North Canterbury
Fish and Game Council

Fish in Schools

Information Booklet

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2007

Forward

The North Canterbury Fish and Game Council is delighted to introduce the *Fish in Schools* project to Christchurch Secondary schools. The aim of this project is for students to develop an understanding of New Zealand salmon and the environmental pressures facing Canterbury's aquatic habitats and waterways.

The Fish in Schools Project was first introduced in 2002 at Shirley Boys High school with sponsorship from Hagans Tavern. It is based on a Canadian fish in schools programme.

This booklet provides an overview of salmon, their lifecycle and habitat and the environmental pressures that threaten their survival. It may be used as a background for teachers or copied to students.

The booklet is by no means definitive. Further information is available from a variety of sources including the internet, New Zealand Fish and Game Councils and other research institutes.

Acknowledgements

Fish and Game wish to thank Dominic Bell and Tony Humphries for their contributions and Edgar Russ "Rusty" for the many hours he has devoted to this project

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1.0 Chinook salmon

Oncorhynchus tshawytscha

Chinook salmon are one of a number of sportsfish found in New Zealand.

There are many different species of salmon in the world. The main salmon found in New Zealand are Chinook salmon.

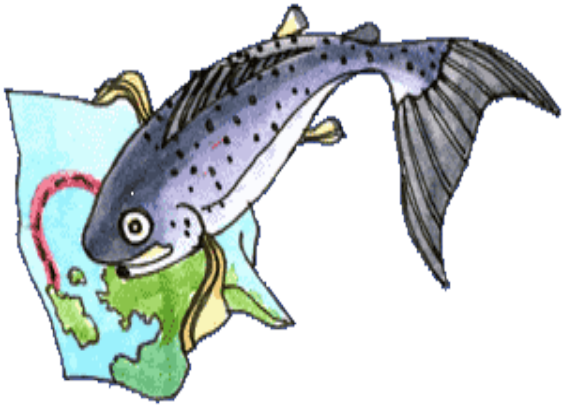
The picture on right shows a male and female Chinook. They are also known as "quinnat", "pacific" or "king" salmon. Chinook are the largest salmon found in New Zealand, sometimes reaching 10–15 kilograms in weight.

Chinook salmon *Oncorhynchus tshawytscha*

Salmon spend their lives in freshwater and at sea. There are considered to be two types of Chinook salmon, depending on how much time they spend in freshwater. Ocean-type Salmon spend a brief time in freshwater rivers. They then migrate to the river mouth area where they stay for a while before heading out to sea. Stream-type Chinook remains in freshwater rivers for about a year before passing through the river mouth and moving out to sea.

Scientists know very little about what happens to New Zealand salmon when they are out at sea. Most research has concentrated on the freshwater stage of the salmon life cycle.

How did they get here?



Salmon were introduced to New Zealand in the 1880's.

New Zealand Chinook salmon came from the upper Sacramento River in California. By 1915, salmon were established on the east coast of the South Island. Attempts to establish Chinook salmon in other Southern Hemisphere countries, such as Australia and Chile, have failed.

Why were they introduced?

Salmon were introduced to New Zealand as a sports fish. Chinook salmon are now a highly prized sports fish in New Zealand. When the spawning migration of adult salmon is in progress between November and April, picket lines of eager anglers are a common sight at major river mouths along the East Coast of the South Island. Because salmon deteriorate as they migrate upstream, the most prized fish are those caught soon after their arrival to fresh water at the river mouth.

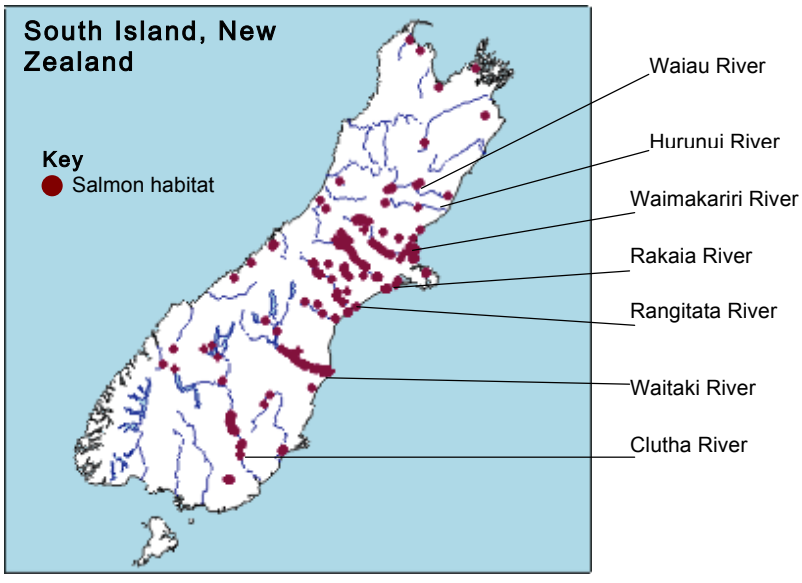
The salmon population is not large enough to support commercial fishing as in Canada. However, there are a number of salmon farms in New Zealand, and salmon is available in most supermarkets.

Where do salmon live?

Chinook salmon live in freshwater and seawater, depending on their stage in the lifecycle. Chinook salmon occur mainly on the East Coast of the South Island from the Waiau River in the north to the Clutha River in the south.

The main runs occur in the large braided rivers — the Waimakariri, Rakaia, Rangitata and Waitaki. There are also small runs in rivers such as the Paringa, Taramakau, and Hokitika rivers on the West Coast.

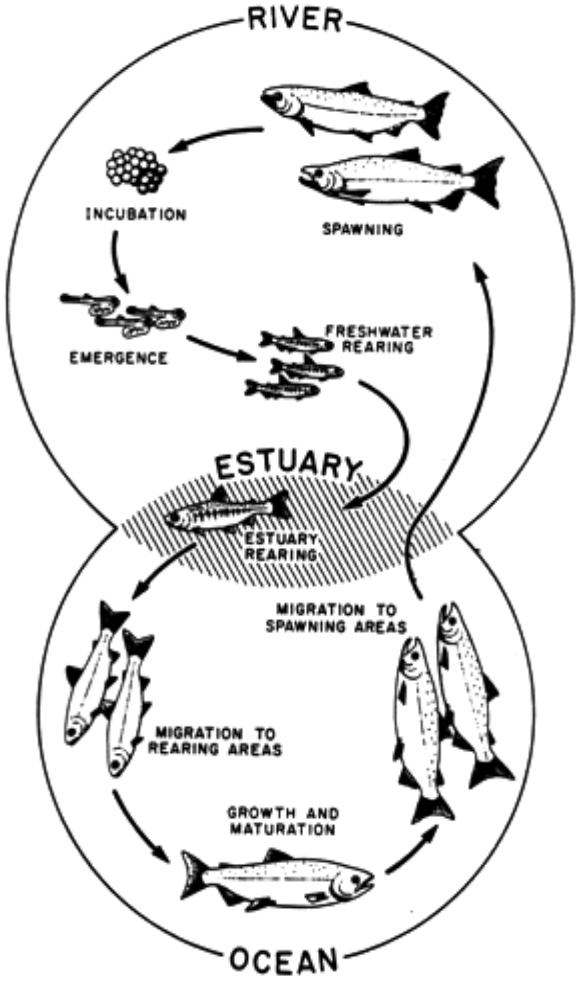
Other records of Chinook salmon on the West Coast are probably stray fish. A few land-locked stocks also exist in lakes along the east and west coasts.



The salmon life-cycle

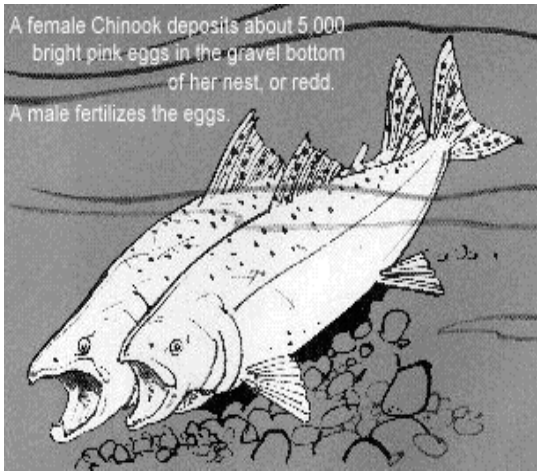
The life cycle of salmon is illustrated on the right. It is a complex and treacherous life that starts and ends in the headwaters of rivers. Much of the salmon's life revolves around the process of spawning or, reproduction.

The salmon-spawning season generally starts in April and can continue through until the end of July. Salmon use external fertilisation - this means that the female fish lays her eggs and the male fertilises them once they are laid.



The Chinook salmon life cycle

Eggs hatch in spring and the young fish spend three months on average in fresh water before migrating downstream to enter the ocean in summer. In some populations a second downstream migration of fish that spend a year in fresh water occurs a year later. The salmon migrate to the ocean here they grow to maturity before returning to freshwater at the end of their lifecycle (2-4 years later) to breed and eventually die. This behaviour is characteristic of their natural homing ability that enables salmon to locate their natal stream after a return migration that can amount to hundreds of kilometres.



Wild salmon lay their eggs in a

Egg-laying

After returning to the river from the sea, salmon make their way to the headwaters where they hatch. It is believed that when salmon are mature and ready to return to freshwater to breed they navigate by the position of the sun. Once a salmon reaches the general region of the river leading to its home stream a keen sense of smell takes over. The water that flows from each stream into a river carries a unique scent from the types of plants, soil and other components in the stream. This scent is imprinted in the memory of the young salmon before they migrate to sea. During their return journey salmon follow these chemical cues at each fork in the river system.

Adults reach maturity after two to four years at sea and return to the river mouth between October and April with up river migration peaking during February and March. The fish move upstream, up to 100 kilometres in the largest rivers, until they arrive at their place of origin to spawn.

The female salmon selects clean, relatively silt-free, well-aerated, stable gravels or small cobbles to spawn. Salmon prefer to lay their eggs in clean, spring-fed streams that do not flood. The females use their tails to excavate the gravel to lay from 2,000 - 5,000 eggs. The eggs are then fertilised by the male.

The females excavation reduces the amount of fine sediment in the gravel pockets where eggs are deposited. The females move upstream to scatter gravel over the eggs. Several pockets of eggs can occur in a single redd.

A female salmon uses her tail to create a redd (nest)

Hatching

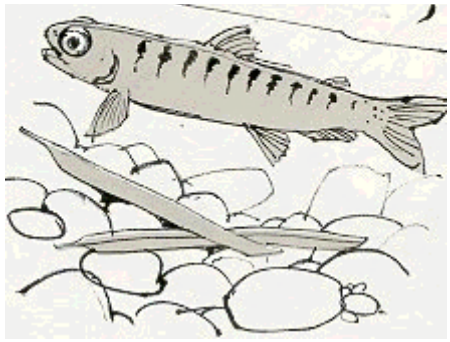
The salmon eggs go through three different developmental stages: **eyed eggs**, **alevins**, and **fry**. The alevins do not need to eat as they still have their yolk sac attached. Once they use that up (3-4 weeks later) they need food quickly or they will starve.

An alevin with yolk sack

Fry emerge from redds in their natal streams from June to October. When juvenile salmon, or fry, emerge from the redd they must find food immediately. Fry eat a variety of foods in the wild but mostly aquatic insect larvae. [When fry are raised artificially like in the classroom, they are fed an artificial fish food.] After the wild fry emerge from the redds they quickly enter the main river.

Ocean-type fry gradually move down river over two or three months. The first fish arrive at the river mouth in mid October and continue through to January. These fish are often less than 40mm in length and weigh less than one gram when they finally leave the river. When floods occur the fish will be forced downstream and leave the river much quicker. Larger fry are more likely to survive the transition from fresh to salt-water.

Less is known of the downstream dispersal of stream-type fry, although it is thought that they remain in the upper river from July or September of their second year when then disperse downstream quickly. Hatchery fry are usually released the following year in August when they weigh over 30g.



Fry, or young salmon, fresh from the gravel are about the size of a pine needle

Juvenile fish

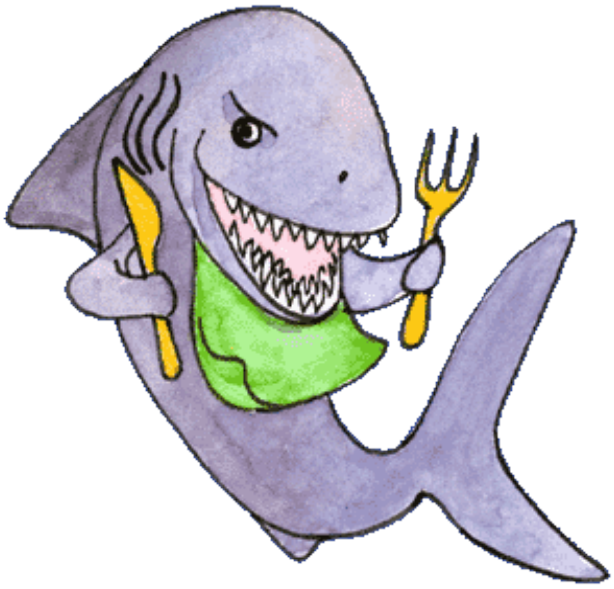
The juvenile ("teenage") stages of salmon are **parr** and **smolt**. Parr have camouflage stripes so they can blend in with stream vegetation whereas smolt are silvery. These colours help to hide or camouflage the parr among the stones on the river bottom. As the fish vary in colour to match their surroundings parr hatched in tanks will grow to blend with the tank colour. When they are released into a river it takes time for their colour to adjust to the new surroundings. Unfortunately this makes them easily visible to predators.

The smolt migrate downstream to the sea and must undergo many physiological changes so that they can live in salt water including colour changes. Smolt and adult salmon need a different colour to live at sea. They lose the parr colours and develop a silver sheen on their sides with a dark back

and a white belly. This way predators have a hard time finding them because when a predator is above looking down on the salmon's back the fish blends into the dark sea bottom. Similarly, a predator looking up will not see the salmon because its white belly blends in with the water surface. A predator looking sideways looks into the silver mirror of the salmon's side and sees only the reflection of the water. Salmon returning to a river from the sea change their silvery colour to dark bronze.

Estuaries are also very important in the life cycle of salmon. Estuaries are areas where fresh and salt water mix to form brackish water. When fry enter the brackish water, the smoltification process begins. Rivers in North America, where Chinook salmon originate, have very large estuaries. This allows salmon to undergo the physiological changes required to live in salt water and means they can change gradually. Gradual change may increase survival of smolt. Because most New Zealand salmon rivers only have small estuaries, or lagoons, this transition period is often much quicker.

If a flood occurs on a river or stream parr or smolt may be washed out to sea before most of the physiological changes occur. The large volume of water entering the ocean during a flood creates an artificial estuary around the river mouth that gives salmon more time to adapt to the salt water. Estuaries are also areas of high predation of juvenile salmon. The physiological changes that occur cause the smolt to become less active making them more susceptible to predation. There are many predators in both estuaries and at sea including gulls, shags, seals, trout and eels. They each form part of the natural food chain.



Salmon make huge migrations in the ocean and can move hundreds of kilometres. Salmon gain most of their weight in the ocean where food is abundant.

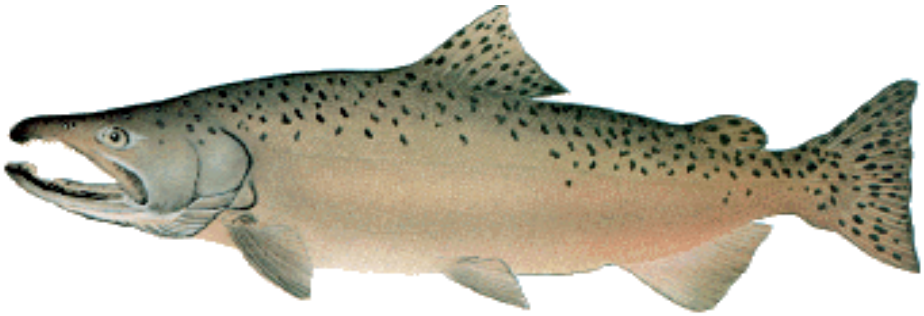
The first year of life in the ocean is the most critical year for the young salmon. There are many predators in oceans that like to eat them. Since salmon have not grown to their full adult size in the first year it is harder for them to avoid predators. Salmon are also caught in the nets of fishing boats.

Mature salmon

Chinook salmon return to the place of birth after spending two to five years in the ocean. When they return they devote all their energy to spawning purposes. Their energy goes into:

- changing from a sleek, silvery fish to the colourful fish with humped bodies and hooked jaws,
- migrating upward to the streams where they were born,
- engaging in courtship,
- nest (redd) building and spawning.

The physical change of spawning salmon is caused by changes in their fat composition, blood chemistry, hormones, enzymes and skin pigmentation. Their arteries become clogged, their muscles soften, and their skin thickens. Once they enter freshwater they also stop feeding. At this stage they become more vulnerable to disease.



A male salmon ready to spawn

Once the Chinook enter the river mouth they migrate upstream towards their natal streams. This is a long journey usually to high country streams in the Southern Alps. Spawning in the wild usually occurs in small, stable streams that then flow into larger streams.

Spawning can also be done artificially by removing the eggs from the female and fertilising them by adding milt (or sperm) to the eggs. This is how the classroom eggs were produced and how salmon farm eggs are produced.

After the salmon spawn the female salmon guards her eggs for about two weeks until she eventually dies. During this stage her condition deteriorates and she turns black. Dead salmon provide food and nutrients for other plants and animals in the stream as they decompose.

After a few weeks, the eggs begin to hatch and a new salmon life cycle begins.

2.0 Classroom Eggs

The eggs that will be hatched in school have already been fertilised. The next stage is incubation in a specially constructed tank.

The tank is constructed from laminated safety glass and consists of a hatching chamber and main tank.

Each tray holds approximately 700 eggs. Of these about 500 should survive. Water flow is provided by a circulating pump and filter system or by a continuous flow from a mains tap, depending on water quality.

The eggs are reasonably robust until just before hatching when they become very sensitive and any jostling or disturbance can kill them. Students must take great care when observing hatching eggs and to limit the time spent looking into them. The hatching salmon eggs should not be exposed to too much light.

Dead or infected eggs must be removed from the trays. Because of the way the system is set up one bad egg could infect them all. Once the salmon begin to hatch, any dead fish will also need to be syphoned out regularly.

A classroom incubator ready for use

One way to tell the difference between normal and dead eggs is to look at the colour. Normal salmon eggs are pinky-orange, but dead ones are white. This happens because the membrane around the egg breaks and lets in water; the eggs become lighter and the proteins are transformed. It is similar to frying an egg and seeing the clear part turn white.

Water quality is also very important during incubation, which is why the tank is set up to allow freshwater and oxygen to circulate. Salmon need clean water to survive whether they're being raised in a hatchery or growing up in the wild.

Fish in Schools

Raising Salmon in the Classroom

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Introduction

The Pacific or Chinook Salmon was first released into New Zealand in 1908 in the Hakataramea River which is a tributary of the Waitaki. Since their introduction, they quickly spread into many others including the Waimakariri, Rangitata and the Rakaia. They have thrived in New Zealand river systems for many years but a decline in numbers has been noted by anglers and researchers alike. This decline can be attributed to many factors within the ecosystem that the salmon lives.

The Fish in Schools Project

The Fish in Schools project was begun in 2002 as a project between Fish and Game and Shirley Boys' High School with some sponsorship from Hagans Tavern. It is based on a very successful program run in Canadian schools called "Fish Friends" Canadians see Salmon as their national fish. The purpose of Fish in Schools is to develop an understanding of New Zealand Salmon and the environmental pressures faced by Canterbury's aquatic habitats.

In 2002, two tanks were constructed by Edgar Russ for Fish and Game to be used as part of the fish in schools project. Both tanks were made from large chilly bins mounted on a metal frame. Enclosed in the frame were a pump and filter as well as a water temperature control unit. One of the units was kept at the Fish and game offices while the other was placed in a classroom at Shirley Boys' High School.

In June approximately 600-700 salmon eggs were put into the SBHS tank to hatch. As the year progressed several challenges were encountered including a high survival rate so there were several mini-releases in a local stream. At the end of the year during late November with some media attention the fish were released at the Groynes with the help of some students.

It proved a beneficial project for the students in three areas.

1. It increased student interest in fishing
2. During class time it provided a stimulus for student learning about the Canterbury river environments. (they see the fish and ask why)
3. For some students it was simple activities that they could be involved in that made them feel valued, in that they were looking after some living organisms.

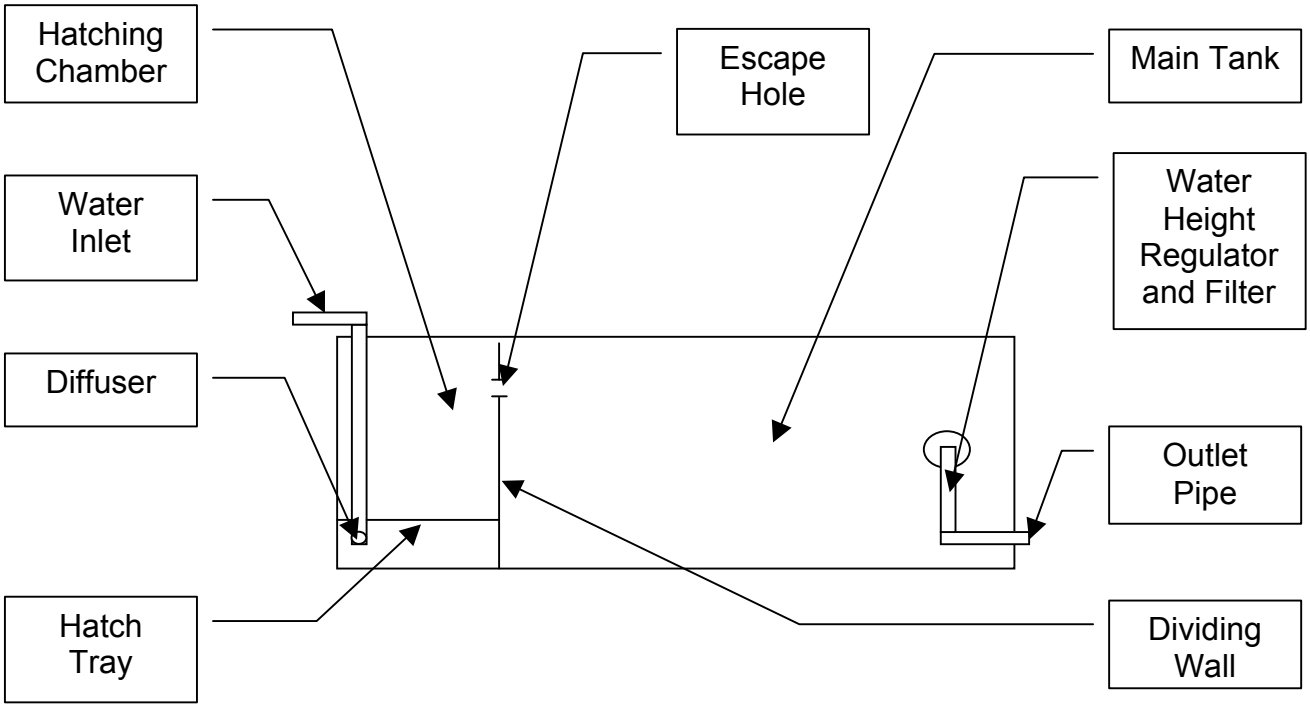
With the experience gained during the first run the tanks were redesigned and the project expanded to include more schools. Furthermore this booklet was written to assist teachers with their salmon and with some resources to help introduce river conservation to students.

It is a worthwhile project.

The Mark one tank

The Tank

The tank that is currently used to hatch and rear salmon eggs is constructed from laminated safety glass with water flow provided by a circulating pump and filter or by continuous flow from a mains water tap. The current tank has been designed for ease of cleaning and maintenance as well as functionality for rearing salmon.



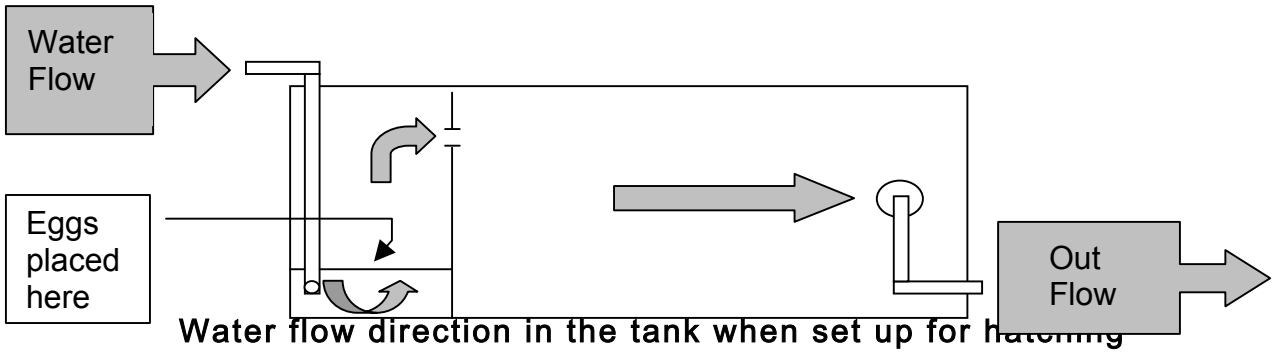
Part		Function
Hatching Chamber	-	This is the small compartment where the salmon eggs are placed for hatching.
Water Inlet	-	Fresh, clean water flows in through here.
Diffuser	-	Inflowing water into the tank is passed through several small holes to prevent the salmon from swimming upstream into the water supply.
Hatch Tray	-	This stainless steel tray allows oxygenated water to flow up through the eggs.
Main Tank	-	Where the salmon will live.
Water Height Regulator and Filter	-	Used to control the depth of water in the tank with a course filter to prevent the salmon from escaping.
Outlet Pipe	-	Water out
Escape Hole	-	A small hole in the glass
Dividing Wall	-	The removable wall with an escape hole to allow the newly hatched alevin to move into the main tank.

How the Tank Works

The tank is a simple flow through system that allows the salmon to be maintained in relatively constant conditions (temperature and oxygen concentration). Water enters the tank and flows through the diffuser then up through the hatch plate. By having the water flowing up through eggs placed on the hatch plate it mimics the salmon's river environment as salmon will lay their eggs where clean fresh water is able to flow through the newly deposited eggs.

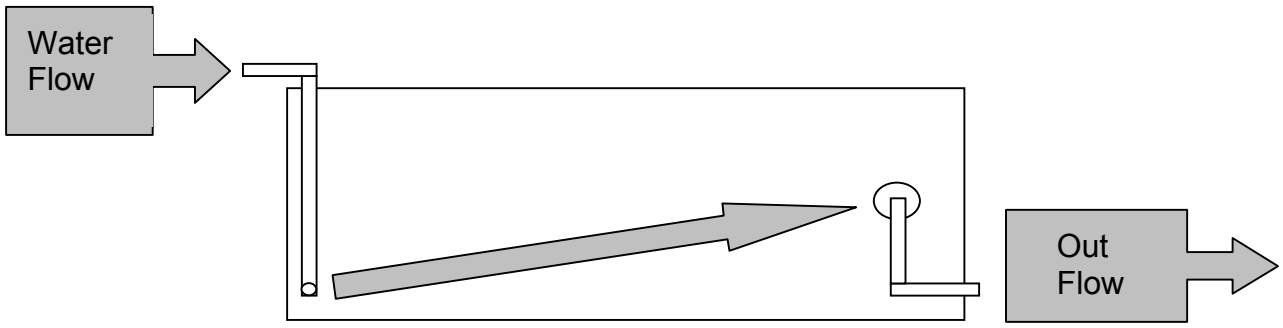
As the eggs mature they hatch and become alevin. Alevin are identified by their bright orange egg sac they have attached to their ventral (lower) surface. Alevin will follow the natural current of the water out of the hatching chamber through the hole in the glass dividing wall. The alevin are negatively photo sensitive (move away from the light) in that they seek the protection of dark places so the main tank should remain covered during this stage of their life cycle.

As the Alevin hatch the hatching chamber should be kept clear of dead eggs (white or grey in colour) and spent egg cases as this helps prevent fungal growth. This can be achieved by simply siphoning out the waste from the hatch chamber. The flow through nature of the tank prevents the build up of yolk in the tank water which will decrease the oxygen content.



Water flow direction in the tank when set up for hatching

Once the eggs have hatched and the dead and spent egg cases have been removed it is then possible to remove the dividing wall and hatch tray. This will then allow the alevin to swim freely throughout the tank. The flow of water through the tank will hardly change.



Water flow through with hatch plate and dividing wall removed

Operating the Tank

The following information is based on experience gained while rearing salmon in the mark one tank.

Water flow – The water **MUST** be kept flowing at all times to ensure that the fish or eggs have an adequate supply of oxygen and to carry away waste. The flow does not need to be huge but it should be continuous. During the time that eggs are in the tank it is very important to keep a constant flow of water. This is because as the eggs hatch the fluid inside the egg is released into the water. Salmon are sensitive to nitrates (ammonia) which this fluid contains.
With the flow through system this should not be a significant problem at all. If foam starts to form on the surface of the water then remove the foam with some form of a scoop and increase the water flow for a few days.

Light – As juveniles the young salmon are sensitive to light. Until the alevin have buttoned up it is best to keep them pretty much in the dark. Exposure to direct sunlight is not good for them however periodic exposure to light during cleaning would do them no harm. When the young salmon have started to button up and the front of the tank is exposed to the classroom it is important to have three sides covered by something dark. By having the students produce a poster depicting their natural environment it can be wrapped around the tank. The salmon will colour themselves (within reason) according to their environment so if their environment is light coloured the salmon will become light coloured. They will therefore be easier targets when released.

Handling – It is strongly advised that the salmon are not handled at all. When in the alevin stage their yolk sacks are very delicate so it is only natural that some will die.

Natural attrition – As the salmon progress through the various stages there will be a certain level of mortality. As their age increases the mortality rate does decrease as per all natural populations. This is nothing to be concerned about as long as the dead fish are removed to prevent contamination of the water supply.

Temperature – The water temperature should be kept constant. If the water is flowing through the tank from the classrooms water supply then this should not be a problem. The temperature of the water should be monitored by placing a thermometer in an easily viewable position in the tank. Ideally the temperature should be kept around $12^{o}C$, Christchurch tap water is usually around this temperature. If the temperature rises above 14 then it would be useful to fit a water cooler to the tanks plumbing system. It would be beneficial to keep the tank out of direct sunlight and away from heaters.

Cleaning – Algae will build up on the tank surfaces along with uneaten food residue. This should be removed at regular intervals by wiping the tank surface and siphoning out the residue. As a guide the tank should be cleaned once a week and food residue removed daily. A simple siphon can be constructed from a 1m length of clear tubing with a diameter the size of a garden hose. By taping a length of strong wire along the 30cm that is submerged in the water a useful handle is formed. By placing your thumb over the lower end of the tube the siphon can be easily controlled.

Mini-Releases – Depending on the survival of the fish it may be necessary to release some to prevent overcrowding. This can be easily achieved by removing some of the fish

into a bucket and releasing them into a local stream (preferably one that will provide suitable salmon habitat eg North Waimakariri at the Groynes)

Eggs – When the eggs arrive they are already fertilised. If an egg has been fertilised it starts to develop an eyespot. This is easily seen as a dark region on the egg. A healthy egg is pink in colour with an eye spot. Unhealthy or unfertilised eggs will appear grey or cream, they should be removed from the tank as soon as possible. If they are left the resulting fungus that will grow on them will infect the other eggs. Occasionally this fungus may infect swimming fish so they should be gotten rid of.

Feeding – As the alevin button up and become fry feeding must begin so that these immature fish learn how to feed. Feeding the fry does require constant attention as they need feeding regularly. They generally only eat food on the surface therefore any feed that sinks to the bottom of the tank should be removed as it promotes algal and fungal growth. One small pinch of food approximately once an hour should be enough for the fry initially, as they grow more will be required. There is no difficulty with leaving them unfed overnight is they only feed during the day. Weekends and school holidays are a difficult issue to overcome however by using an automated feeder the problem was solved.

The **Automated feeder** was simply a device that plugs into a mains supply and dispenses food to the fish on a pre-programmed cycle. The quantity of food and the time between feedings is easily adjusted. The timer unit switches itself overnight and back on again in the morning. This device was ideal during the school holidays as the fish could be left undisturbed for a week. It is still necessary to clear the tank of uneaten food.

Some fish never learn to eat and are called “pin-heads” because of their large heads relative to the size of their bodies, they will continue to swim around but they will eventually die. If you do have pin-heads they will all die at approximately the same time.

Class Activities

The class activities contained in this booklet are remastered copies taken from a teachers resource book called “The Pacific Salmon in New Zealand” compiled by Tony Humphreys.

These activities can easily be modified to suit different student age groups.

The first activity is particularly important as the young salmon will adapt to their surrounding environment or more importantly its colour. To increase their survival chances in the wild the young salmon really need to have some camouflage.

Activity One – Poster

As salmon come from an environment far removed from the glass fish tank a small amount of effort should be made to cover the tank with a suitable background. Some form of a poster depicting their natural environment wrapped around the tank will suffice. It also makes the tank took more presentable in the classroom.

It could be an easy task to have a competition designing posters of the salmons natural environment where the students must first discover where salmon eggs hatch. The poster could include plants, animals and objects that the young salmon would see in their natural environment.

Additional Projects

Here are a few other suggestions

- Monitor the temperature by recording it each day as a data recording exercise. This could be easily done by leaving a thermometer in the tank. These measurements are called Temperature Units (TU’s). If for example the over 2 days the temperature was recorded at 15^{o}C then the fish have been exposed to 24 TU’s (2 x 12 = 24). From the day the eggs are fertilised they will hatch after a particular number of TU”s.
- Monitor the water flow and record by measuring the water flow from the outlet pipe into a measuring cylinder. Again this could be used as a data gathering exercise for the students as the water flow may vary considerably from day to day. Those who had tanks overflow during the night will attest to this.
- As an extension project for a student with good engineering ability they could design and build an automatic feeder for when the fish require feeding. This project is not as easy as it sounds as each of the two components (feeder and timer) both have interesting challenges to overcome.