Salmon Life Cycle

Salmon begin their life in freshwater streams, rivers and lakes. Their life begins in the gravel of stream or lakebeds. Mature females dig a nest, called a **redd**, in the gravel. Here they lay as many as 6,000 eggs (chinook may lay up to 17,000 eggs). The average is between 2,500 and 3,000. The male salmon fertilizes the eggs, and the female covers them with gravel for protection.

The eggs slowly develop under the gravel over the winter months. When the eggs hatch they are called **alevins**. Alevins continue to live in the gravel and take nourishment from a **yolk sac** attached to the underside of their bodies. By the spring, they finish the yolk sac, and miniature salmon called **fry** come out from the gravel.

Coho, chinook and sockeye salmon and steelhead trout remain in fresh water for a time. Chum and pink salmon travel downstream to the sea soon after they come out from the gravel.

Salmon fry eat constantly and grow quickly. When they reach what is called the **smolt** stage, they move downstream to the **estuary**, where the river meets the sea. They stay in the estuary for a time while their bodies adapt to being in salt water. Once the smolts can survive easily in salt water, they travel into the ocean.

Some types of salmon wander as far as 3,200 kilometres from their home stream. Others stay closer to home. As they grow to adulthood, the salmon eat small fish and tiny animals that live in the sea.

When they are ready to **spawn**, or lay their eggs, the salmon return to the stream or lake where they hatched. During the difficult journey to the spawning grounds, their bodies change colour and shape. Once they lay and fertilize their eggs, their life cycle is complete and the salmon die.

Salmon Eggs

When adult salmon swim upstream to spawn in the fall, the female chooses a site in a stream with a gravel bed and plenty of flowing, fresh water. With her body, she digs a shallow depression called a redd, like a nest in the gravel.

Depending on the species and size, each female lays from 2,000 to 6,000 round, pinky-orange eggs, about 6 to 9 mm in diameter. Instead of a hard shell like a chicken, each egg has a soft, transparent wall. This wall, or membrane offers little protection against predators or other disturbances, so after the male fertilizes them the female covers the eggs with gravel. Birds, bears and raccoons eat the eggs if they can find them, and flooding, pollution and disease also destroy the eggs.

Salmon eggs are very sensitive--only one in 10 surives to hatch. In the first days, even a slight disturbance of the streambed can be fatal Changes in water level or temperature can kill many eggs; they are also very sensitive to pollution in the water. The eggs need pure, clean water, with little silt and a small amount of oxygen dissolved in the water.

Salmon begin to develop inside the egg. Because they are cold-blooded, the water temperature controls the rate at which the salmon develop. The ideal temperature for salmon eggs is from 5 to 9°C. The eggs will die above 20°C or below freezing. Eggs develop more slowly at lower temperatures.

Salmon Alevin

Wiggling energetically, the salmon embryo in an egg breaks through the egg lining and makes its way out of its egg and into the gravel. For the next 30 to 50 days, it lives as an alevin (A-le-vin – the A can be pronounced like play or like cat) in the dark spaces between the stones in the gravel of its home stream. As with the egg, the rate of an alevin's development depends mainly on the water temperature, which should range from 5°C to 14°C.

The yolk sac, which remains attached to the alevin's belly, provides the food it needs. The sac shrinks as the alevin develops, gradually allowing it to move about more easily.

The alevin's respiration, or breathing, system also develops, allowing it to breathe through its gills. Clear, flowing water is still important, but an alevin can swim through spaces in the gravel away from gravel that is too silty. Also, an alevin can clear small amounts of silt from its gills, so it can live in water that has more silt than salmon eggs can accept.

Alevins need cold running water that is rich in oxygen and they need clean gravel with spaces in which they can hide. Threats include predators in the water, siltation, pollution, floods and other activities that can disturb the gravel. People can protect the alevins by keeping dirt or other pollutants out of the water and by staying out of stream gravel.

Because alevins keep the orange colour of the salmon egg and their yolk sac slows their movements, they are an easy target for predators. Alevins avoid light and live as much as 30 cm down in the gravel. However, as they grow stronger and their yolk sac grows smaller, they begin to move up to the surface of the gravel. They develop dark markings on their skin that help them hide on the streambed.

When the yolk sac is completely absorbed, or "buttoned up", alevins are about 2.5 cm long. In spring, when the water begins to warm and algae, insects and plankton grow in lakes and rivers, alevins emerge as fry to begin the next stage of their life.

Adapted from Jim Wiese,
Salmon Below the Surface, pp 35-36

Salmon Fry

Alevin emerge from the gravel to begin the next stage of their life as "swim-up" fry, and then "free-swimming" fry.

Rapidly vibrating their tail, they push themselves up to the surface of the water and swallow a mouthful of air. The air is not for breathing, but to balance the weight of their body and allow them to float in water. It goes into a **swim bladder**, an organ like a balloon in their abdomen. They may have to take several gulps until they have enough air.

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. Salmon fry eat the nymphs and larvae of insects such as stonefly, mayfly, caddisfly and black fly. They also eat plankton and some land insects that fall into the water. They grow from about 2.5 cm to between 4.5 and 5.5 cm during the summer.

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**, dark bars across their bodies. The mixture of light and dark helps them blend into the shadows on the stream bed so they are harder to see. They also dart very quickly from spot to spot.

Almost 90 per cent of all fry die from predators, disease or lack of food. They still need fresh flowing, cold water, with plenty of oxygen and shade to keep the water from getting too warm. People can help increase their survival by protecting their environment from pollution, flooding or blockages.

A crucial part of the salmon life cycle begins at the fry stage— **imprinting**. Salmon fry remember the smell of the water they grew up in. When they return as adults, they try to find the same spot. The rocks and soil in the stream bed, plant life and other aquatic organisms all create the scent that salmon return to. Changes in the environment of the stream can confuse the returning salmon, and prevent them from spawning.

Some salmon species spend just a few days in their home stream, but most spend one to three years.

Salmon Smolt

As salmon begin to mature, they leave their home stream to head to the ocean.

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, preparing for the time they will spend at sea. Some species spend up to a year in estuaries, while others leave almost immediately.

Salmon must adapt to the changes that salt water causes to their bodies. Salt water draws fresh water out of an organism's body. Saltwater fish, like salmon, survive by drinking salt water to replace the fresh water that is lost. However, too much salt is harmful. Saltwater animals develop a way to get rid of salt from their bodies before it harms them. Salmon excrete water and salt in their urine and they excrete excess salt through the fine membranes in their gills.

The appearance of smolts also changes as they prepare for ocean life. They lose the dark colours of the fry, which helped them hide in the shady water of a forest stream, and begin to take on the silvery colour of adult salmon. In an estuary, and in the open ocean, there is no shade – only the bright colour of sunlight reflecting on the waves. The smolts' silvery colour helps them hide in the silvery light at the surface of the ocean.

In an estuary, the mix of river and sea creates a nutrient-rich environment that supports plant and animal growth. Thick beds of eelgrass and sedge provide a home for insects and crustaceans, such as shrimps. Salmon smolts feast on these microscopic animals and on smaller fish that also live among the estuary plants. While in the estuary, smolts can grow from 4 or 5 cm in length to as much as 9 cm. They also add to the imprinted memories that help them find their way home after they migrate to the ocean.

However, estuaries are also home to many fish predators. Fish-eating birds, such as herons, stalk fish in the marshes, while hawks watch for them in the sky. Larger fish, snakes, seals and even orcas also prey on smolts.

In addition, people build cities and industries in estuaries. In some areas, less than 10% of the original estuary remains. With less room to mature, feed and adapt, fewer salmon survive to grow into adults in the ocean.

Salmon Adults

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 a mature salmon.

Most salmon spend the first part of their life in coastal waters, then migrate further out to sea. Each of the seven species of Pacific salmon has its own 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, often swimming as far as the Gulf of Alaska, and south in winter.

While at sea, salmon feed on a variety of smaller fish and zooplankton. The salmon can gain many kilograms, with mature adults reaching a few kilos to 20 kilos or more, depending on the species. Salmon are prey for seals and orcas, as well as for fish, such as tuna and cod.

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. B.C. residents catch millions of salmon each year and nonresidents also catch salmon heading for streams and lakes in B.C.

Recreational fishers catch many salmon using single fishing lines with lures and hooks. Aboriginal fishers use modern and traditional methods to catch fish, both in the ocean and in rivers and streams.

After spending from one to seven years at sea, depending on the species, salmon return to their home stream or lake. Mature salmon form large schools and find their way to the mouth of their home stream. They gather at the mouth of their home river before starting the difficult journey upstream.

Salmon Spawners

In the final stage of their life cycle, salmon re-enter their home river and swim back to the stream or lakeshore from which they emerged as fry. Some travel many hundreds or even thousands of kilometres, swimming from 30 to 50 km a day against the current. They follow the scent of the water to their home stream. Fishers and predators such as bears, otters, racoons and eagles catch many salmon on their trip upstream.

When they enter fresh water, salmon usually stop eating and live only on stored body fat. To save energy, they lose the slimy coating that helps protect them, their skin becomes thick and leathery, and they start to absorb their scales. Some internal organs may fail on the journey.

The salmon's appearance changes dramatically, with males and females developing distinct differences. They lose their silvery 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 pronounced in males. Their body shape can change, with some species developing a distinct hump on their back. Eggs develop in the ovaries of females, while males develop sperm.

When she reaches her home stream or lake, the female uses her fins and tail to find a spot with the right gravel size and water conditions. With her tail, she rearranges the stones in the gravel bed to form a redd, the nest-like depression in the stream- or lakebed where she will lay her eggs.

The female deposits her eggs in the redd, then the male deposits his sperm to fertilize them. Some species deposit up to 6,000 eggs, but the average is about 2,500. The female covers the eggs with gravel to protect them, often moving on to build a second or third redd which may be fertilized by other males.

Both males and females die within a few days of spawning. (Steelhead and cutthroat may survive to spawn more than once, although once is most common. If they survive, they go back out to sea as kelts, spawned-out salmon, then return to the spawning area in another year or two. Altogether, they may spawn three or four times.) The salmons' bodies decompose, releasing valuable nutrients, including minerals from the sea. The nutrients from the salmon carcasses form a rich food source for other wildlife, as well as fertilizing the stream and lake along the shore. When salmon carcasses are carried onto the riverbank, they also fertilize the forest and bushes. The ocean compounds in the salmons' bodies can be very scarce in the upstream environment. If few adult salmon return to spawn, the lack of nutrients can make the forest and the water a poor environment, with few nutrients for growing salmon fry and other species.

Salmon Habitat

Small streams and lakes produce most of the West Coast's fish. They 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, but human activities are changing to protect streams and revitalize waterways that have been damaged in the past.

Water. Salmon prefer cool, clean water (between 5°C and 9°C is best). A healthy salmon stream runs over a gravel bottom containing a mix of rock sizes. Water flowing over riffles picks up oxygen and washes away silt. Salmon need at least seven parts per million (7 ppm) of oxygen in the water.

Young salmon also need still pools that form at the edge of a stream and behind rocks, logs or other debris. The still water allows the salmon to rest and to hide from predators. Eggs need 2 - 30 centimetres of water; fry need 10 - 40 centimetres.

Young salmon are very sensitive to pollutants. Household chemicals, such as bleach, oil or paint, can be fatal. Unless diverted, runoff from roads can carry hazardous pollutants into a stream. Ideally, the water in a salmon stream should be clear, with a pH between 6.5 and 8.

Stream banks and lakeshores. The banks of a stream soak up water during heavy rain, then release it slowly into the stream. This prevents flooding and reduces the chance of streams and lakes drying up in hot weather. Thick vegetation along the banks of a stream shades the water, keeping it cool and allowing salmon to hide in the shadows. Insects that fall from overhanging bushes and trees provide food for the salmon. To protect the stream banks, laws prohibit construction or logging within 50 or 100 metres of streams.

Food. Salmon fry catch tiny insects that float past them. As they grow, the fry can also 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 fry can also eat smaller fish in the stream or lake.

People. People disturb streams and lakeshores when they remove the vegetation, divert the waterflow, pollute the water or build docks. People sometimes erode the banks by playing or driving along the edges of a stream or lake. This can crush salmon eggs in the gravel. People and pets sometimes harass spawning salmon in shallow streams, and people sometimes leave garbage along the banks and in the water.

Salmon Survival

A single pair of salmon produces thousands of fertile eggs, but the number of adult salmon that will survive depends on harvest levels and salmon habitat, especially ocean conditions.

After release, hatchery fish may not survive as well as wild ones, and they compete with wild populations for food and safe places to grow. Hatcheries cannot remedy the loss of fish habitat, but they remain tools that managers can use to help support endangered salmon populations.

The chart below shows the average number of salmon that survive at each stage of their life cycle, or the **survival rate**. (The chart uses average numbers for coho salmon. The numbers for other species of salmon are different, but they follow the same general pattern. The survival rate at each stage can vary considerably from the average.)

Wild coho salmon survival

Stage of development	Number	Deaths	Number of survivors	Survival rate	Causes of death
Eggs/Alevins	2,500	2,125	375	15%	• Unfertilized eggs • Gravel movement • Low oxygen in water • Drastic changes in water temperature • Pollution and/or sedimentation • Disease • Predators • Poor habitat conditions
Fry Eggs/Alevins	375	245	30		• Lack of adequate food or space • Predators (rainbow trout, doll varden, char, grayling trout, sculpin, steelhead trout, ducks, merganser, tern, kingfisher) • River blockage or diversion along migration route • Pollution

This chart uses average numbers for coho salmon. The numbers for other species of salmon are different, but they follow the same general pattern.

Salmon Survival

Wild coho salmon survival (cont'd)

Stage of development	Number	Deaths	Number of survivors	Survival rate	Causes of death
Smolts	30	25.5	4.5		• Predators (other fish, killer whale)
Adults	4.5	2.5	2.0		• Harvesting (sport, commercial, Aboriginal food fishery) • Predators
Spawners	2	2	0		• Water levels too high or low • Predators (bears, otters, minks, birds) • Obstructions (dams, rock slides, log jams) • Diseases • Death after spawning

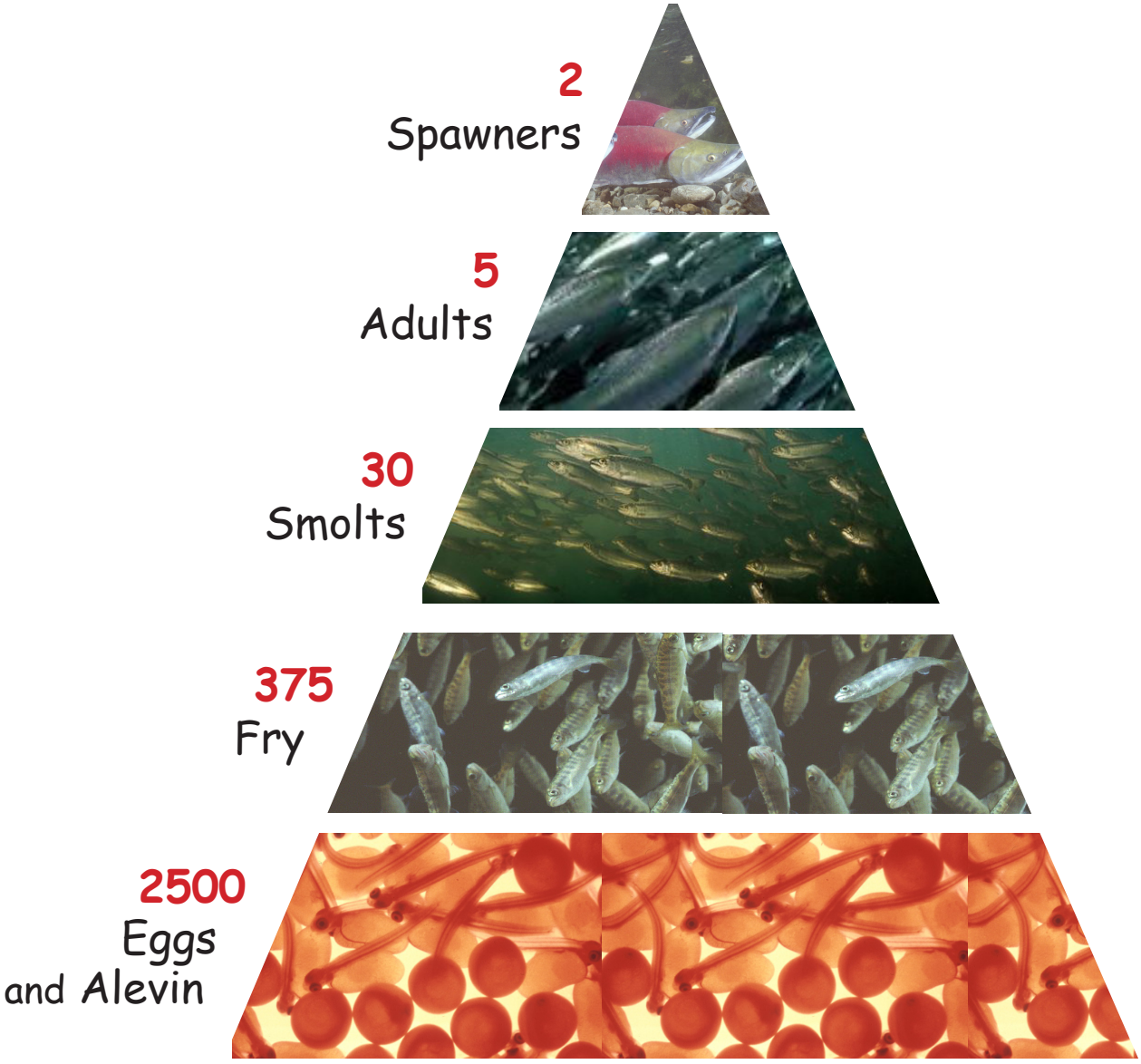
Fish hatcheries can greatly increase the number of salmon that survive the early stages. However, the smolts from hatcheries may not survive as well as wild smolts. Only a few grow to become adults and return to spawn in their home stream or lake.

The next chart shows the number of salmon that survive when the eggs are reared in a hatchery.

Hatchery coho salmon survival

Stage of development	Number	Deaths	Number of survivors	Survival rate	Causes of death
Eggs/Alevins	2,500	250	2,250		• Unfertilized eggs • Failure of hatchery systems • Disease
Fry	2,250	450	1,689		• Disease • Predators (otters, minks, birds)
Smolts	1,689	1,530	253		• Predators (other fish, killer whale)
Adults	253	162	111		• Harvesting (sport, commercial, Aboriginal food fishery) • Predators
Spawners	111	111	0		• Water levels too low or too high • Predators (bears, otters, minks, birds) • Obstructions (dams, rock slides, log jams) • Diseases • Death after spawning

Salmon Survival



A MODEL OF WILD

Coho Salmon Survival