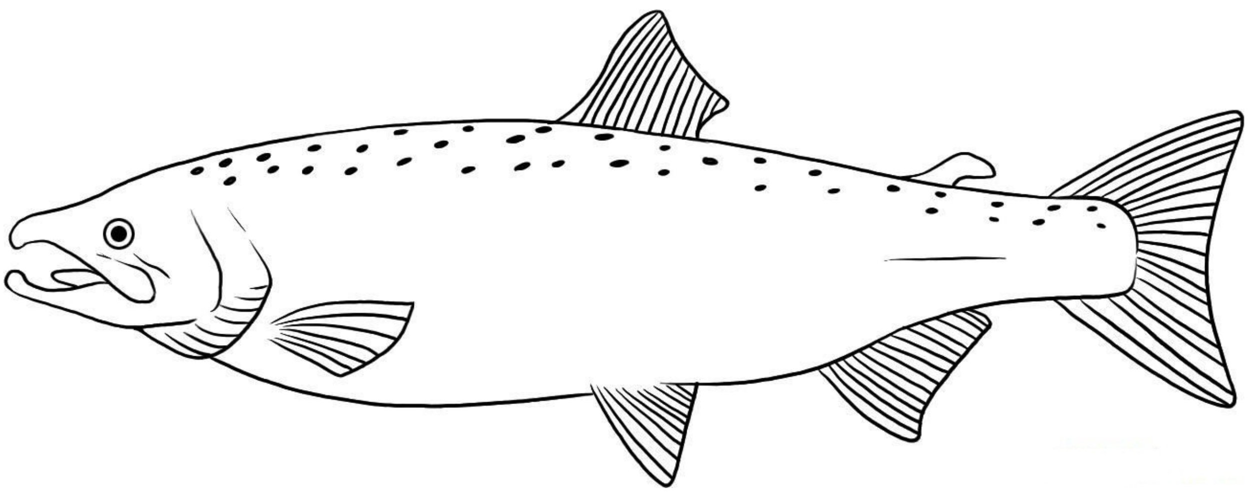
Background Information

SALMON LIFE CYCLE NEEDS & THREATS

Life Cycle Stage	Needs		Threats	
	Habitat	Food	Predators	Other
EGG • Head and body formation begin • Organ formation begins • Eyes become visible	• Oxygenated water • Temperature from 5° to 9°C (42° to 50°F) • Silt-free gravel bed • Steady water flow • Stream cover	• Yolk of Egg	• Fish, such as: trout, char, grayling, burbot, whitefish, sculpin, and suckers • Birds, such as: kingfisher, gulls, terns, ducks, and shore birds • Mammals, such as: minks and river otters	• Gravel movement • Drastic change in water temperature • Drastic change in water level • Siltation • Fine sediment • Disease • Pollution
ALEVIN • Embryo breaks through egg membrane • Oxygen absorbed through gills • Lives in gravel spaces	• Oxygenated water • Temperature from 5° to 14°C (42° to 60°F) • Silt-free gravel • Steady water flow • Stream cover	• Yolk sac	• Fish, such as: trout, char, grayling, burbot, whitefish, sculpin, and suckers • Birds, such as: kingfisher, gulls, terns, ducks, and shore birds • Mammals, such as: minks and river otters	• Gravel movement • Drastic change in water temperature • Drastic change in water level • Siltation • Fine sediment • Disease • Pollution
FRY • Inflates swim bladder • Catches food • Exhibits darting reflex • Avoids light • Guards territory • Imprints home scent • Develops scales	• Oxygenated water • Temperature from 5° to 14°C (42° to 60°F) • Even water level and flow • Stream cover	• Larval and adult terrestrial and aquatic insects (e.g. mayfly, caddisfly, stonefly) • Rotting fish carcasses • Fish eggs	• Fish, such as: trout, char, grayling, burbot, whitefish, sculpin, and northern pike • Birds, such as: kingfisher, gulls, terns, ducks, shore birds, and eagles • Mammals, such as: minks and river otters	• Gravel movement • Drastic change in water temperature • Drastic change in water level • Siltation • Fine sediment • Disease • Pollution • Blockage of migration route

SMOLT • Migrates to estuary • Adapts to salt water • Scales develop silver color • Increases size	• Unpolluted water in river and estuary • Estuary vegetation for shelter	• Zooplankton (copepods, amphipods, euphausids) • Insects (e.g. beetles, ants, grasshoppers, caterpillars) • Worms • Sandfleas • Shrimp • Smaller fish	• Fish (saltwater), sch as: other salmon, pollock, cod • Birds, such as: kingfish, gulls, terns, ducks, eagles • Mammals, such as: otters, seals, and whales	• Filling or dredging of estuary • Pollution of estuary • Diversion of river water
OCEAN-PHASE ADULT • Migrates into ocean • Increases size • Stocks intermingle, then return to natal river	• Ocean water	• Zooplankton (copepods, amphipods, euphausids) • Larval crustaceans (e.g. crab, shrimp) • Smaller fish	• Fish (saltwater), sch as: other salmon, pollock, cod, lingcod, and sharks • Birds, such as: kingfish, gulls, terns, ducks, eagles • Mammals, such as: seals, whales, sea lions, and people	• Ocean pollution • Ocean temperature change • Fishing
SPAWNER • Eggs, milt develop • Secondary sexual characteristics develop (color, shape, teeth) • Scales absorbed • Eating stops • Organs degenerate	• Migration route free from obstruction • Oxygenated water • Cool clean water • Silt-free gravel	• None	• Fish: None • Birds, such as: gulls, and eagles • Mammals, such as: seals, whales, sea lions, bears, wolves, and people	• Very high or low water levels • Warm river temperatures • Obstructions (dams, slides, log jams, etc.) • Diseases • Pollution

Salmon Life Cycle Book



By: ______________________

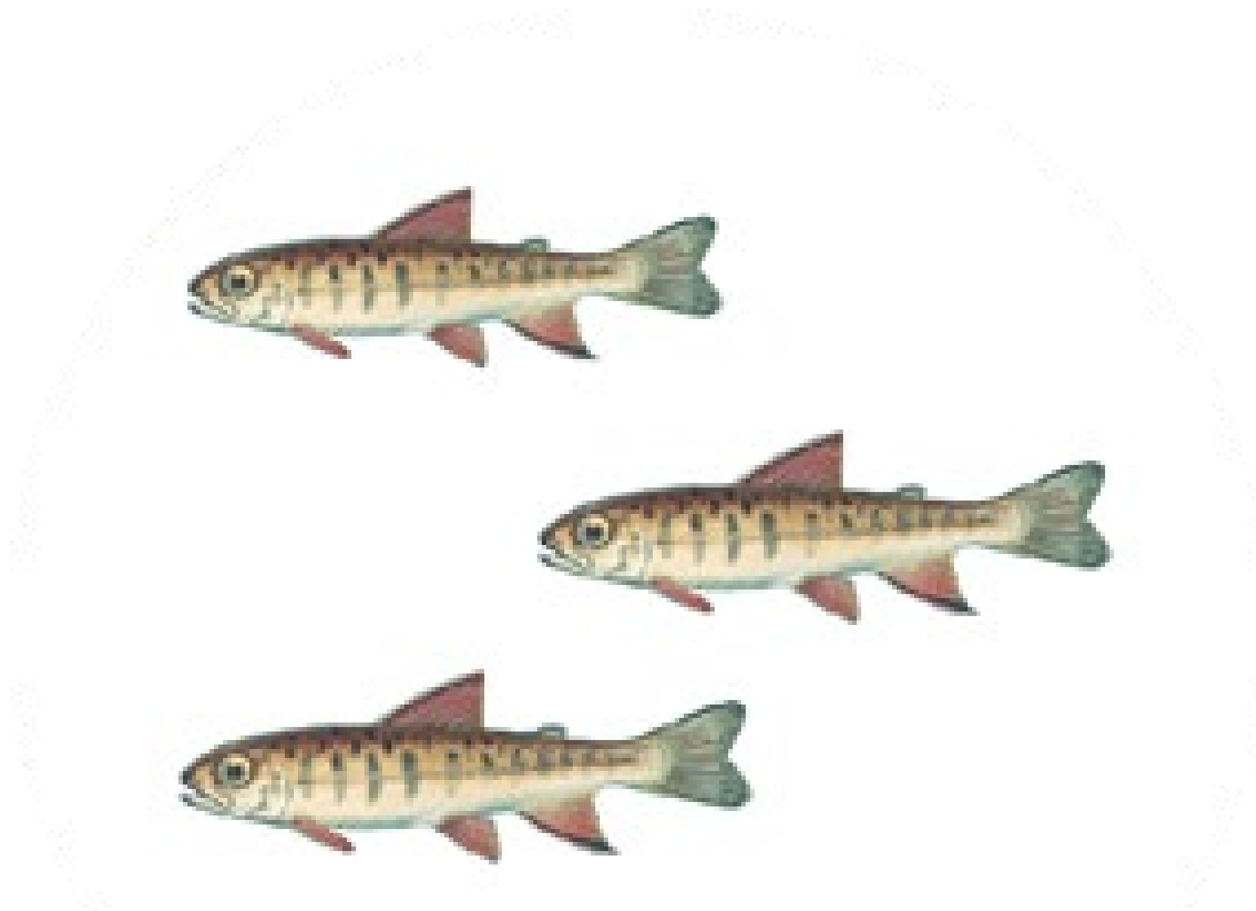
Egg

In the fall, salmon start their lives as eggs buried in GRAVEL at the bottom of a freshwater stream. A female salmon can lay over 7,000 eggs! The female beats her tail in the gravel to make a nest, called a REDD. Eggs need COLD, CLEAN and CLEAR water to survive.

Alevin

After a few months, the eggs hatch into ALEVIN. The alevins stay in their gravel nest until they've used up all of the nutrients in their YOLK SAC and they're now strong enough to swim and inflate their SWIM BLADDER by taking a gulp of air at the water surface.

Fry



Once the alevin absorb their yolk sac, they get hungry. They are now FRY. They leave their gravel nest in search of food. Fry love to eat insects like STONEFLIES, MAYFLIES and CADDISFLIES. Fry have PARR marks that camouflage them in the stream from predators.

Smolt

In the spring, the fry lose their camouflage color and turn silver. They are now SMOLTS! They migrate downstream though many obstacles to reach the ESTUARY, where freshwater mixes with saltwater.

Adult

When the smolts are big enough, they leave the estuary and live in the OCEAN. It takes many years to grow big enough to become an ADULT. Salmon migrate to the ocean because the ocean has more FOOD. Some salmon swim 2,000 miles in search of cold water and nutrients.

Spawner

As SPAWNERS, salmon return to their NATAL stream—the same stream where they were born. They navigate home by using their sense of SMELL and following Earth's MAGNETIC field like a compass. After they lay their EGGS they die. Their carcasses provide NUTRIENTS for the ECOSYSTEM.

UNIT #2: Egg Delivery

Today your salmon eggs arrive!

What have we learned about what salmon eggs need to survive and how will we provide that for them in our classroom aquarium?

They need COLD water. Our aquarium will be kept at 48 degrees Fahrenheit.

They need CLEAN water. Our aquarium will need to have the water TESTED and CHANGED once a week.

They need CLEAR water. Our aquarium will have a FILTER.

They need DARKNESS Our aquarium will have a COVER.

PREDICT THE HATCH

Salmon eggs develop at a rate that is partially determined by water temperature. Even cold water contributes thermal energy that is measured in Thermal Units (TUs). When a salmon egg has accumulated enough TUs, it hatches. Very cold water will result in slower egg development and a later hatch date. Warmer water will result in quicker egg development and an earlier hatch date. The optimal temperature for developing salmon eggs is 40-55 degrees F, with 48 degrees as a desirable goal. Eggs will survive temperatures close to freezing but develop very slowly. If the water is too warm, the eggs die.

Accumulated Thermal Units (ATUs) provide us with a way of using math to predict salmon hatch date and when they will be free-swimming as fry.

Here is a chart with some examples of ATUs for various salmon species (Note - we only raise chum and coho salmon for Salmon in the Schools):

Accumulated Temperature Units (ATUs) in Fahrenheit Required to Reach Developmental Stages in Salmonids		
SPECIES	**HATCH**	**FRY**
Chinook	920-980 (avg. 950)	1500-1800 (avg. 1650)
Chum	**870-1000 (avg. 935)**	**1520-1900 (avg. 1710)**
Coho	820-900 (avg. 860)	1360-1520 (avg. 1440)
Pink	1000-1200 (avg. 1100)	1600-1900 (avg. 1750
Sockeye	1120-1280 (avg. 1200)	1720-2000 (avg. 1860)

This is how ATU prediction of salmon egg hatch date works:

1. ATU is the addition of each day's temperature increment over freezing to the previous sum. In degrees Fahrenheit, 32 is freezing. If your chiller is set to 48 degrees Fahrenheit, each day your eggs will accumulate 16 ATUs because 48-32=16. Similarly, if your chiller is set to 50 degrees Fahrenheit, each day your eggs will accumulate 18 ATUs because 50-32=18.
2. Your hatchery will provide the date the salmon were spawned and the temperature the eggs have been kept at. Looking at calendar, have the kids count out how many days have elapsed since egg fertilization (spawn date) and eyed-egg delivery to your school.
    a. Example:
        i. The eggs were spawned on November 20, 2021.
        ii. Eyed eggs were delivered to your school on January 3, 2022.
        iii. The eggs were kept at an average of 48 degrees Fahrenheit every day.

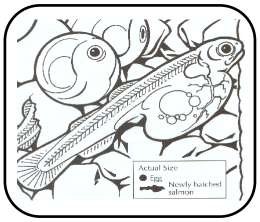
    iv. Looking at the calendar, 44 days have elapsed between spawning and egg delivery (not counting the day of delivery).
    v. We use our formula of average daily temperature – freezing temperature to calculate 48-32=16
    vi. We multiply days by ATUs, so 44 days x 16 ATUs = 704. This means our eggs have already accumulated 704 thermal units.
3. Using the table above, we know that Chum salmon need an average of 935 ATUs to hatch and 1710 ATUs to start swimming freely as fry. To calculate hatch date, we need to subtract the ATUs the fish have already accumulated in the hatchery from the total ATUs required to hatch and become fry. Then we need to divide this number of ATUs by the average temperature of the classroom aquarium.
    a. Example:
        i. Chum need 935 ATUs to hatch. Our eggs have already accumulated 704 ATUs.
            1. To calculate remaining ATUs needed, we find that 935 – 704 = 231
        ii. Next, we need to divide our remaining ATUs to hatch by the average tank temperature (in this case, 16 ATUs per day since our tank chiller is set at 48 degrees Fahrenheit)
            1. We calculate 231 / 16 = 14 days
        iii. Now we know that our eggs should hatch approximately 14 days.
        iv. Have your students look at a calendar to count out how many days from now that is. In this example, it would be a predicted hatch date of January 16, 2022.
4. Do the same calculations to predict days until the eggs are fry as you did for hatch.
5. Use the following worksheets to predict hatch date and fry stage with your students.

Introducing the worksheets to students:

1. Begin the worksheet by asking students what factors might influence when the eggs will hatch. They will probably think of temperature. Students may be aware that birds sit on their eggs to make them hatch. Body heat is a form of energy and energy is needed for growth. Discuss how fish also get energy from their immediate surroundings - the water. Challenge students to think of how they could predict when their fish eggs will hatch.
2. Students will probably offer comments like "When they get warm enough (get enough heat) they will hatch". Discuss the temperature of your aquarium. You have probably been monitoring this daily during the week prior to getting the eggs. How could water temperature affect egg hatching?

3. Explain to students that salmon eggs need energy—heat or thermal energy—to develop and hatch. The more heat they get, the faster they develop. This heat is measured in Thermal Units or TUs. Show students the Thermal Unit Chart and distribute the When Will the Eggs Hatch and the When Will the Salmon Become Fry worksheets. Work as a class or in small groups to determine what information is needed to predict exactly when hatching will occur.
4. Students should write down the information and the steps they will take to get their predictions. Help them do this by writing all the relevant information for the whole class to see - the date fish were spawned, the average water temperature at the hatchery, the average water temperature in your aquarium and the number of TU's required for hatching.
5. Ensure you have collected all the data needed for your calculations.
6. Complete the worksheets or have students devise their own way of presenting the information.
7. Each day record the water temperature. If it changes at all during the day, take two readings and find the average temperature. Use the weekly tank care sheet to record the number of TU's that accumulate each week.
8. After hatching, compare predictions to what actually happened. If the fish did not hatch on the predicted day, discuss what factors might have been involved—temperature variations throughout the day, using average temperature, miscalculations, etc.

Name: ___________________________________



WHEN WILL THE EGGS HATCH?

Chum Salmon eggs need between 870 and 1000 Accumulated Thermal Units (ATUs) to hatch. The average ATUs to hatch is 935. A Thermal Unit is the average temperature in degrees Fahrenheit minus 32 degrees (freezing).

1

Date the eggs were spawned: ___________________

Date the eggs were delivered: ___________________

Number of days at the hatchery: __________

2

To find the amount of TUs the eggs received while at the hatchery:

Temperature at the hatchery: _______

— 32 deg. F

Equals: _______

Multiplied by the days at the hatchery: x _______

Equals the amount of TUs the eggs have accumulated by arrival: _______

3

To find the amount of TUs left until hatching:

	Lower	Upper	Average
Thermal Units needed to hatch:	870	1000	935
Minus the amount of TUs the eggs had accumulated by arrival:	— ______	— ______	— ______
Equals Thermal Units left until hatching:	______	______	______

4

To find the amount of TUs the eggs will receive each day:

Average temperature in the aquarium: _______

— 32 deg. F

Equals the amount of TUs the eggs receive each day: _______

5

To estimate hatch time:

	Lower	Upper	Average
Thermal Units (TUs) left until hatching:	______	______	______
Divided by the TUs the eggs receive each day:	÷ ______	÷ ______	÷ ______
Equals # of days left until the eggs hatch:	______	______	______

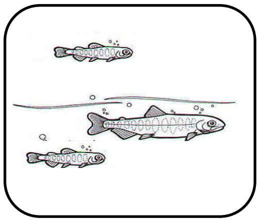
6

Use a calendar to count the # of days for lower, upper, & average hatch dates.

I predict the eggs will hatch between __________ and __________.

The average date the eggs may hatch is _________.

Name: ___________________________________



WHEN WILL THE SALMON BECOME FRY?

Chum Salmon eggs need between 1520 and 1900 Accumulated Thermal Units (ATUs) to start swimming freely as fry. The average ATUs to hatch is 1710. A Thermal Unit is the average temperature in degrees Fahrenheit minus 32 degrees (freezing).

1

Date the eggs were spawned: ___________________

Date the eggs were delivered: ___________________

Number of days at the hatchery: __________

2

To find the amount of TUs the eggs received while at the hatchery:

Temperature at the hatchery: _______

— 32 deg. F

Equals: _______

Multiplied by the days at the hatchery: x _______

Equals the amount of TUs the eggs have accumulated by arrival: _______

3

To find the amount of TUs left until fry stage:

	Lower	Upper	Average
Thermal Units needed to become fry:	1520	1900	1710
Minus the amount of TUs the eggs had accumulated by arrival:	— ______	— ______	— ______
Equals Thermal Units left until fry stage:	______	______	______

4

To find the amount of TUs the eggs will receive each day:

Average temperature in the aquarium: _______

— 32 deg. F

Equals the amount of TUs the eggs receive each day: _______

5

To estimate when the salmon become fry:

	Lower	Upper	Average
Thermal Units (TUs) left until fry stage:	______	______	______
Divided by the TUs the eggs receive each day:	÷ ______	÷ ______	÷ ______
Equals # of days left until salmon are fry:	______	______	______

Use a calendar to count the # of days for lower, upper, & average fry dates.

6

I predict the salmon will become fry between ________ and ________.

The average date the salmon may become fry is ________.

UNIT #3: Salmon Species

There are five species of Pacific salmon.

- Chum (nickname: dog salmon)
- Chinook (nickname: king salmon)
- Coho (nickname: silver salmon)
- Sockeye (nickname: red salmon)
- Pink (nickname: humpback salmon)

There are two species of trout that are anadromous like salmon. Unlike salmon, however, they do not die after spawning.

- Steelhead
- Coastal cutthroat trout

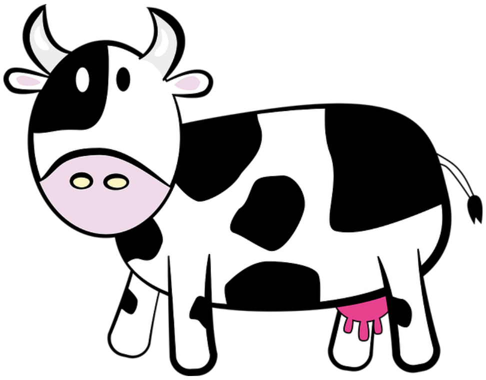
Salmon Species

Scientists classify living things based on shared traits. First, we look at whether they have a backbone (VERTEBRATES) or do not have a backbone (INVERTEBRATES) We know that animals have backbones.

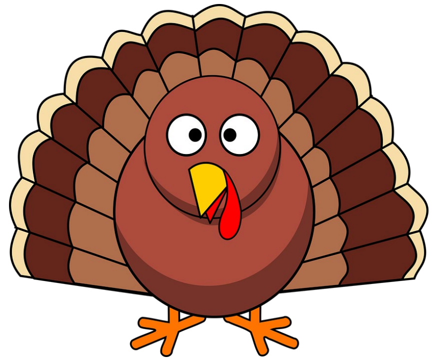
There are six animal classifications:

MAMMAL	Warm blooded, produce milk, hair on body
BIRD	Warm blooded, lay eggs, have feathers
FISH	Cold blooded, live in water, have gills, fins, and scales
REPTILE	Cold blooded, usually lay eggs, have scales
AMPHIBIAN	Live on land and in water, have smooth, moist skin
INSECT	Have an exoskeleton, segmented bodies, jointed limbs

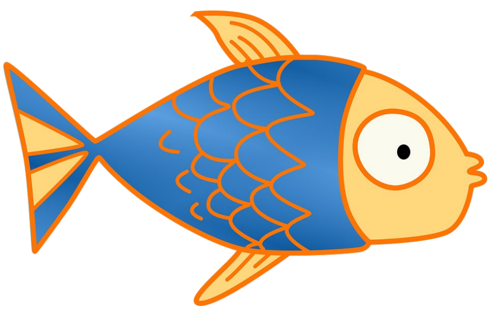
Animal Classification Practice



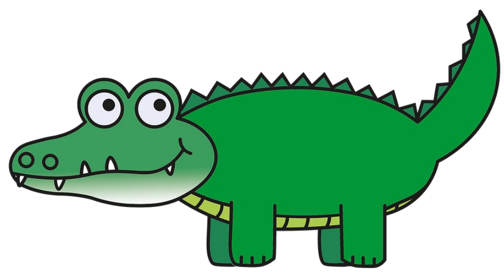
MAMMAL



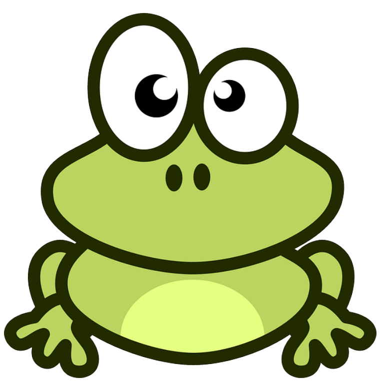
BIRD



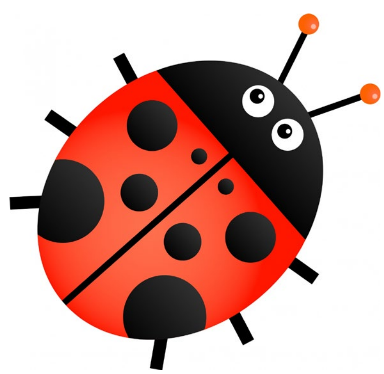
FISH



REPTILE



AMPHIBIAN



INSECT

What is a species?

All of the animals within the classifications that we just learned share common traits. For example, in the class of mammals there are cows and humans because we both are warm-blooded, produce milk, and have hair on our bodies. But are we the same species? No! Why? Because cows and humas cannot create babies together.

Within the class of fish, there are many different types of fish that cannot produce babies together. Each species has a unique set of habitat requirements and life histories. Some fish live in saltwater. Some fish live so deep down in the ocean that they never see daylight. Some fish live in freshwater. Some fish lay eggs. Some fish give birth to live babies.

Fish that share many but not all characteristics are grouped together as a family. The salmon family all:

- Dig REDDS to lay their eggs.
- Are anadromous, meaning they start their lives in FRESHWATER migrate to SALTWATER to grow big, and return to FRESHWATER to spawn.
- DIE after spawning, bringing marine-derived nutrients to freshwater ecosystems.
- Develop HOOKED noses (males) as they prepare to spawn. The scientific name of all Pacific Salmon starts with *Oncorhynchus*, which means hooked nose.

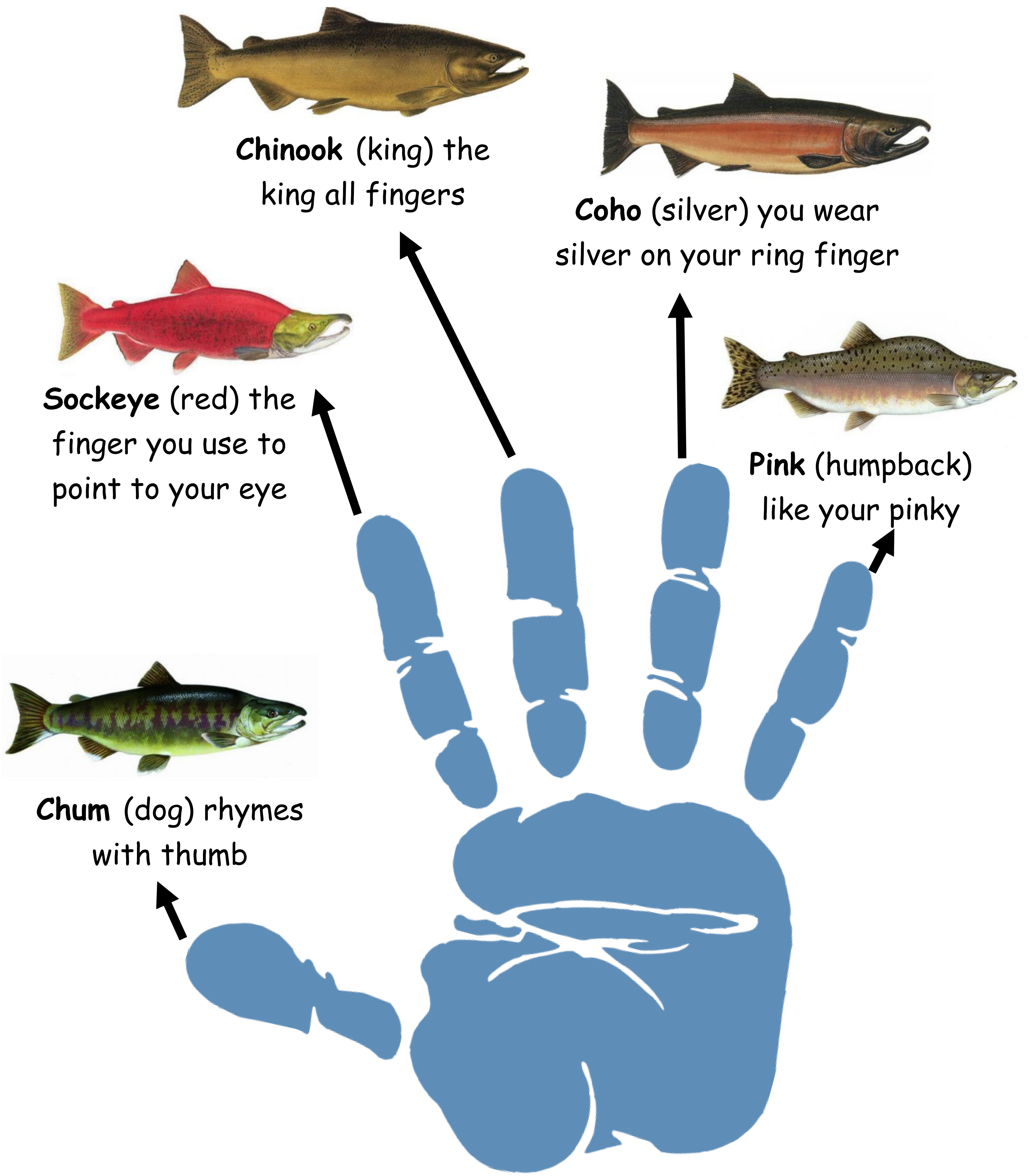
What are the 5 species of Pacific Salmon?

Within the salmon family, there are many species. Each species is unique and only breeds with other salmon of the same species. There are five major species of Pacific Salmon found in Washington State:

- CHUM
- SOCKEYE
- CHINOOK
- COHO
- PINK

Each species also has special traits that set them apart from each other. Some juveniles live in the steam where they were born for a year while others swim out in the estuary immediately after emerging from the gravel. Read on about each species to learn what makes them special.

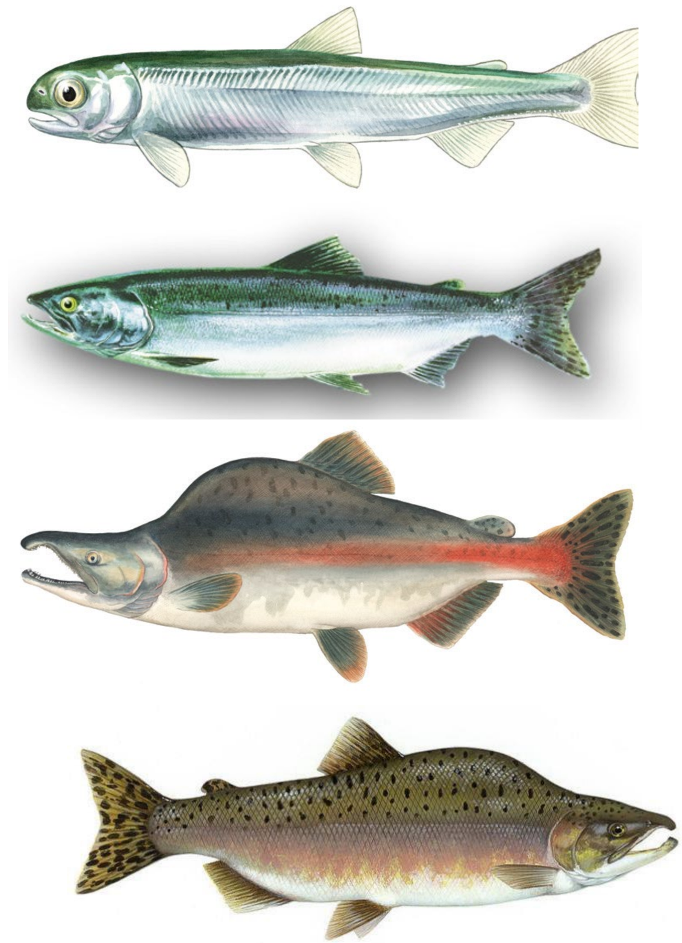
Use your fingers to remember the 5 Pacific Salmon species!



Pacific Salmon Fact Chart EXAMPLES

Species Name (Common and Scientific)	Weight	Length	Spawning Age	Interesting Fact
PINK SALMON, ONCORHYNCHUS GORBUSCHA	2-5 LBS	20-30"	2 YEARS	ONLY RETURN EVERY OTHER YEAR
SOCKEYE SALMON, ONCORHYNCHUS NERKA	4-8 LBS	25-33"	3-6 YEARS	JUVENILES REAR IN LAKES NOT STREAMS
COHO SALMON, ONCORHYNCHUS KISUTCH	6-15 LBS	24-38"	3 YEARS	JUVENILES SPEND 1-2 YEARS REARING IN FRESHWATER
CHUM SALMON, ONCORHYNCHUS KETA	9-15 LBS	25-40"	3-5 YEARS	MIGRATE TO ESTUARY VERY SOON AFTER EMERGING AS FRY
CHINOOK SALMON, ONCORHYNCHUS TSHAWTSCHA	10-24 LBS	36-58"	3-7 YEARS	LARGEST OF THE SALMON

Pink Salmon



Nicknames: Humpback, humpy

Scientific Name: *Oncorhynchus gorbuscha*

Weight: 2-5 lbs., up to 12 lbs.

Length: 20-30 inches

Spawning Age: 2 years

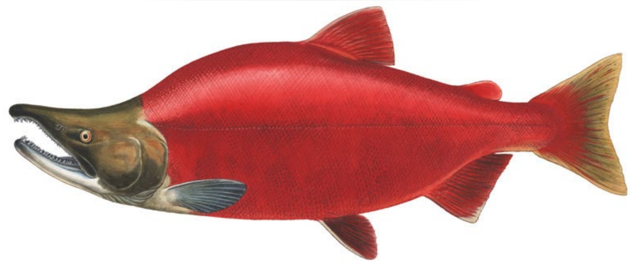
Facts:

- Young pink salmon migrate to saltwater right after emerging from the gravel.
- Adult pink salmon spawn close to the estuaries of streams and rivers.
- They only return every other year.
- Males develop very large humps behind their head during the spawning phase.
- They are the smallest of the Pacific Salmon species and spend the least amount of time in freshwater and saltwater.

Sockeye Salmon

Nicknames: Red, redfish, blueback

Scientific Name: *Oncorhynchus nerka*



Weight: 4-8 lbs., up to 15 lbs.

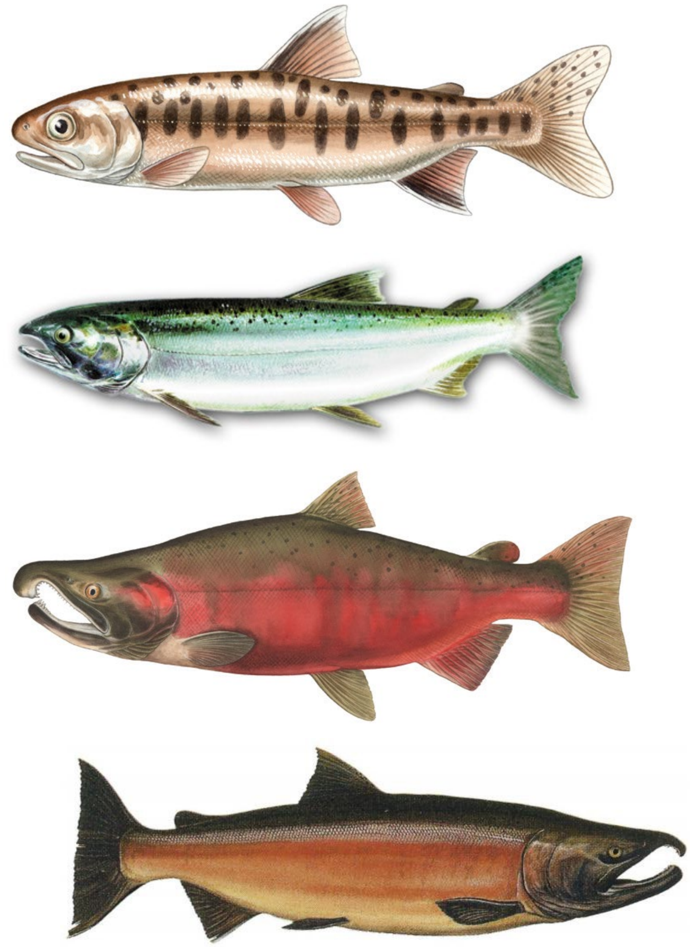
Length: 25-33 inches

Spawning Age: 3-6 years

Facts:

- Young sockeye spend 1-2 years rearing in lakes (not streams) before migrating to the ocean.
- Adult sockeye spawn in lakes or hundreds of miles upstream in tributaries to large lakes.
- They are the most important commercial species.
- They primarily feed on plankton in the ocean.
- During the spawning phase, the head and caudal fin become bright green and the body turns red.
- Land locked populations are known as kokanee.

Coho Salmon



Nicknames: silver, silverside

Scientific Name: *Oncorhynchus kisutch*

Weight: 6-15 lbs., up to 31 lbs.

Length: 24-38 inches

Spawning Age: 3 years

Facts:

- Young coho spend 1-2 years in freshwater, preferring small creeks and off-channel areas like beaver ponds.
- Adult coho spawn in the upper sections of small, lowland creeks and streams.
- Some coho travel less than 100 miles out into the ocean from the mouth of their natal stream while others travel over 1,000 miles.

Chum Salmon

Nicknames: dog, calico, keta

Scientific Name: *Oncorhynchus keta*

Weight: 9-15 lbs., up to 40 lbs.

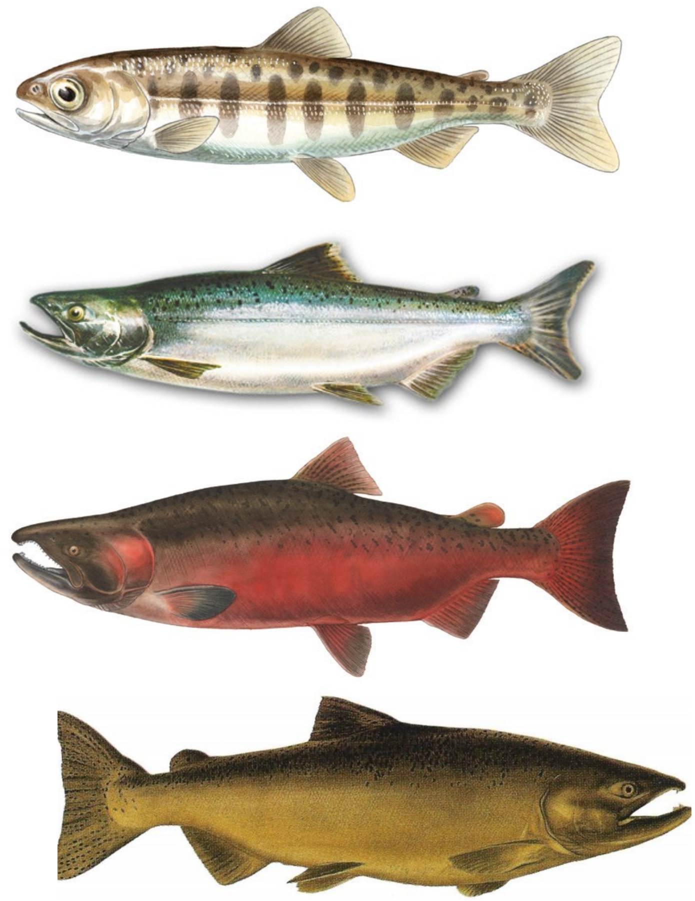
Length: 25-40 inches

Spawning Age: 3-5 years

Facts:

- Young chum migrate to saltwater soon after emerging from the gravel.
- Spawn in the lower sections of streams close to the estuary, where groundwater upwells.
- Adult chum are mass spawners, meaning their gravel nests (redds) overlap as many fish lay eggs next to each other or on top of each other's redds.
- Second largest salmon.
- Most widely distributed species of salmon, found from California to Korea.

Chinook Salmon



Nicknames: king, Tyee, blackmouth

Scientific Name: *Oncorhynchus tshawytscha*

Weight: 10-24 lbs., up to

125 lbs. (!!!)
(!!!)

Length: 36-58 inches

Spawning Age: 3-7 years

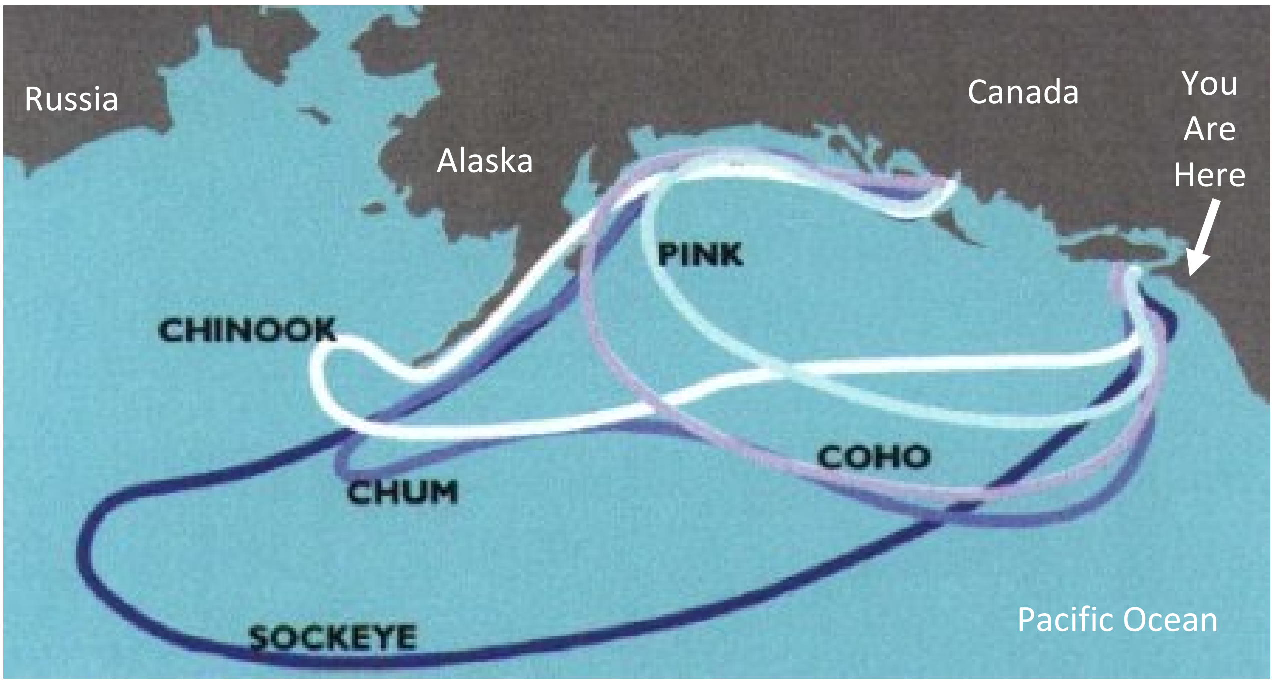
Facts:

- Young Chinook live in rivers and streams for up to a year before venturing to the ocean.
- Adult Chinook spawn in large rivers with fast side channels and fist-sized gravel.
- Chinook is named after a native tribe, so always capitalize the name.
- They are the largest, but least abundant salmon.

Salmon illustrations from Kate Spencer in the Atlas of Pacific Salmon

Salmon Species Migrations

Some salmon travel over 3,000 miles to get home!



Do you remember how they find their way home?

Earth's magnetic field then sense of smell

What makes salmon special?

What is one physical feature that all 5 salmon species have in common?

Develop hooked nose before spawning

Have an adipose fin

Able to switch osmoregulation to live in freshwater then saltwater

Change colors for spawning

What is one feature that makes one species unique?

Use any of the facts from the species sheets

How are salmon different from other fish?

Anadromous – start in freshwater, grow big in saltwater, return to freshwater

Die after spawning

Unit #4: Salmon Form and Function

Background information

salmon anatomy

Only some of the animals that live in water are fish. All fish have four things in common:

- a flexible backbone,
- cold blood,
- fins, and
- gills.

Other animals that live in water have only some of these characteristics. For example, whales have flexible backbones, but their blood is warm and they use lungs to breathe. Frogs have flexible backbones and cold blood, but they breathe with lungs.

Fish are usually torpedo-shaped, although they may be long and slender, short and stocky, or even balloon-shaped. The shape allows the fish to move easily through water with the least amount of energy. Whatever their shape, all fish have a head, a body and a tail.

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

Salmon have six bony fins on their body, which they use mainly for balance and steering:

- two pectoral fins near the head,
- two pelvic fins on the belly,
- an anal fin behind the belly, and
- a dorsal fin on the centre of the back.

Salmon also have an adipose fin, a small fatty fin on the back just in front of the tail, with no known use.

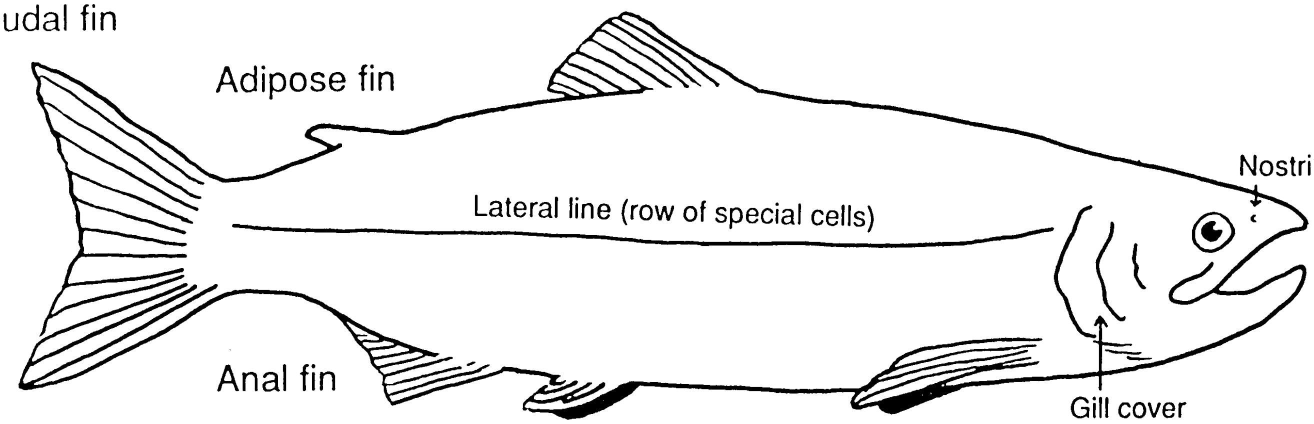
The tail, also known as the caudal fin, helps the fish keep balance, and pushes the fish forward through the water. Female salmon also use the tail to dig the redd in which they lay their eggs.

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

Scales and skin cover the body of most fish, including salmon. Scales are small hard plates like fingernails, but they overlap like shingles on a roof and protect the fish from predators, as well as from bruising. Scales begin to grow when the salmon are very young, and show annual growth rings, like trees. If scales are knocked off, salmon can grow new scales. Salmon and many other fish also have a slime layer that makes them slippery and protects them from disease organisms in the water.

From: Salmonids in the Classroom Primary, Fisheries and Oceans Canada

The external anatomy of a salmon



Fins – help salmon turn and balance

- **Pectoral Fin**
- **Pelvic Fin**
- **Anal Fin**
- **Dorsal Fin**

Adipose Fin – no known purpose

Tail (**Caudal Fin**) – moves salmon forward

Eyes – let salmon see

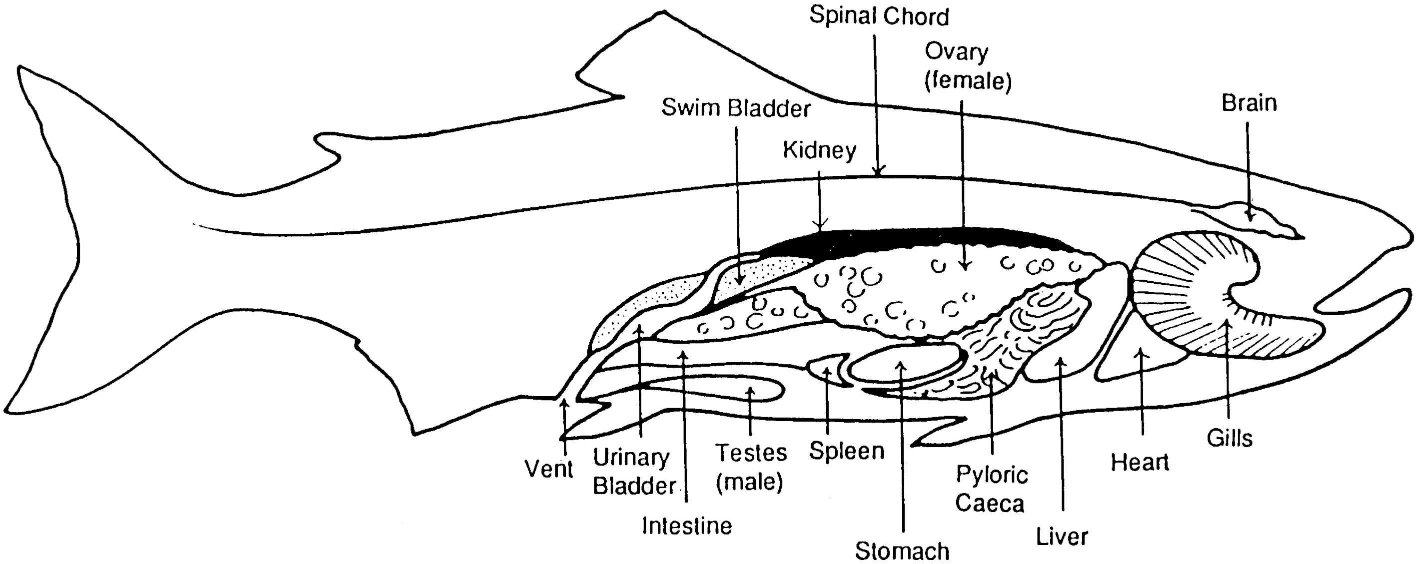
Nostrils – let salmon smell water

Mouth – let salmon eat

Gill Cover – protects gills and sends water to gills

Lateral Line – detects movement of water and other fish

The internal anatomy of a salmon



Spinal Cord – transmits information to/from the brain

Swim bladder – helps fish float

Kidney – removes waste from blood, produces urine, aid in osmoregulation (the control of substances like salt in body fluids compared to liquids outside the fish)

Vent – where waste, eggs, and milt are excreted

Urinary Bladder – stores urine

Liver – stores and distributes essential nutrients, maintains blood sugar

Intestines – absorbs nutrients into blood, regulates metabolism

Ovary (female) – produces eggs

Testes (male) – produces milt

Spleen – produces white blood cells, stores emergency blood

Stomach – digests food

Pyloric Caeca – digests food, absorbs nutrients into the blood

Heart – circulates blood

Gills – extract air from water

Brain – control center of the nervous system

External Anatomy Questions for Dissection

1. What is the first thing you notice when you handle a fish? If you had a fish in a big bag and you put your hand in, what would be the first thing you would notice?
   Slime.

2. Why is a fish slimy?
   - To slip away from predators
   - As an anti-abrasive to slip over rocks
   - Lubricant to enable easy swimming through the water
   - An "envelope" for protection from fungus, parasites and disease

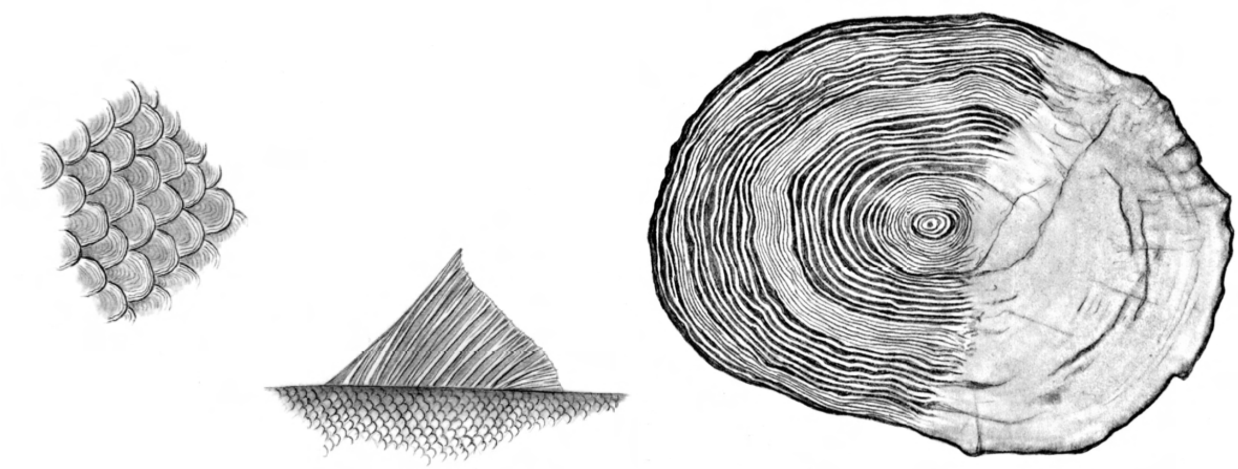
3. Identify the external anatomy. Eyes, gills, operculum, fins, nostrils, vent, lateral line.

4. Identify both single (caudal, anal, dorsal, adipose—if wild, hatchery fish have had their adipose fin clipped to identify it) and paired fins (pelvic & pectoral).

5. What are the fins for?
   Not for swimming, but for steering. The muscles of the entire body of the fish are used for propulsion, and even if the fish had no fins at all it could still make progress through the water; however it would not be able to right itself well.

6. How are the fins attached?

To muscle tissue, not to the skeleton. Why is that? Attachment to muscle provides greater flexibility.



7. What are the scales for?

   As "armor plating". Scales protect the fish when the glide over rocks or logs. They are also hard for birds or animals to grab. Remove a scale for later observation under a microscope or a hand lens.

8. Did the fish always have as many scales? Are there more now than when it was little?

   Fish have the same number of scales all their lives. The fish stacks up "plates" in order to grow the scale. This can be seen under magnification as rings. It is similar to a tree ring, with the difference being that the rings develop as food is available, and the groups of rings coincide with the seasons. Scales grow a little every year. An experienced biologist can determine the age of a fish by looking at the rings. Can you?

9. What do you think happens when a scale is shed?

Scales are regenerated to fit into the missing space, and so these scales will have a clear center, since it does not have the "plates" of previous growth stacked above.

10. Do all fish have the same scale arrangement?

The arrangement and placement of rows or scales is positive species identification. Each type of fish has a different arrangement.

11. What is the lateral line for?

It emits low level vibrations, somewhat like sonar. It functions something like an organ of touch, something like an organ of hearing, and something like an organ of seeing. It helps fish find their way when they cannot see, such as at night, or when the water is muddy.

12. How does a fish breathe? Ask for a volunteer to demonstrate.

The gulping action demonstrates how water is drawn in through the open mouth, the mouth and the throat closes, and the water is forced out past the gills. Gills extract oxygen from the water. Cold water, if saturated with oxygen and holding as much as it can, may have 13 parts of oxygen for every million parts of water.

To demonstrate what 13 ppm is, imagine that you have a million marbles, of which 13 are white oxygen marbles, and the rest are plain water marbles. If you were to drop one marble per second into your pocket, how long would it take you to reach a million? 12 days! Imagine how large your pocket must be.

At the end of 12 days of marble dropping, you would then drop in the 13 oxygen marbles: that shows how efficient gills must be, and how sensitive they are to material in the water. In fact some pollutants cause problems at levels of parts per billion. Using the same analogy, it would take 38 years of marble dropping to get a billion! Fish and all living things must live within an environment, which is why it must be clean!

13. Remove both sets of gills. Cut out the gills at their apex near the throat, then pare away up toward the spine on both sides. Take care not to cut along the belly but rather up toward the spine. Cut only as far as is necessary, as once the gills are freed near the throat they can be pulled out with the fingers.

14. What do the gills look like? How are they used?

The gills have an extensive blood supply, which accounts for their color. The laminae, or branches of the gills, perform the same function as the small sacs or alveoli within your lungs, in that they act to transfer the carbon dioxide from the body of the fish and absorb the oxygen from the water. The laminae are only two cells thick and present maximum surface area to permit the most efficient transmission of gases. Under a lens, the laminae look like a Christmas tree.

15. Look for the gill rakers. (The sharp spines that guard the opening of the throat). What do the gill rakers do?

The gill rakers prevent food from entering the gill passages, and instead guide it into the throat.

Internal Anatomy Questions for Dissection

1. When cutting open the fish, what do you expect to see?
   Place the fish on its side, belly away from you, on newspaper. If right-handed, hold the tail firmly with the left hand. It may help to use paper towels to improve the grip. Insert the tip of the knife into the vent and cut forward only as far as the pectoral fins, passing between the pelvic fins. A safe cut is away from your body with a truly sharp knife. A knife that is thin and flexible is best.

2. What is the first thing that you will see?
   If the fish is a mature female, a large portion of the body cavity is filled with eggs. If the fish is ripe and ready to spawn, the eggs will be loose within the body cavity; more likely the eggs are contained within a membrane. Pull out one of the roe sacs by hand and observe the blood vessels contained within the membrane. What are these for?

3. A mature Coho has 2,000-3,500 eggs. The egg provides one half of the genetic information needed in order for fertilization to occur. Why are so many eggs needed?
   On the average, and in rough proportions, Coho salmon lay about 2,500 eggs. Of these, only 15 percent live to hatch, leaving 375. Of those remaining, only 30 last the first year. Of those, only 4 make it to adult, and only 2 live long enough to spawn. What about the rest? If the fish is a male, a white bladder of milt will be easily observed. The milt provides the other half of the genetic information needed.

4. Looking into the body cavity, you will see a large dark red organ. What is this organ; the largest within a fish (or a person's) body? Remove it with your fingers.
   The liver stores, synthesizes and secretes the essential nutrients that were contained in the food. It plays a part of maintaining the proper levels of blood chemicals and sugars. The gall bladder, which is attached to the liver, contains green bile which in part is used to help digest fats.

5. Remove the stomach and upper gut. Use your fingers. It is attached at the throat and, which you cut when you remove the gills, and attached again at the vent. It will come away with the "spaghetti" of the pyloric caeca and the dark spleen attached. It will strip out to the vent.

6. The pyloric caeca act like a small intestine, in that they exude the digestive juices needed to break down the food, and absorb the components into the blood stream which passes it on to the liver.

7. The spleen acts as a storehouse of blood, to be used if there is an emergency, and to recycle worn-out blood cells.

8. If the fish has been taken from a river, it is unlikely that there is any food anywhere in the digestive system. Salmon do not eat once they enter freshwater, and it may be as much as 16 weeks from the time that they take their last meal in the ocean and the time that they spawn and die.

9. The digestive tract is surprisingly short and simple, and does not have the extensive intestine that mammals have. This is because

fish are cold-blooded, and do not require a large amount of energy to be extracted from their food since they do not heat their body by their metabolism.

10. We have not seen the heart yet-is it where you thought? Carefully continue to belly cut forward to the throat, but only deep enough to cut through the skin. Find the heart and remove it. What does it look like?

11. The heart is located where the gill covers begin to come together high up in the throat, and it may be removed with the fingers. It is triangular in shape, and consists of 4 chambers, as does your heart. The white tube is the venal aorta, and it leads the short distance to the gills. Why is it located so close to the gills?

12. Remove the swim bladder that is attached to the esophagus by stripping it out from the front with your fingers. Would anyone care to demonstrate how the swim bladder can be inflated?

Most fish are able to adjust the amount of air in their swim bladder so that they are able to stabilize their movement within the pressures of the water. Notice that the swim bladder is just below the spine, which is just below the center line, or the center of balance of a fish. This is why fish float upside down when they die.

When a fish, such as a salmon, is deep in the ocean, it adjusts the amount of air in its swim bladder so that it can hover comfortably without sinking or rising in the water. If it wants to come up to the surface, it must release some of this air, something like a burp, in order to hover at the higher depth. Some bottom fish, such as a rockfish, are unable to adjust their swim bladders by burping, and this is why when a bottom fish is caught and brought to the surface its stomach protrudes into its mouth: the swim bladder has expanded due to decreased pressure and is forcing the internal organs out through their throat.

13. The dark red line along the backbone is the kidney. Where are your kidneys located and what are they for?

The forward part of the fish kidney functions to replace red blood cells, and the rearward part filters waste out of the blood. The kidney can be removed by slicing through the membrane along each side, and then scraping with the spoon.

Unit #5: Salmon Habitat and Water Quality

Background information

SALMON HABITAT

Small streams and lakes produce most of the West Coast's fish, including six salmon species and over 80 species of freshwater fish. Salmon all spawn in shallow water, and many species spend a year or more in the stream or lake after they hatch. Salmon habitat is easily damaged by logging and mining activities, by urban and industrial construction, and by pollution. Many of these practices are changing to protect streams and revitalize streams that have been damaged in the past.

Water. At every stage in their life, salmon need clean water that is between 5˚C and 10˚C and which contains oxygen. A healthy salmon stream has a mix of fast running water and deep pools. Fast running water washes over rocks in riffles and picks up oxygen. Deep pools that form at the edge of a stream and in the water behind rocks, logs or other debris allow salmon to rest from the current and hide from predators. Cloudy water contains silt and mud that can smother eggs and irritate the gills of young salmon. Cloudy water also makes it harder for salmon fry to find and catch food.

Young salmon are very sensitive to pollutants in the water. Household chemicals like bleach, soap, oil or paint can be fatal if people dump them into a stream. Many pollutants enter streams through storm sewers, which carry rainwater from paved streets to nearby streams. Pollutants dumped down storm drains can kill salmon and wildlife in nearby streams.

Stream banks and lakeshores. The gravel bottom of a salmon stream or lake contains a mix of rock sizes. Salmon need gravel to spawn, but once the alevin emerge, the presence of pools and riffles is more important. The slope and curves in the streambed are important to control the flow of water and reduce flooding during storms.

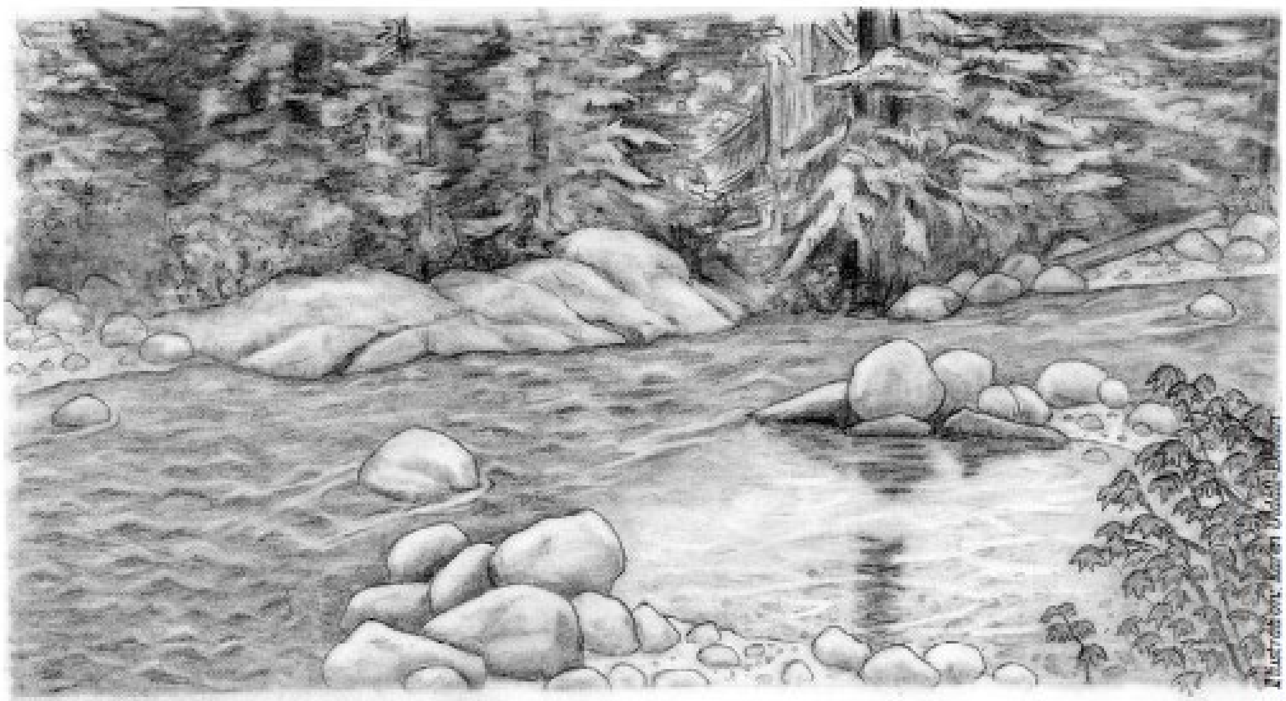
Stream banks lined with plants soak up water during heavy rain and release it slowly into the stream. Marshes and similar wetlands also absorb rainfall to prevent flooding and reduce the chance of streams and lakes drying out in hot weather. Bushes and trees growing along the banks of a stream create shade and keep the water cool in the summer, keep the banks stable and allow salmon to hide in the shadows. Insects live in the vegetation along the banks and fall into the water as food for salmon. To protect the stream banks, laws prohibit construction or logging near the streams.

Food. Salmon fry catch tiny insects that float past them. As they grow, the salmon can catch larger insects and caterpillars that fall into the stream or lake, as well as mayflies and stoneflies that land on the water to lay their eggs. When they are large enough, the salmon can eat smaller fish in the stream or lake.

People. People disturb streams and lakeshores and their natural residents when they remove the vegetation, divert the water flow, pollute the water or build docks. People can erode the banks by playing or driving along the edges of a stream or lake. They can crush salmon eggs in the gravel or expose them at a very sensitive stage. People and pets sometimes harass spawning salmon in shallow streams or leave garbage at the site.

But people can also protect and restore streams and lakes. Many groups and individuals act as streamkeepers, conducting stream inventories and monitoring environmental health, working for the streams' protection, replanting and restoring streams that have been damaged or buried in culverts. People should be conscious that they share the stream with others and that every organism contributes to the health of the ecosystem.

A Healthy Salmon Habitat



Salmon need many things to make a home.

Salmon live in streams and lakes. They like cold water. The water must run fast. It must be clean. Salmon also like to rest in still pools.

The lakebed or streambed must have clean rocks and gravel. Gravel is a mix of small stones and sand. Salmon do not like mud or dirt.

Salmon need bushes and branches to shade the water. The shade keeps the water cool. Salmon can hide in the shade.

If a lake or stream has all these things, it is a good home for salmon.

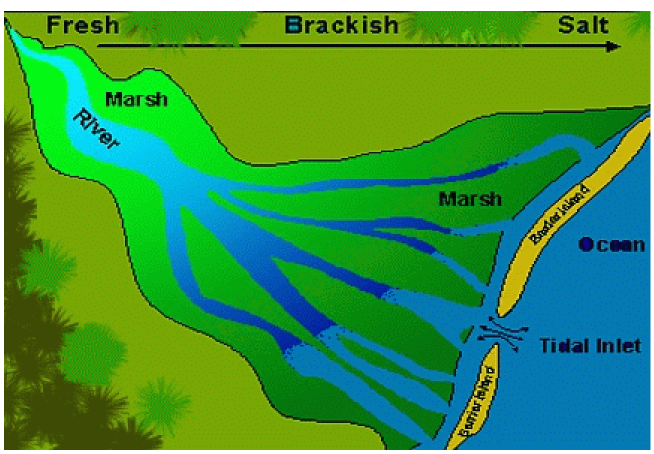
Do not play in a salmon stream. Salmon do not like to be disturbed.

Salmon need a cool, clean habitat.
Is this stream a good salmon habitat?

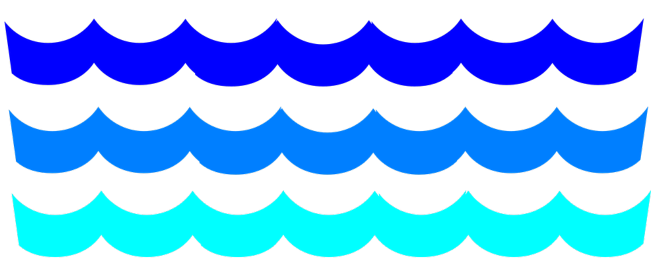
What are the 3 habitats that salmon live in throughout their lives?

There are 3 types of water habitats that salmon live in throughout their life cycle.

Salmon begin their life in **FRESHWATER** streams and rivers.



Then they swim downstream into an **ESTUARY,** where freshwater and saltwater mix.



Then they travel even further out into the **OCEAN** saltwater to grow big before returning home to the freshwater again.

What are the 3 Cs of salmon habitat?

Salmon need water that is

cOLD

cLEAN, and

cLEAR.

COLD water can hold more oxygen than warm water because the molecules in are denser. Salmon pull that oxygen out of the water with their gills.

CLEAN water is important because pollutants and trash can inure or kill salmon. What things might be considered pollution in a stream?

_____________________ _____________________

_____________________ _____________________

_____________________ _____________________

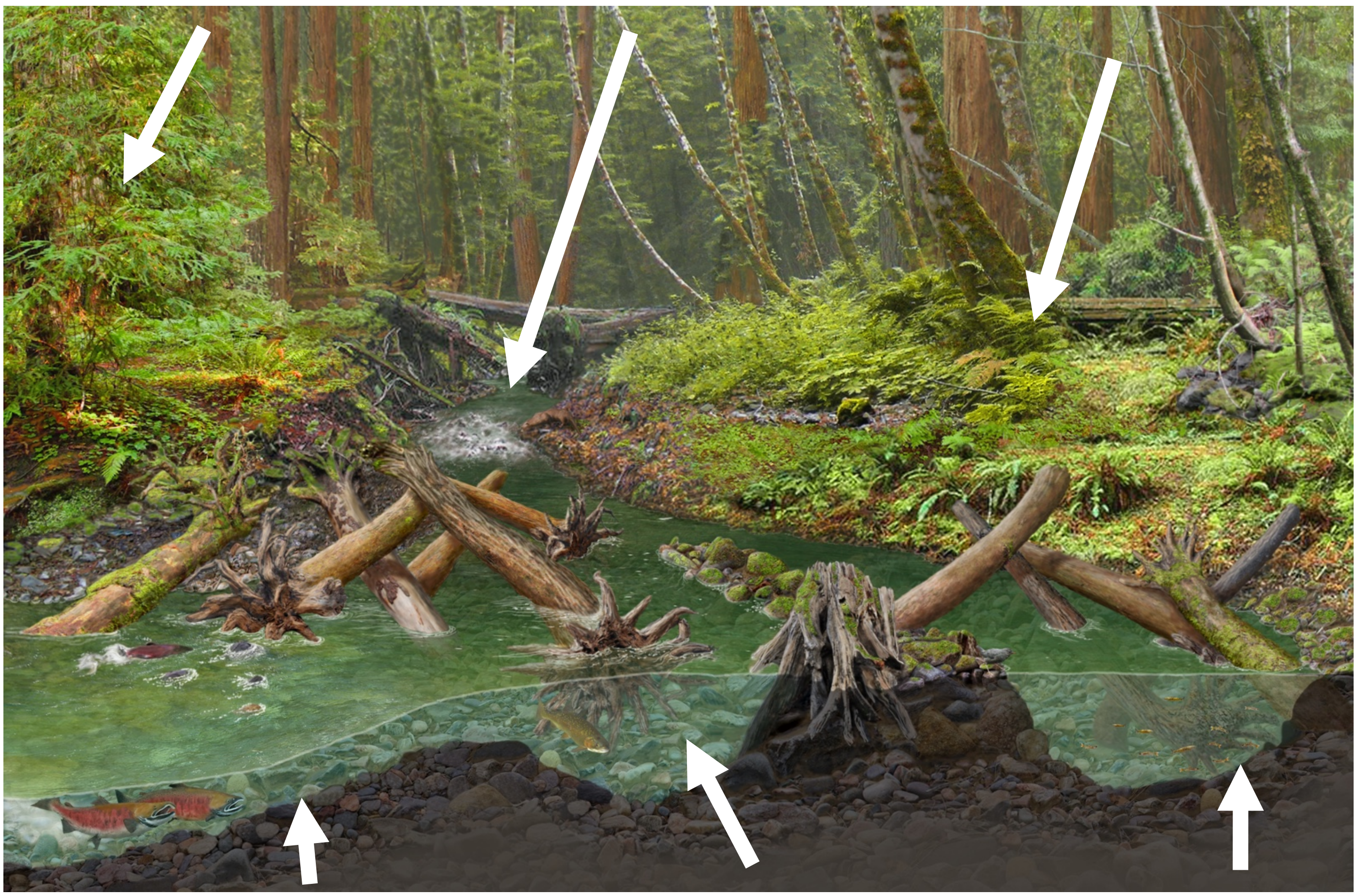
CLEAR water allows salmon to breathe without being smothered. Just like smoke makes it hard for us to breathe, dirt in the water clogs salmon's gills so they can't breathe.

What else makes for good salmon habitat?

TREES shade the river and keep the water cold

RIFFLES over rocks put more oxygen into the water

TREE ROOTS hold soil in the riverbank so it doesn't wash into the water and smother fish



GRAVEL for the redd isn't too big to move and not so small it smothers the eggs

POOLS provide a resting place for fish to take a break from swimming

Dead TREES fall into the river and provide shelter for fish

Macroinvertebrates

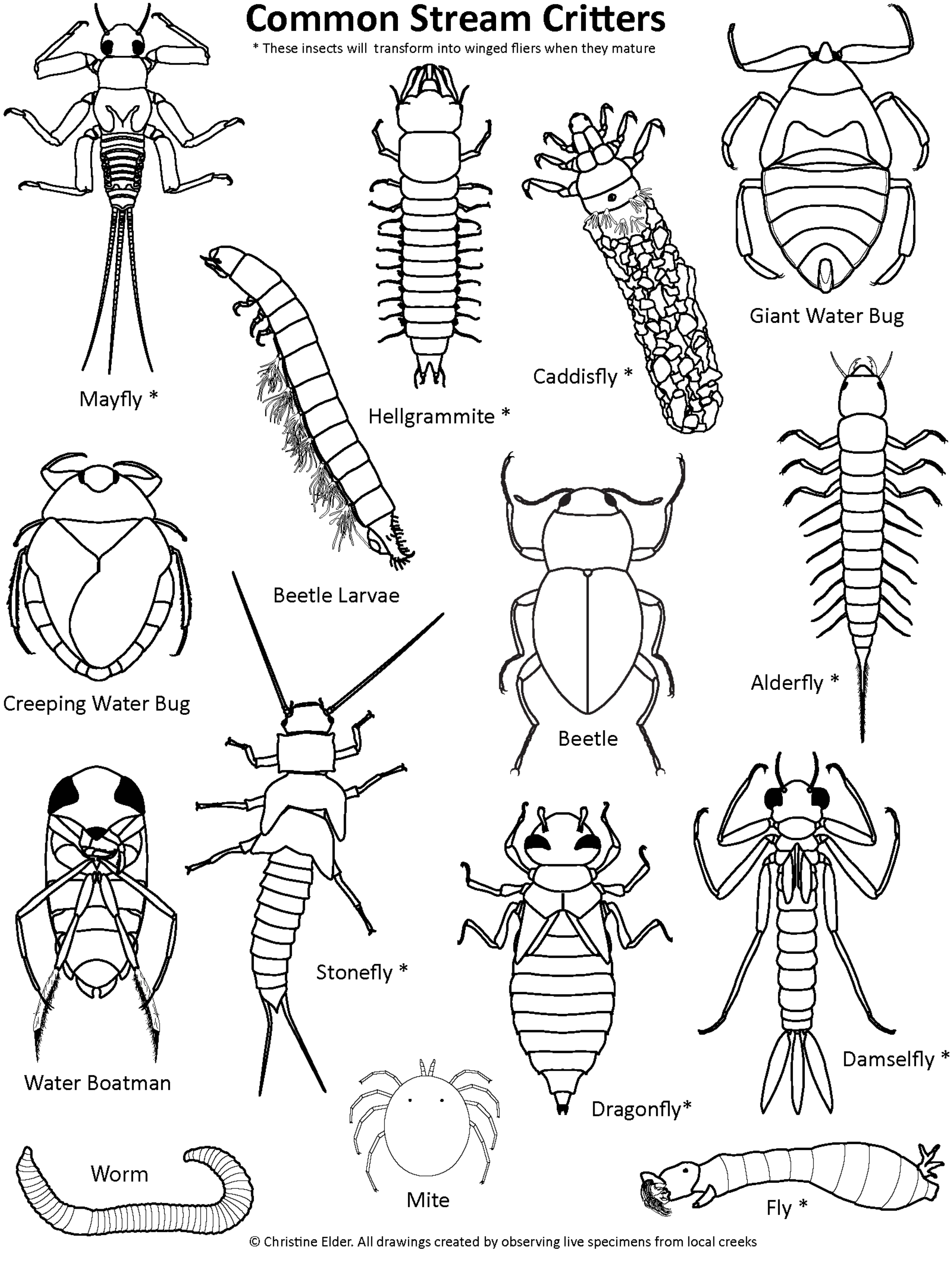
The stream bugs that live in the water are called aquatic macroinvertebrates. The ones that live on the bottom of the stream are called benthic macroinvertebrates. Benthic means living on the bottom.

Benthic macroinvertebrates are important for salmon for two reasons: 1) they are a food source for juvenile salmon, and 2) they are used as indicators of pollution levels in the stream because some species of stream bugs do not tolerate pollution and only live in very clean streams.

Let's label some common types of macroinvertebrates found in Washington streams that juvenile salmon like to eat.

Common Stream Critters

* These insects will transform into winged fliers when they mature



How is water important for humans and salmon?

What would happen to humans if the water in streams and lakes dried up?

Humans would not have water to drink and would die.

What would happen to salmon if the water in streams and lakes dried up?

Salmon and their eggs would die.

What would happen to humans if the water in streams and lakes was very muddy?

Without clean water, swimming would not be very fun. The water could also make humans sick.

What would happen to salmon if the water in streams and lakes was very muddy?

Salmon and their eggs would smother.

What would happen to humans if there were no shady trees or air-conditioned buildings to take shelter in on hot days?

Humans would overheat and be harmed by heatstroke.

What would happen to salmon if there were no trees along their river or lake to shade it on hot days?

The water would become too warm and would harm salmon and their eggs.

What would happen if you were swimming in a stream and the water flowed too fast?

You could get carried away by the current.

What would happen to salmon if stream water flowed too fast?

Eggs, young salmon, gravel, and foods might be washed away. Stream banks would erode and make the water muddy, suffocating salmon.

Pollution

DOG POOP contains dangerous bacteria. Pet waste is one of the leading causes of bacterial contamination in streams. Always scoop the poop!

When your car leaks OIL onto the road, rain washes it down storm drains that lead directly to water where salmon live. Oil is toxic to salmon. Fix car leaks or ride your bike instead of driving.

FERTILIZERS and PESTICIDES contaminate streams when they get washed away by rain. They can kill salmon and the insects that salmon eat in the streams.

Clean Water and Salmon

Like every living thing on earth, salmon need water to survive. Their **habitat** or home is water. Salmon live in rivers, streams and oceans. They depend on clean water to stay healthy and produce the next generation of fish. Water pollution is a major problem for salmon. When the water is polluted, the salmon are in danger of dying before they have a chance to complete their life cycle.

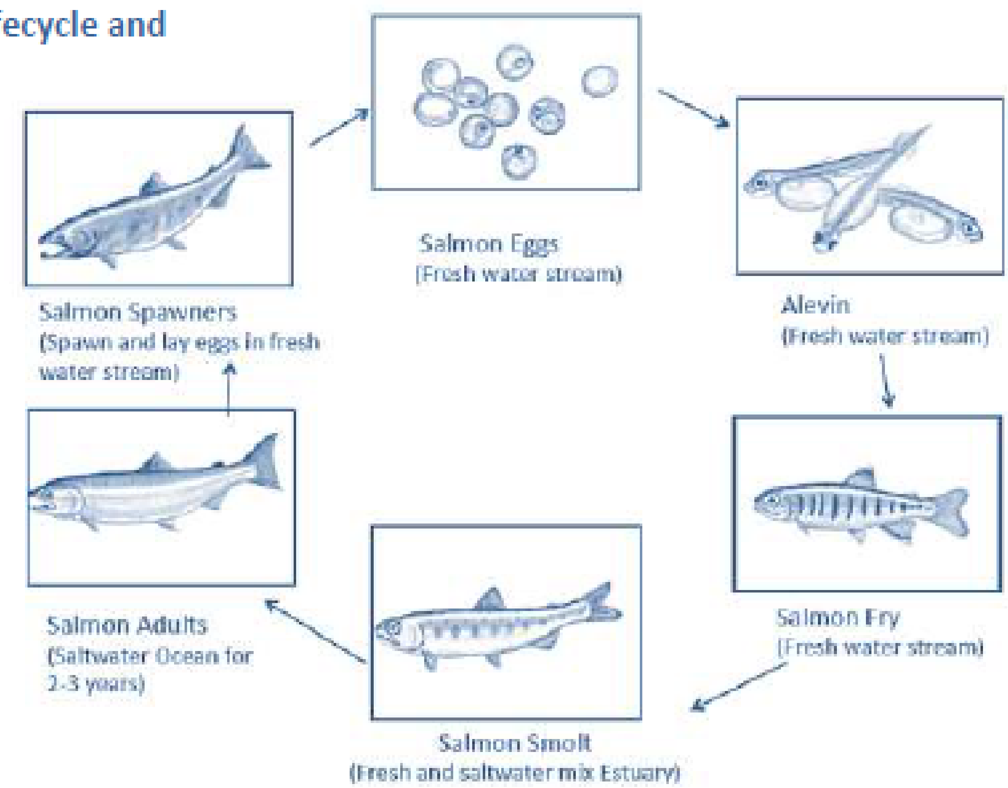
Fresh and Salt Water

Salmon live in two different habitats. One habitat is fresh water and the other is salt water. Salmon begin their life cycle in the shallow fresh water of a stream. Adult salmon lay eggs in the stream. When the salmon eggs hatch, the small fish (alevins) begin their lives. The salmon continue to grow larger in fresh water until they are big enough to begin their journey as adults to the ocean.

Alevins

The ocean is made up of salt water. The salmon become large and strong by swimming and feeding in the ocean. After three or four years, depending on the type of salmon, the fish return to their homes in the fresh water of the streams. They travel from salt water into the mouths of rivers and swim up them to the streams where they were born. Here, the salmon will spawn and lay their eggs. This begins a new life cycle for the salmon.

Salmon Lifecycle and Habitat



Water Pollution

Salmon call water their home as do many other plants and animals. When the water is polluted, the salmon cannot stay healthy. Trash in rivers and streams can block the salmon from swimming to their birthplaces. Chemicals and certain bacteria can also harm the water. Chemicals that we use on our lawns and gardens can be **toxic** to fish. Soap from washing our cars can find its way down storm drains and out into the rivers and ocean. Pet waste is another major way that water is polluted. Here are some actions you and your families can take to help save our salmon:

What can YOU do?

- ✓ Use lawn and garden products that are safe for the environment.
- ✓ Wash cars on grass or at car washes where the water is recycled
- ✓ Pick up pet waste and dispose in the garbage
- ✓ Buy cleaning products for the home that are free of ***toxic*** chemicals
- ✓ Do not dump garbage in streams, rivers or oceans
- ✓ Volunteer to pick up trash along water ways, including ocean beaches

Water is the home to many living creatures including the Northwest salmon. When chemicals, garbage, and pet waste pollute these habitats, salmon may not be able to survive. Can you image life without salmon? Salmon are an important food source for people all over the world. Clean water is one way we can Save Our Salmon. Do your part to protect the habitat of these amazing fish!

Clean Water and Salmon

Why do salmon need clean water?

Because the water is their home. They cannot survive in contaminated water.

How does water become polluted?

Dog poop that wasn't picked up gets washed into the water when it rains.

Oil on the road flows into storm drains which empty into streams and estuaries.

Fertilizers and pesticides run downhill when it rains and end up in streams.

What actions can we take to keep the water clean?

- Use lawn and garden products that are safe for the environment
- Don't overfertilize your lawn or garden
- Wash cars on grass instead of letting it run down the street directly into storm drains.
- Pick up pet waste and dispose in the garbage.

- Buy cleaning products for the home that are free of toxic chemicals.
- Do not dump garbage in streams, rivers, or oceans.
- Fix oil leaks in your family's cars.
- Volunteer to pick up trash along water ways, including ocean beaches.

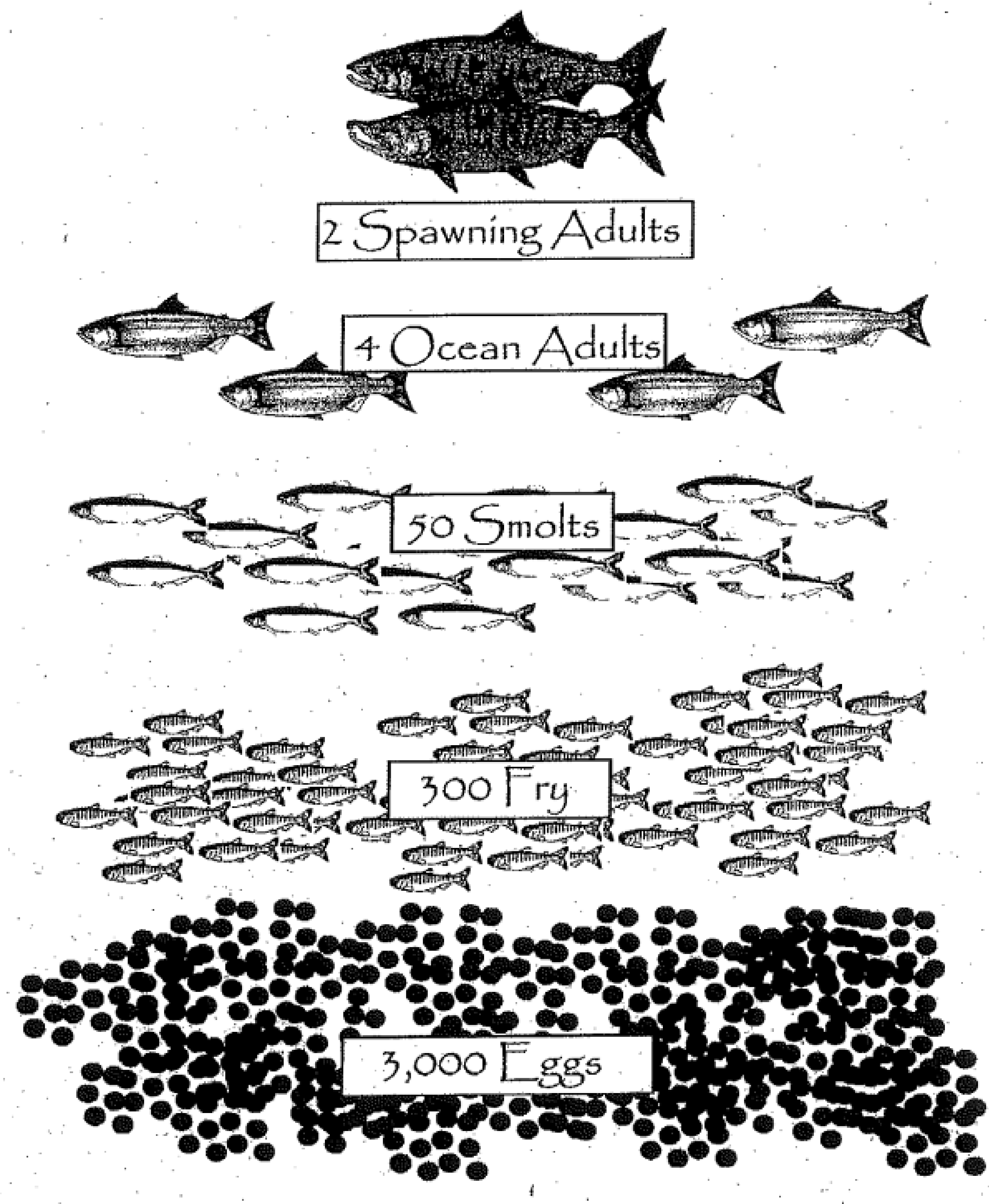
Salmon Vocabulary Match-Up

Draw a line between the word and its definition:

Adult	The nest where salmon lay their eggs
Alevin	Freshwater life stage where a salmon embryo develops
Culture	Freshwater life stage where salmon have a yolk sac
Ecosystem	Freshwater life stage where salmon have parr marks
Egg	Life stage where salmon migrate to the estuary
Endangered	Life stage where salmon grow big in the ocean
Environment	Life stage where salmon return to their home river spawn
Erosion	To move from one place to another
Estuary	Threatened with disappearing
Fertilize	An animal that hunts other animals
Fry	Where plants and animals naturally work together
Habitat	Something that makes water, soil, or air unclean or toxic
Larva	A group of animals or plants that has many things in common
Migrate	The plants, animals, soil, and climate around us
Pollutant	Ways of living that hold a group of people together
Predator	The baby form of an insect
Redd	The place where a plant or animal lives
Smolt	To enrich so that an animal or plant can reproduce or grow
Spawner	Where freshwater and saltwater mix
Species	The process of wearing down and carrying away of soil/rock

Unit #6: Salmon Survival

How many salmon survive each life stage?



What threats do spawning adults face?

Fishermen, eagles, chemicals in the water from pollution

What threats do ocean adults face?

Bigger predators like orca whales and fishermen

What threats do smolts face?

Clean/cold/clear water in estuary, lack of food (krill, shrimp), predators like seals and bigger fish and birds

What threats do fry face?

Lack of food due to no trees for insects, clean/clear/cold water, predators like ducks, bigger fish, birds

What threats do eggs and alevin face?

Temperature, pollution, turbidity, drought, flood

Why are salmon important in Washington State?

Cultural Importance:

Salmon FEED the native tribes.

Salmon are part of important tribal CULTURE.

Ecological Importance:

Salmon feed other animals like BEARS, EAGLES, and ORCA WHALES.

Salmon carcasses bring marine-derived NUTRIENTS to trees. Trees are what our homes are made of. So in one sense, salmon help build our homes.

Economic Importance:

Commercial salmon FISHING provides many jobs and food for people in Washington.

Recreational salmon FISHING brings money into small towns that fishermen visit on their fishing trips.

How are salmon connected to your local community?

How can we help salmon?

Salmon need cold water. What can we do to help?

Plant trees to shade streams. Keep old forests alive.

Salmon need clean, pollution-free water. What can we do to help?

Don't leave trash in or near streams. Pick up dog waste. Don't overuse fertilizers or pesticides. Don't dump chemicals down storm drains.

Salmon need clear, dirt-free water. What can we do to help?

Plant trees so the roots hold the dirt in the riverbanks instead of washing into the stream when it rains. Let streams meander so they can filter dirt through a series of pools and riffles.

Salmon need to be able to swim upstream a long way. What can we do to help?

Don't build rock dams in streams. Fix old culverts that are too small or high for salmon to swim through.

Salmon need to be able to grow big enough to not be eaten by predators. What can we do to help?

Plant lots of different native plants alongside the river for insects to live in to feed the salmon. Open up access to different habitat types to allow salmon to grow big in sheltered areas.

Salmon need to make it back home to spawn. What can we do to help?

Don't take more fish than we need when fishing. Don't overfish the smaller fish that big salmon eat.

Salmon Haiku Poetry

Objectives

- Students will compose a haiku poem about salmon.
- They will learn what a haiku poem is and translate their knowledge, wonder, or feelings into haiku form.
- They will exercise creativity by writing their haiku on a piece of salmon artwork.

Materials

- Printout of salmon outline to color with space for writing below
- Scratch paper to write drafts of haikus
- Colored pencils
- Pencil/pen to write haiku

Introduction (5 minutes)

- What is a syllable? What is a Haiku?
- Examples of haiku poetry

Determined swimmers
leaping through the ocean waves
their journey goes on

Swimming down the stream
Coho, Chinook, and Sockeye
Ocean bound to live

The tree has fallen
Salmon fry take shelter here
All life connected

Salmon swim upstream
Leaves born green, turn brown, fall down
Life's unending progress

Leaves fall to the ground
The chum salmon bury eggs
Death smells like new life

Fry swim to the sea
Growing big and swimming fast
Far away from home

- Introduce haiku poetry to the class by showing them examples. Emphasize the syllable count:

first line: 5 **second line: 7** **third line: 5**

- Write this syllable count on the board.
- Give some examples of words and the number of syllables they contain.

1 Syllable Words		**2 Syllable Words**		**3 Syllable Words**	
Egg	Chum	Salmon	Welcome	Alevin	Oxygen
Fry	Home	Adult	Little	Alaska	Pollution
Parr	Bugs	Spawner	Marine	Washington	Potato
Smolt	Bear	Gravel	Ready	Butterfly	Survival
The	Whale	Water	Noble	November	Universe
Fish	Fall	Ocean	Autumn	Beautiful	Victory
Dead	Spring	River	Winter	Fantastic	Family
Smell	Cold	Swimming	Shallow	Habitat	Animal
Tree	Day	Coho	Fearless	Magnetic	Dinosaur
Leaf	Long	Chinook	Stormy	Halibut	Dangerous
Leaves	Food	Sockeye	Slimy	Sediment	Calendar
Dirt	Eat	Future	Stinky	Curious	Quietly
Life	Tail	Journey	Smelly	Energy	***Bonus 4**
Swim	Fin	Hungry	Eagle	Existence	**syllable word:**
Pink	Splash	Lucky	Otter	Library	superhero

Activity (30 minutes)

- Give each student a salmon printout and supplies to color it. (Set a time limit!) Ask them to think about what they might want to say in their haiku as they color. When all are finished, direct them to set their papers aside.
- Guide students in writing a haiku about a salmon fact, a behavior they have observed in their tank, what they see in their mind's eye when they picture salmon in the wild, salmon habitat/what salmon need to survive, their relationship with salmon, what salmon bring to the ecosystem, etc. Encourage them to write multiple drafts on scratch paper until they are satisfied.
- Direct them to use a pen/pencil to write their haikus below their coloring.

Closing Activity/Assessment (10 minutes)

- As time permits, ask each student to read his or her haiku to the class.
- Cut out the salmon profile and post in the classroom or hallway for all to see and enjoy as the fish "swim" along the wall.
- Teachers may submit photographs of their students' work via email to meganb@spsseg.org to participate in South Puget Sound Salmon Enhancement Group's Student Salmon Haiku Poetry Contest. Students must attend a public school in Mason, Thurston, or Pierce counties to participate. One winning haiku poem will be chosen from each grade level that participates. The winners will earn a prize for their entire classroom.

Adapted from Salmon in the Schools-Seattle lesson plan.

3-LS1-1. Develop models to describe that organisms have unique and diverse life cycles but all have in common birth, growth, reproduction, and death. [Clarification Statement: Changes organisms go through during their life form a pattern.] [Assessment Boundary: Assessment of plant life cycles is limited to those of flowering plants. Assessment does not include details of human reproduction.]

3-LS3-1. Analyze and interpret data to provide evidence that plants and animals have traits inherited from parents and that variation of these traits exists in a group of similar organisms. [Clarification Statement: Patterns are the similarities and differences in traits shared between offspring and their parents, or among siblings. Emphasis is on organisms other than humans.] [Assessment Boundary: Assessment does not include genetic mechanisms of inheritance and prediction of traits. Assessment is limited to non-human examples.]

3-LS3-2. Use evidence to support the explanation that traits can be influenced by the environment. [Clarification Statement: Examples of the environment affecting a trait could include normally tall plants grown with insufficient water are stunted; and, a pet dog that is given too much food and little exercise may become overweight.]

3-LS4-3. Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all. [Clarification Statement: Examples of evidence could include needs and characteristics of the organisms and habitats involved. The organisms and their habitat make up a system in which the parts depend on each other.]

4-ESS3-1. Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment. [Clarification Statement: Examples of renewable energy resources could include wind energy, water behind dams, and sunlight;

non-renewable energy resources are fossil fuels and fissile materials. Examples of environmental effects could include loss of habitat due to dams, loss of habitat due to surface mining, and air pollution from burning of fossil fuels.]

MS-LS1-5. Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms. [Clarification Statement: Examples of local environmental conditions could include availability of food, light, space, and water. Examples of genetic factors could include large breed cattle and species of grass affecting growth of organisms. Examples of evidence could include drought decreasing plant growth, fertilizer increasing plant growth, different varieties of plant seeds growing at different rates in different conditions, and fish growing larger in large ponds than they do in small ponds.] [Assessment Boundary: Assessment does not include genetic mechanisms, gene regulation, or biochemical processes.]

MS-LS1-4. Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively. [Clarification Statement: Examples of behaviors that affect the probability of animal reproduction could include nest building to protect young from cold, herding of animals to protect young from predators, and vocalization of animals and colorful plumage to attract mates for breeding. Examples of animal behaviors that affect the probability of plant reproduction could include transferring pollen or seeds, and creating conditions for seed germination and growth. Examples of plant structures could include bright flowers attracting butterflies that transfer pollen, flower nectar and odors that attract insects that transfer pollen, and hard shells on nuts that squirrels bury.]

MS-LS1-5. Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms. [Clarification Statement: Examples of local environmental conditions could include availability of food, light, space, and water. Examples of genetic factors could include large breed cattle and species of grass affecting growth of organisms. Examples of evidence could include drought decreasing plant growth, fertilizer increasing plant growth, different varieties of plant seeds growing at different rates in different conditions, and fish growing larger in large ponds than they do in small ponds.] [Assessment Boundary: Assessment does not include genetic mechanisms, gene regulation, or biochemical processes.]

MS-LS2-5. Evaluate competing design solutions for maintaining biodiversity and ecosystem services. [Clarification Statement: Examples of ecosystem services could include water purification, nutrient recycling, and prevention of soil erosion. Examples of design solution constraints could include scientific, economic, and social considerations.]

MS-ESS3- 3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment. [Clarification Statement: Examples of the design process include examining human environmental impacts, assessing the kinds of solutions that are feasible, and designing and evaluating solutions that could reduce that impact. Examples of human impacts can include water usage (such as the withdrawal of water from streams and aquifers or the construction of dams and levees), land usage (such as urban development, agriculture, or the removal of wetlands), and pollution (such as of the air, water, or land).]