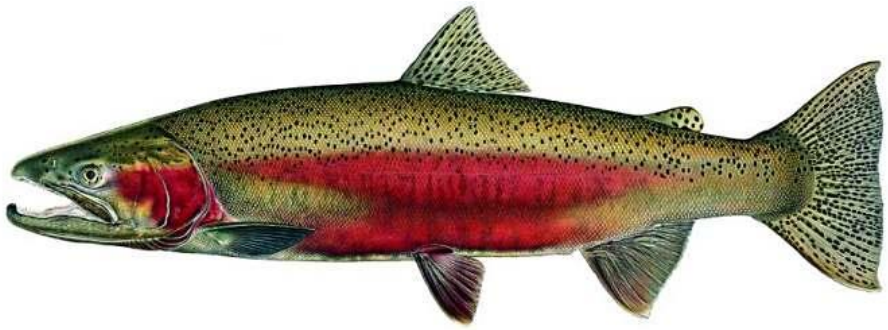

SALMONID ANATOMY & DISSECTION WORKSHOP HANDBOOK

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Introduction

This guide and accompanying diagrams were developed to aid Educators in conducting dissections of salmonids. **Salmonidae** is a family of ray-finned fish, the only living family of the order **Salmoniformes**. It includes salmon, trout, chars, freshwater whitefishes and graylings. The Atlantic salmon and trout of genus *Salmo* give the family and order their names. The guide was written with teachers in mind, though it might be appropriate for high school students as a laboratory exercise. For younger students it is suggested that the Educator use this guide as a resource for developing lesson plans. It is important to have good tools when performing dissections. We suggest the following: a large strong knife (serrated knives work well), a sharp craft knife (x-acto knives work well), a sharp pair of scissors, tweezers, pencils and Popsicle sticks for probing and pushing things around, paper towels for soaking up fluids. For younger children scissors can be used. A dissection kit is available for loan from OSU Extension Klamath County that could serve and entire class of 30+ students. Contact: OSU Klamath Falls Research & Extension Center for equipment loan information.

Safety Warning: When working with sharp instruments, safety guidelines should be discussed with all participants. This dissection is a guideline only, and individuals participate at their own risk. This dissection can be done with scissors; we do not recommend using knives/scalpels.

This is going to be a messy, somewhat smelly exercise.

We would recommend doing the dissection on paper towels, newspaper or some other absorbent material with a garbage bag or sheet of plastic underneath. All surfaces should be thoroughly washed afterwards or you will have a stinky reminder of your dissection exercise.

Fish are euthanized with chemicals and are not suitable for human consumption.

Educators are granted permission to make unlimited copies this guide and the accompanying illustrations for educational purposes only.

HAVE FUN!

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. Slime-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. See attached labeled Figure 1 page 8.

- Eyes, gills, operculum, fins, nostrils, vent, lateral line

4. Identify both single (caudal, anal, dorsal, adipose) and paired fins (pelvic & pectoral):

Caudal fin, anal fin, pelvic fins, pectoral fins, dorsal fin, adipose fin-*unless it is a hatchery fish, in which case the adipose fin may have been clipped to identify it*. Clipped hatchery fish will also have a tiny steel pin, or coded-wire tag, embedded in the nose cartilage. If your specimen is missing the adipose fin, the head should be removed and turned into the nearest Oregon Fish & Wildlife or California Fish & Game office with information on when and where the fish was caught - *Unless you received hatchery fish for your dissection.*

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". 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. 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)

- 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.
- **Check out Figure 2 on page 9 for labeled internal organs.**

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?
- 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.

3. 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.
- 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.

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

6. 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.

- 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.

7. 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?

- 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?

8. 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.

9. 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.

10. What is left is a fish that is well cleaned!

- If fish prints are to be done with the carcass then the dissection cannot progress any further, as the prints will be affected.
- If a barbecue is planned, it is possible to look further if desired.
- The head can be split by placing the fish on its back, pressing vertically with a knife into the backbone at the base of the head, and then levering forward into the mouth. The brain is visible by looking into the split that has been made. The eyeball can be pushed out from the inside with the fingers. The otoliths (ear stones) are located in two little pockets behind and above the brain. Like scales, otoliths can be used to determine the age of a fish.
- The head can be removed; don't waste the meat in the throat area! Fillet the fish by slicing close to the ribs, first on one side, then on the other.

Taken from: http://www.sf.adfg.state.ak.us/Region2/ie/sicc/html/dissectn.stm

EXTERNAL ANATOMY OF SALMON AND TROUT

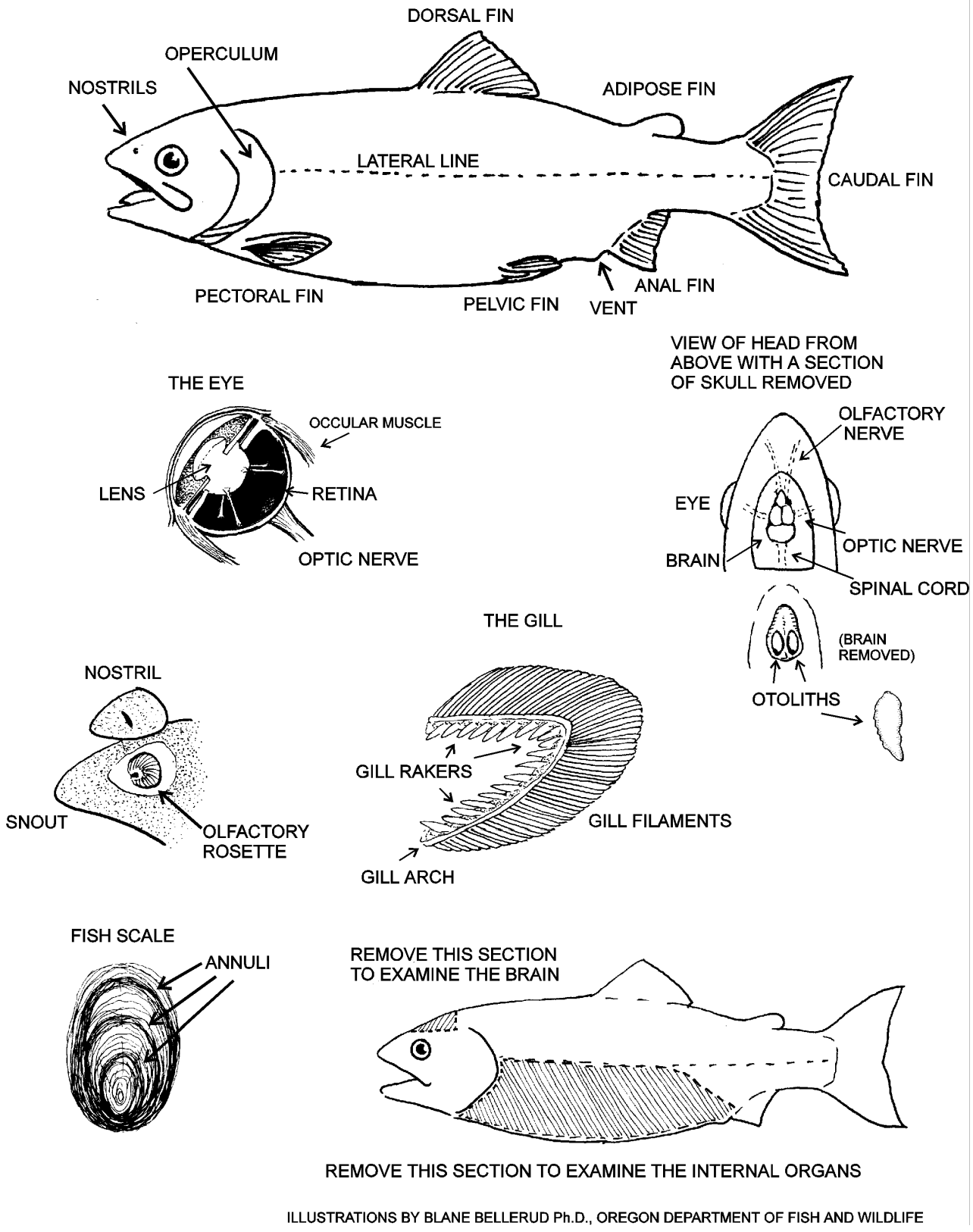


Figure 1

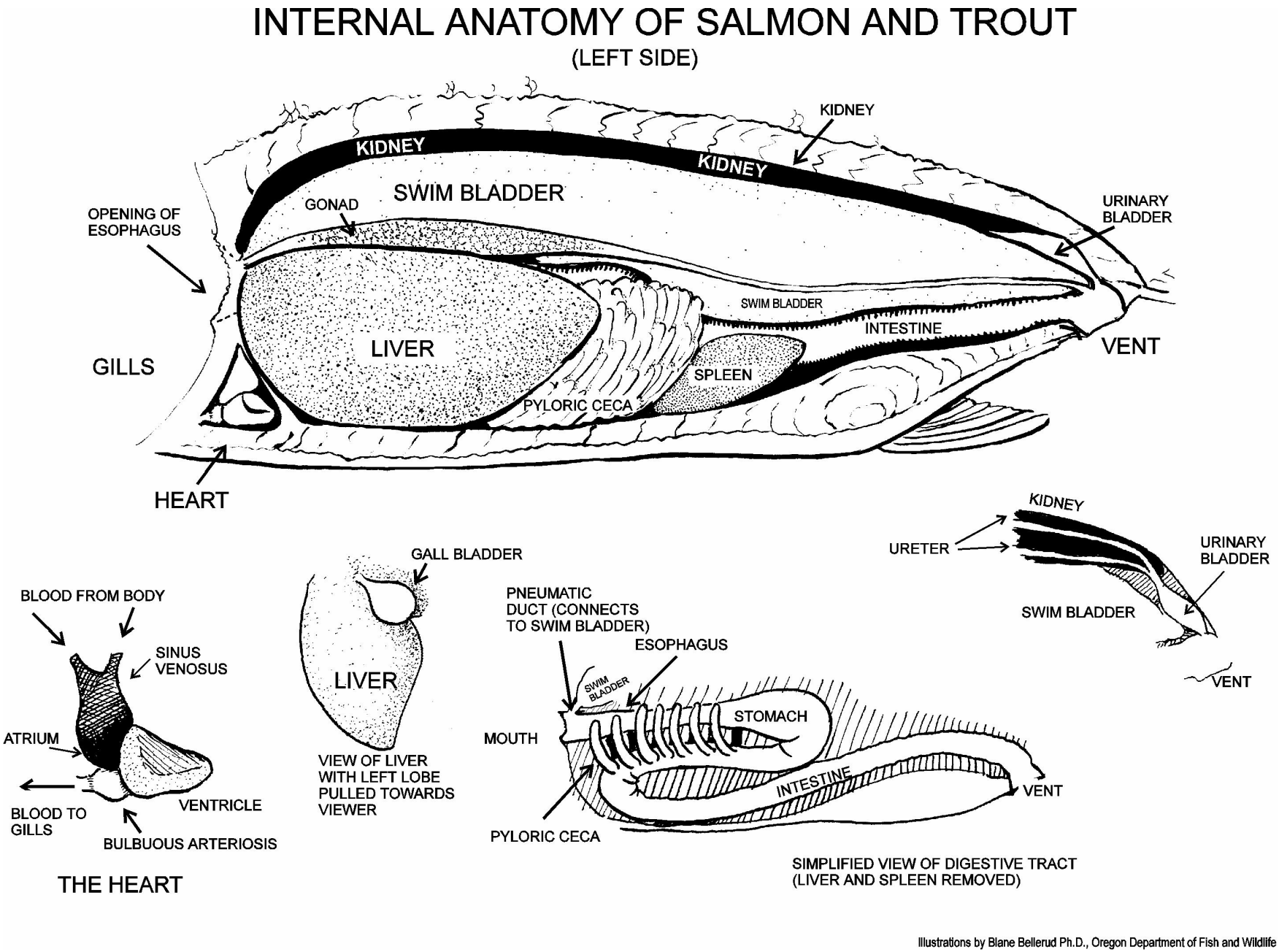


Figure 2

Oregon State University OSU Klamath Basin Research and Extension Center

How Does a Fish Compare To a Human?

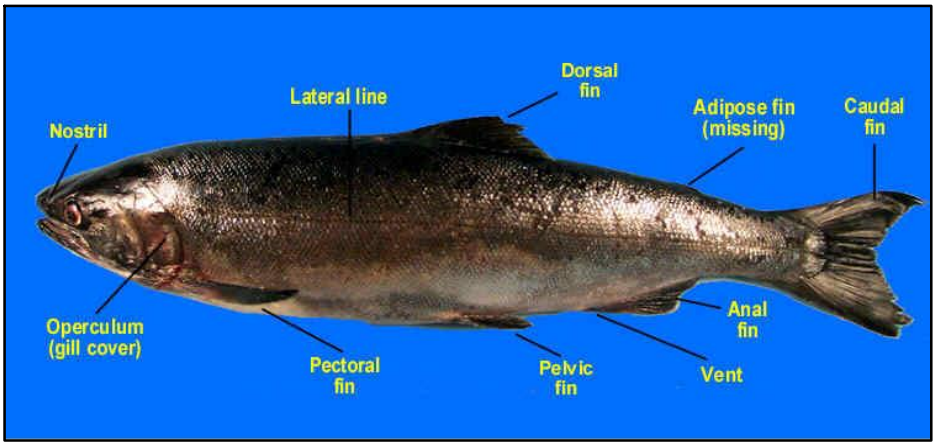
Fish	Human
Respiratory System	
Water enters the mouth. It is forced between the gills. Thin membranes absorb the oxygen from the water and carbon dioxide is released.	Air enters the nose. The respiratory system includes the larynx, trachea and lungs. This system provides oxygen for the body cells and removes the waste products (carbon dioxide).
Circulatory system	
The circulatory system carries blood throughout the body. Arteries carry blood to the heart. The heart is like a pump. Veins carry blood away from the heart.	The human circulatory system includes the heart, veins, arteries and capillaries. The blood carries oxygen plus nutrients to the cells and removes waste products. The heart is like a pump which circulates blood throughout the body.
Reproductive system	
Female salmonids deposit between 500-10,000 eggs in redds and the male fertilizes them with milt. The eggs incubate for about one to four months and hatch as alevins.	The ovaries of the female produce eggs cells. The testis of the male produces sperm cells. The two cells unite and the embryo develops in the uterus of the female.
Nervous system	
The brain and spinal chord of all vertebrates are similar in structure and function. The central nervous system controls all conscious body functions. It includes the brain, spinal chord and peripheral nerves.	
Digestive system	
The alimentary or digestive canals are similar. They prepare food for use, absorb nutrients and eliminate waste.	

BACKGROUND INFORMATION

Taken from: http://www.pskf.ca/sd/

Salmonoids in the classroom

EXTERNAL ANATOMY



Shape

- Salmon are streamlined to move easily through water. Water has much more resistance to movement than air does, so it takes more energy to move through water. A streamlined shape saves the fish energy.

Fins

- Salmon have eight fins including the tail. They are made up of a fan of bone-like spines with a thin skin stretched between them. The fins are embedded in the salmon's muscle, not linked to other bones, as limbs are in people. This gives them a great deal of flexibility and maneuverability.
- Each fin has a different function. The caudal or tail, is the largest and most powerful. It pushes from side to side and moves the fish forward in a wavy path.
- The dorsal fin acts like a keel on a ship. It keeps the fish upright, and it also controls the direction the fish moves in.
- The anal fin also helps keep the fish stable and upright.
- The pectoral and pelvic fins are fused for steering and for balance. They can also move the fish up and down in the water.
- The adipose fin has no known function. It is sometimes clipped off in hatchery fish to help identify the fish when they return or are caught.

Slime

- Many fish, including salmon, have a layer of slime covering their body. The slime layer helps fish to:
    - slip away from predators, such as bears.
    - slip over rocks to avoid injuries
    - slide easily through water when swimming
    - protect them from fungi, parasites, disease and pollutants in the water

Magnified salmon scale

Scales

Remove a scale by scraping backwards with a knife. Look at the scale with a magnifying lens.

- Most fish, including salmon, have a layer of scales covering their skin. Scales are small, hard plates, like fingernails, that cover the body for protection. The scales overlap to form a flexible armour plating to protect from predators and bruising.
- Salmon begin to grow scales at the fry stage.
- The way scales are arranged in rows or patterns is different for each species.
- Fish have the same number of scales all their lives. As the fish grows, the scales grow. They form lines, like the rings in a tree. Biologists can tell the age of a fish and how many years it spent in fresh and saltwater from the groups of lines on its scales.
- If a scale is lost, another scale will grow to replace it, but it will not have the growth lines in the center.

Inner ear

- Fish have an inner ear, but no outer ear. Sound waves travel through the water and through their body to the bones (otolith) in the inner ear. Salmon probably use hearing to detect predators and other threats. Fish also detect sound waves through their lateral line.

Lateral line

- The lateral line functions somewhat like an ear. It detects vibrations and pressure waves in the water, just as an ear does in air. The lateral line is a series of liquid-filled canals below the skin along the side of the fish. It combines aspects of touch, hearing and seeing. Fish use the lateral line mainly to tell distance and water flow, and to detect disturbances in the water. Some fish can use the lateral line to find their way when it is too dark or muddy to see.

Nostrils

- Salmon have nostrils above their mouth, but no nose. Fish do not breathe through their nostrils. The nostrils are a small indention that is not connected to the mouth. Fish smell very tiny amounts of chemicals in the water. They use this information to detect harmful pollution and avoid potential threats, if possible. Salmon also use smells to recognize their way home from the ocean.

Mouth

- Salmon have teeth that are sharp and needle-like, which they use to grab their prey. Their tongue also has two sharp shafts. Salmon do not chew their food.
- Salmon have taste buds inside their mouth, like people do. They probably taste salt, sweet, bitter and acid, but their sense of taste has not been studied in detail.

Operculum (gill cover)

- The operculum protects the gills. It is a hard outer lining like a flexible plate that the fish opens and closes to let water pass over the gills.

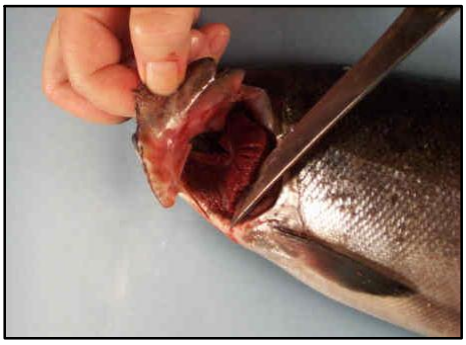
DISSECTION STEP 1

Gills

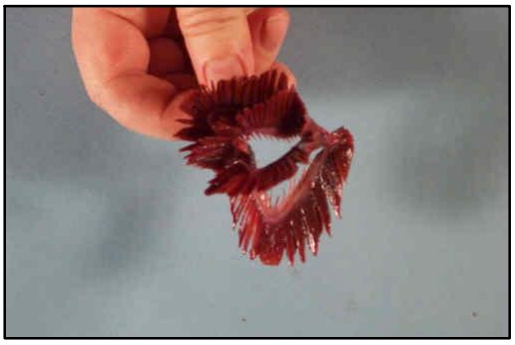
Fish breathe by gulping water through their mouth, and then close their mouth and throat. The water is forced though the opening in the back of their throat that is lined with gills. Gills are very thin; they look like fine, branched structures, like a Christmas tree. This gives the greatest possible surface area to absorb oxygen from the water. Gills are red because they are filled with blood. Oxygen in the water passes into the blood and is carried through their body. Gills are more efficient than lungs at extracting oxygen.

1. Remove the gills on one side of the salmon. Cut through the bone at the top where the gills are joined to the head.

2. Cut through the bone at the bottom where the gills are joined to the head.

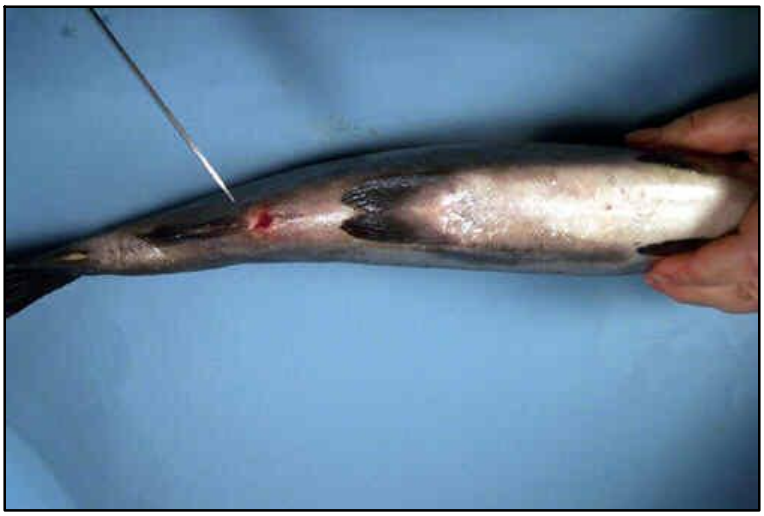


3. Lift the back edge (farthest from the mouth) of the gills and cut away from the skin.



4. Each pair of gills has 4 arches, each with a row of gill rakers. These rakes prevent food from entering the gill and instead guide it into the throat.

DISSECTION STEP 2



The Vent

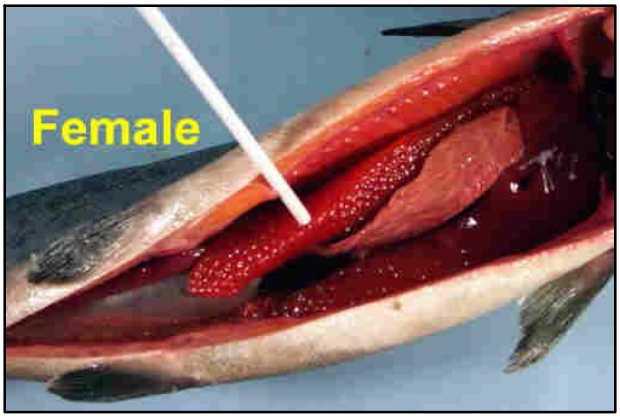
The vent is an opening on the underside of the salmon. Eggs are laid from here by females.
Milt is released from here by males. As well, both males and females eliminate waste from the vent.

1. Cut the fish open beginning at the vent. Do not cut too deeply or the internal organs will be damaged.

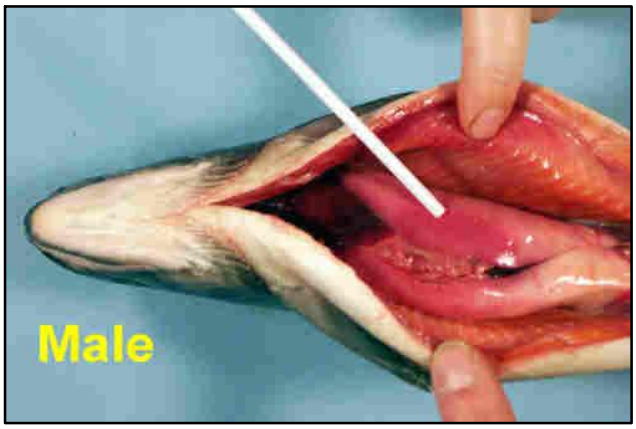
2. Open the fish from the vent to the throat.

INTERNAL ANATOMY

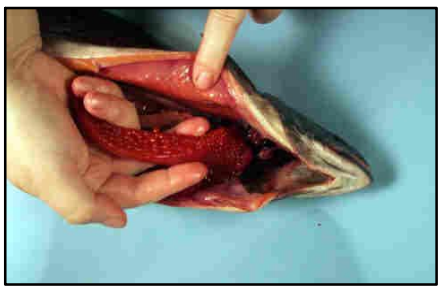
DISSECTION STEP 3



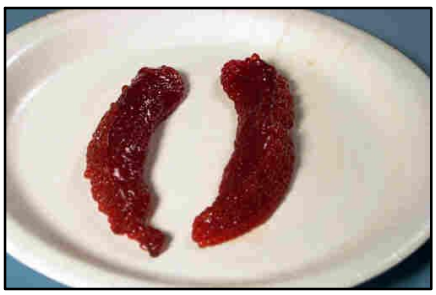
Eggs
If the fish is female there are two sacs of eggs each held with a membrane. When the female is ready to spawn the eggs come loose inside her body and are laid from the vent.

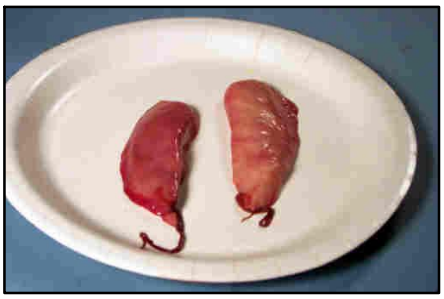


Milt
If the fish is male there are two sacs or testes that produce milt when ready to spawn. The milt becomes liquid containing sperm and is squeezed out the vent opening to fertilize the eggs. The milt sacs are usually firm and white if the male has not spawned.



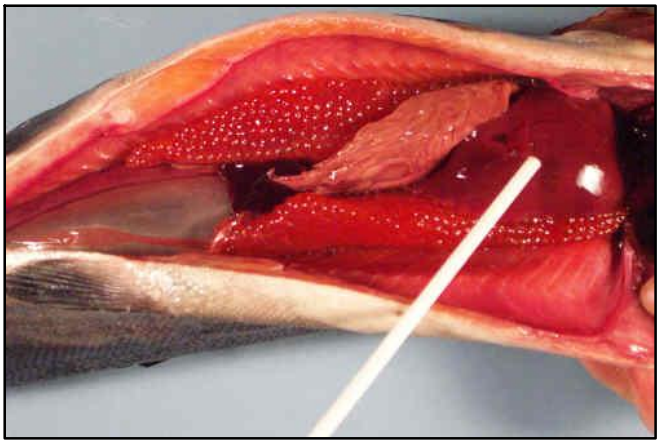
1. Remove the eggs or milt by gently pulling the sacs away from the body.



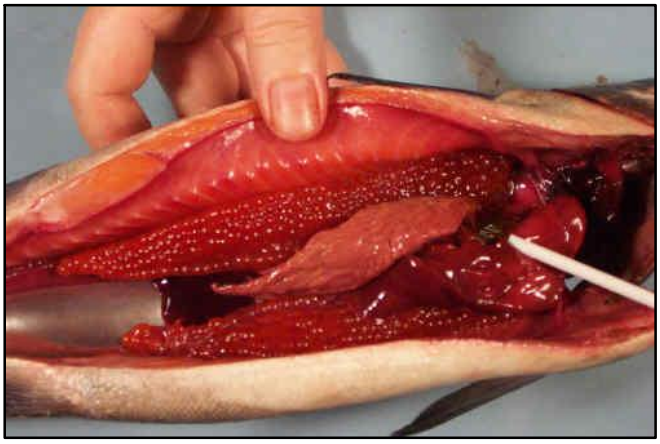


Coho salmon have an average of 2,500 eggs but some species have from 2,000 to 5,000. Only 375 Coho survive to become fry, only 30 survive to become smolts, about 4 to 5 become adults, and only two will return to spawn.

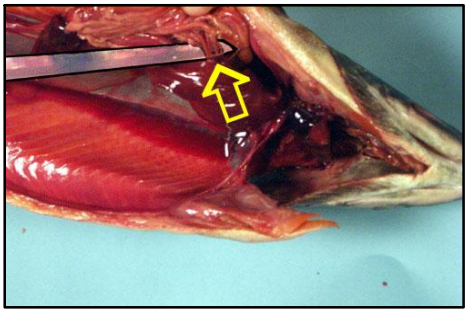
DISSECTION STEP 4



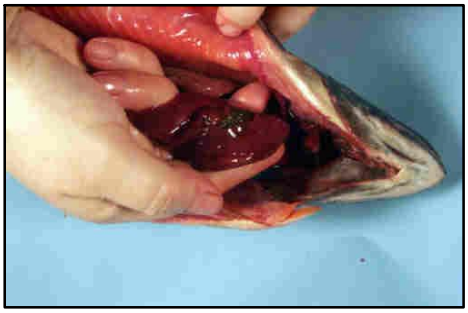
Liver
The liver is the largest organ in the fish's body. It is part of the digestive system. As in humans, it is essential for maintaining the proper level of blood chemicals and sugars.



Gall Bladder
Turn the liver over to view the gall bladder. The gall bladder contains green bile which is used to help digest fats.



1. Remove the liver and gall bladder by gently cutting any small membranes that join it to the digestive system.



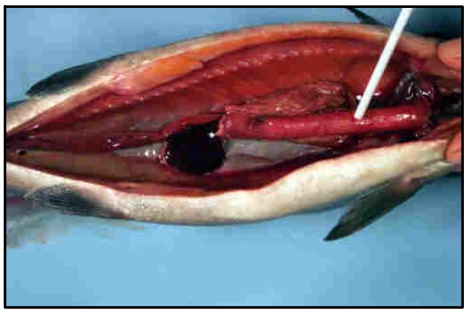
2. Pull away from the stomach and remove.

3. Liver with empty gall bladder.

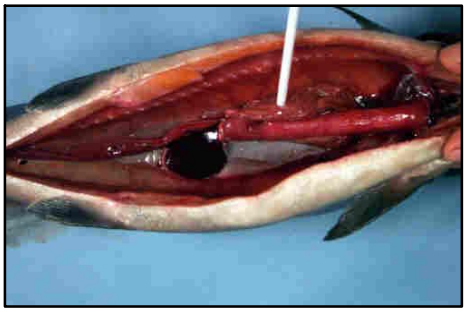
DISSECTION STEP 5

Digestive System
Observe the digestive system by gently pushing a probe (8'' spoon handle or chopstick) through the mouth and into the stomach.

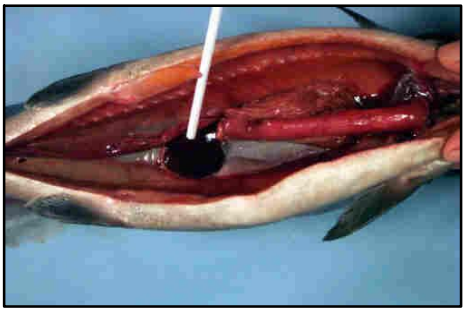
The digestive system is shorter and simpler than in mammals. Because fish are cold-blooded they do not use as much energy to keep warm and do not need as much energy from their food so they expel it more quickly.



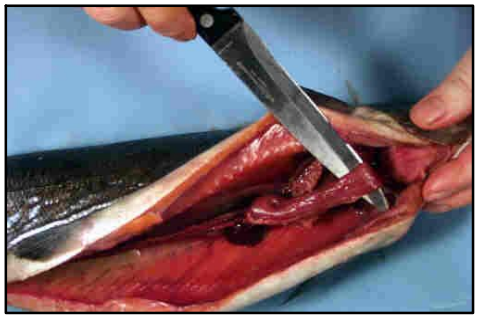
Stomach
The stomach breaks down food with digestive juices.



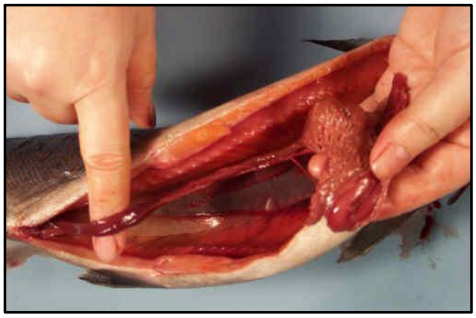
Pyloric Caeca
The pyloric caeca absorbs nutrients into the blood. It is similar to the small intestine in people.



Spleen
The spleen is a storehouse of blood for emergencies and recycles worn-out red blood cells.



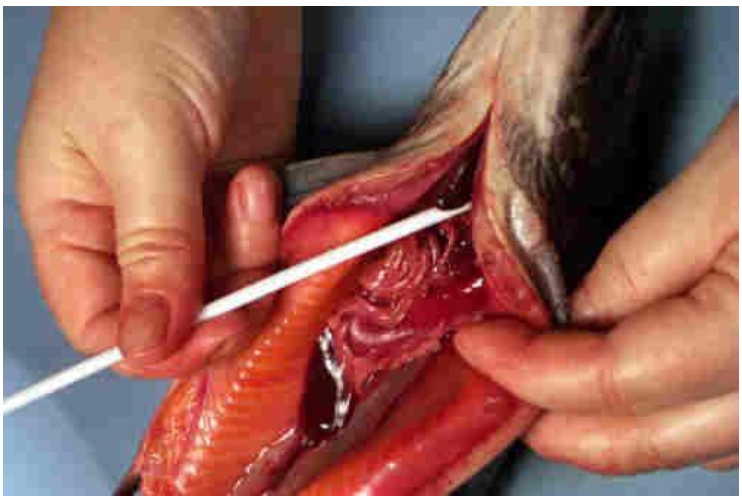
1. Remove the stomach by cutting it away at the throat and gently pulling.



2. Remove the complete digestive system and intestines, which end at the vent.

3. Most food is absorbed in the intestine, the tube-like section at the end of the digestive system.

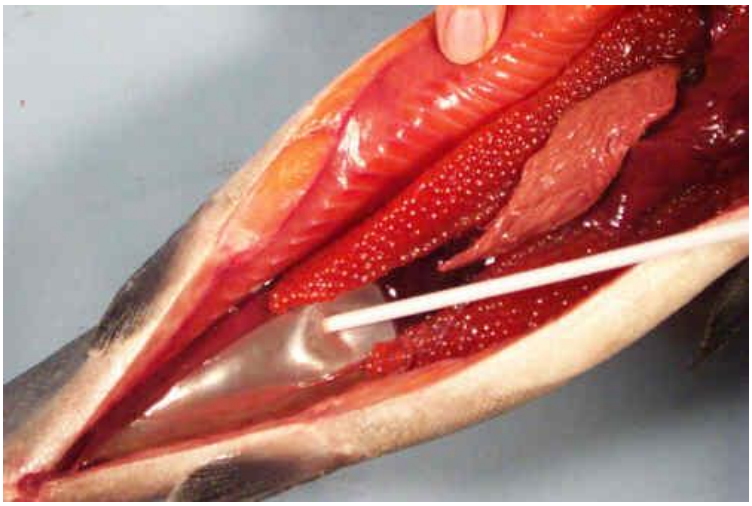
DISSECTION STEP 6



The Heart
The heart pumps blood through the body. It is very close to the gills where fresh oxygen enters the blood. In humans, the heart is close to the lungs to pump fresh oxygen through our bodies.

Heart showing ventral aorta leading to gills.

DISSECTION STEP 7



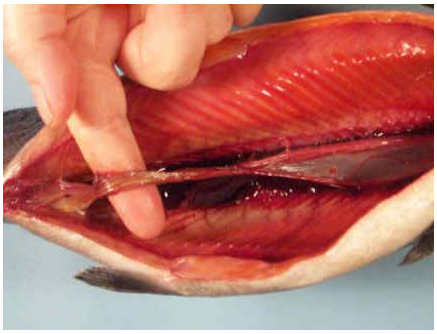
Swim Bladder
Salmon fill their swim bladder with air for the first time as swim-up fry. The air provides buoyancy, allowing them to float in the water.

Salmon can adjust the air in their swim bladder so they can hover at different levels in the water.

Often the swim bladder remains full of air after the salmon dies.

1. If the swim bladder is flat, show it by inserting a straw in the tear and gently adding air.

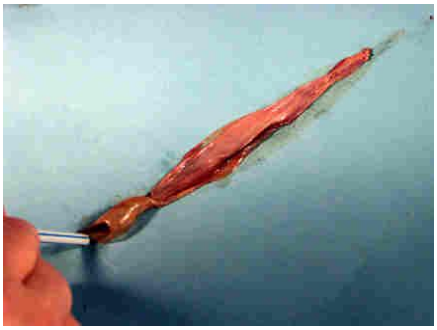
2. Remove the swim bladder by gently scraping it away from the sides of the body with the flat side of the knife.



3. At the vent end of the fish, reach one finger under the swim bladder and pull it away.

4. Continue pulling up to the throat where a gentle tug will release it.

5. Make a clean cut at the vent end of the swim bladder.



6. With a fingertip, gently pull back the top layer of the bladder 1/2 cm. With a straw blow firmly at this end, and it will open up.

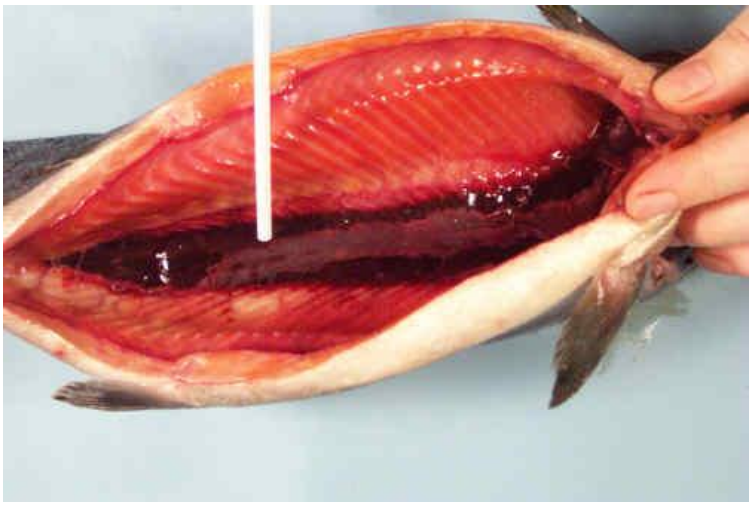
7. Slide the straw into the opening and gently blow to fill the bladder.

8. Seal the bladder opening by pinching it against the straw. Now slide the bladder off the straw.

9. Twist the bladder to lightly seal the opening.

10. Float in water to demonstrate buoyancy.

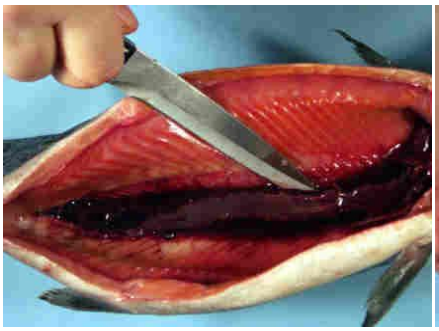
DISSECTION STEP 8



Kidney

Salmon have two kidneys joined together. The front kidney produces red blood cells and the back kidney cleans the blood. Urine is collected by ducts near the vent.

The kidney is also critical in the smolting process (going from fresh to salt water) in a process called osmoregulation.



1. Remove the kidney by cutting along each side.

2. Use a spoon to lift it out.

3. Kidney

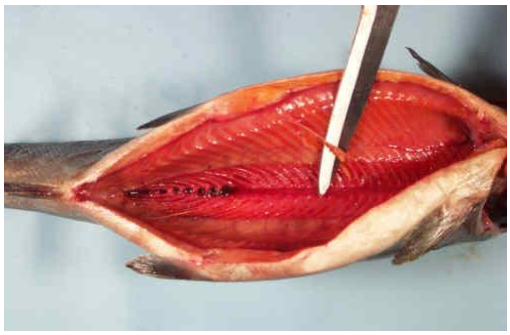
DISSECTION STEP 9

Skeletal System

Fish have a flexible backbone, as do mammals. The backbone is a series of interlocked disks. Salmon can move from side to side, but can only bend up and down a small amount.

The backbone protects the spinal cord that runs through the body to the brain.

The ribs are lightweight, curved bones that give the fish its shape. The ribs protect the salmon's internal organs.



1. Remove a rib by cutting on each side and pulling it up toward the backbone.

2. Cut to disconnect it.

You may also cut off the tail to show the spine.
Membranes carry messages via nerves from the lateral line to the spine.

DISSECTION STEP 10

Eyes

Salmon have two eyes, but unlike people, salmon do not have binocular vision, which would give them depth perception. However, they swivel each eye independently forward and backward to cover a much wider field of vision than people have. Fish have very sharp vision under water. Some can see five meters or more.

1. Remove one eye by reaching under the gill with a finger and pushing hard to loosen the muscles in the socket behind the eye.

2. When it is pushed out of the socket, remove your finger.

3. From the outside, gently pull up on the eye with one hand as you cut it away from the head.

Human eyes are approximately the size of a golf ball.

As do salmon, most of the eye is hidden inside their skull for protection. Unlike humans, salmon have no eyelids and no need to blink. Their eyes are continuously washed in water.

DISSECTION STEP 11

Brain

Like all chordates, salmon have a brain at the end of their spinal cord where the nervous system transmits the information they receive about their environment.

1. Begin by cutting through the salmon's head behind the gill covers.

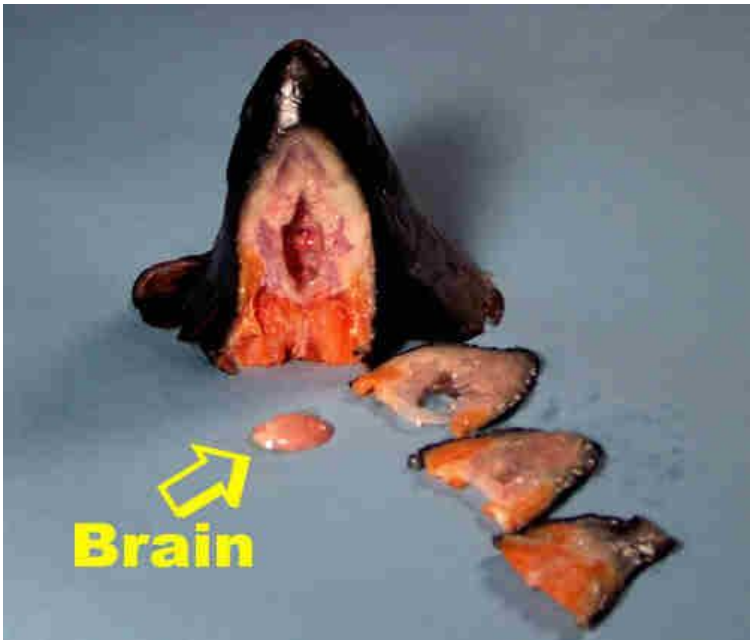
2. Hold the head by the nose and place the back of the head on a cutting surface.

3. Remove a very thin slice (1/3 cm) from the top of the head. Thin slices will prevent damage to the soft brain tissue.

4. Remove a second 1/3 cm slice. The opening to the brain is surrounded by cartilage.

5. Remove a third 1/3 cm slice. There are three pea-shaped sections.

6. Use the tip of the knife to gently probe and scrape out the brain. Tilt the head up side down and continue to scrape until removed.



The salmon brain. The forebrain controls the salmon's sense of smell. The midbrain controls vision, learning and responses to stimuli. The hindbrain coordinates movement, muscles and balance.

Compare the size of the salmon's eye to the size of their brain. Compare a human eye (the size of a golf ball) to the size of our brain. Salmon rely on their senses and an inborn knowledge called instinct to help them survive.

DISSECTION STEP 12

CLEAN UP

Clean the dissection area and all instruments with disinfectant and paper towels.

SUMMARY

You may wish to conclude this dissection by comparing human mammals and salmon. The structural and internal anatomy can be compared, including the muscular, skeletal, respiratory, digestive and reproductive systems. Salmon have many complex biological systems in order to live. Some have similarities to humans and other animals. Some are unique to fish.

Follow up with activities provided in the remainder of this binder surrounding salmonid life history and biology.

EXTENSIONS

1. Show salmon spawning videos (included on CD) and discuss life cycle.

Available Resources:

http://www.streamnet.org/pub-ed/ff/Factsheets/Lifecycle.html

http://www.bpa.gov/power/pl/columbia/stories/Magnificent1.htm

http://www.sf.adfg.state.ak.us/region2/ie/sicc/psposter.cfm
(GREAT POSTER CAN BE REQUESTED-FREE)

http://www.uaf.edu/seagrant/bookstore/pubs/SG-ED-25art.html

PROJECT WET - INCREDIBLE JOURNEY GAME Props to this game can be checked out through OSU Klamath Basin Research & Extension Center

http://www.oregonstate.edu/dept/kits
Fish Ecology Kit filled with fish field guides, posters, games, fish puzzle, stuffed fish, insect collecting equipment, and much more. Contact: Susan Honea, Natural Resource Educator: (541) 883-7131.

http://www.fws.gov/klamathfallsfwo/
U. S. Fish and Wildlife Service's Klamath Falls Fish & Wildlife Office has taxidermied fish, fish scales, preserved specimens, macro-invertebrates for educators to borrow. Contact Akimi King, Fish and Wildlife Biologist: (541) 885-2515 (direct) / (541) 885-8481 (office)

OSU Klamath Basin Research & Extension Center and the U.S. Fish and Wildlife Service's Klamath Falls Fish & Wildlife Office have aquariums, pumps and coolers that can be checked out to raise *Trout Eggs to Fry* in the classroom – funded by a STAC grant. We also offer a Fish Ecology Workshop and a variety of other "Teach the Teacher" workshops.

2. Facilitate educational games and field studies that enhance learning.

Recommended Examples:

Hooks and Ladders: From PROJECT WILD-Aquatic included pages (31-34)

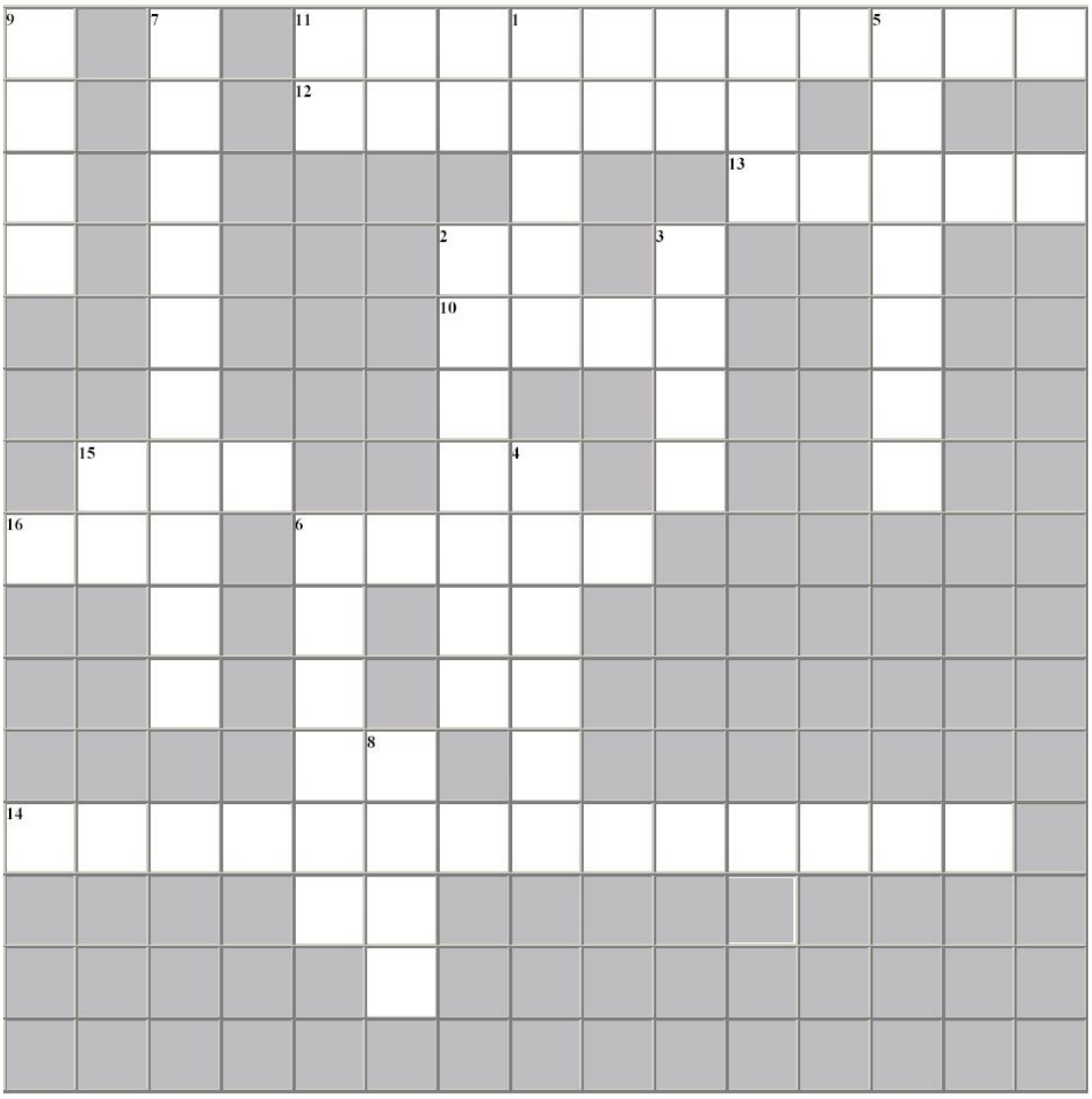
Play life cycle game to demonstrate egg to adult ratio
(EXAMPLE FROM WORKSHOP and page 38)

Visit Klamath Hatchery- Call for details

Klamath Hatchery
46161 Hwy. 62
Chiloquin, OR 97624
(541) 381-2278

Name _____ Date _____

Salmon Life Cycle Crossword Puzzle



Down

1. A major predator of salmon
2. *Oncorhynchus nerka* is the scientific name for this species of salmon
3. The nest that the female digs for her eggs
4. Fish that have hatched from the egg stage and have a yolk sac attached
5. Causes sediment to be dumped into streams and covers the gravel needed for spawning
6. Eggs hatch at this time of year
7. Salmon return to this place to spawn
8. Female lays these in a bed of gravel
9. Eggs are deposited in streams at this time of year

Across

6. This may help salmon find their way back to their home streams
10. This is the number of times that salmon usually spawn during their lifetime
11. These help salmon get past dams during migration
12. This is the point where the river meets the ocean
13. Salmon are in this stage when they start to swim in saltwater
14. Behavior that enables salmon to return to the exact place where they were hatched
15. A young salmon in the stage following the alevin stage
16. Adult salmon do this shortly after they spawn

Answer Key

f		h		f	i	s	h	l	a	d	d	e	r	s
a		o		e	s	t	u	a	r	y		r		
l		m					m			s	m	o	l	t
l		e				s	a		r			s		
		s				o	n	c	e			i		
		t				c			d			o		
	f	r	y			k	a		d			n		
d	i	e		s	m	e	l	l						
		a		p		y	e							
		m		r		e	v							
				i	e		i							
h	o	m	i	n	g	i	n	s	t	i	n	c	t	
				g	g									
					s									

Word Bank

Eggs	Die	Smolt
Home stream	Fish ladders	Once
Fall	Spring	Anadromous
Estuary	Homing instinct	Redd
Alevin	Fry	Smell
Erosion	Sockeye	Human

Hooks and Ladders Summary
-Project WILD Activity Pages Included-

Summary:

Students will gain an understanding of the salmon life cycle, recognize why the fish migrate, and understand what obstacles the fish have to go through in order to arrive at their destination. The objective of this activity is for the students to understand that migration is a part of many organisms' lives and that there are difficulties with it at times.

Objectives:

Students will:

-Participate in a hands-on activity about the salmon life cycle and their migration route.
-Identify the different stages of a salmon lifecycle: egg, alevin, fry, smolts and maturity.
-Identify limiting factors within a salmon life cycle; predators, dropping water levels, erosion, dams, etc..
-Compare the limiting factors for salmon to other organisms.
-Identify the reasons for fish migration and make comparisons to other organisms that migrate.

Grade Level: 5-6

Duration:

Preparation Time: 30 minutes
Lesson Time: 45 minutes

Content Standards:

Life Science
Organisms
- Describe the function of organ systems
- Group or classify organisms based on a variety of characteristics

Heredity
- Describe the life cycle of an organism

Diversity/Interdependence
- Describe the relationship between characteristics of specific habitats and the organisms that live there.
- Describe how adaptations help an organism survive.

Materials:

-Card board box (2)
-Rope or masking tape to mark the boundaries
-Jump rope
-playing field
-signs that mark each area
-tokens

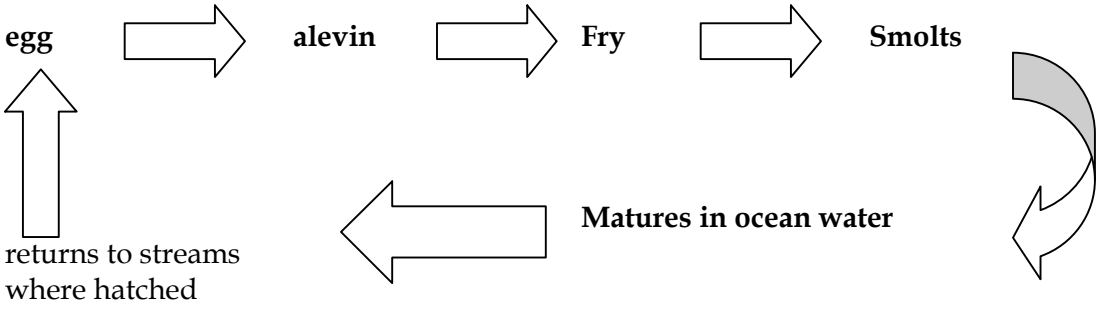
Background:

There are multiple types of fish that migrate from one habitat to another. Many times the fish migrate to mature and reproduce. The pacific (coho) salmon is an excellent example of a fish that migrates throughout its life.

Coho salmon spawn only once during their lifetime. They spawn in streams and rivers. Specifically in tributaries that lead to the ocean. They hatch in freshwater streams and then migrate towards the salt-water ocean where they spend 4 years maturing before making their last journey back to the freshwater rivers and streams where they will spawn and hatch.

The salmon deposits approximately 1,500 to 7,000 eggs in her freshwater stream. The eggs are deposited in a shallow gravel depression which was made by the male and after the eggs are deposited and the male fertilizes them both the female and male cover the eggs up with gravel to provide them as much protection as possible. After hatching the small fish called "alevin" stay in their gravel dugouts for two weeks while absorbing the egg yolk sac, which gives them nutrients to survive. Once the egg yolk sac has been absorbed the fish are now called "fry".

Some start migrating immediately to the ocean and others spend as much as two years in the river. Those that are migrating to the ocean are now called "smolts". Once the smolts have arrived at the ocean, they mature there. So they spend approximately 4 years in the ocean maturing and trying to survive. After two-five years the salmon start their return migration to the streams and rivers that they hatched in. They migrate back to the same tributaries that they hatched in. Once back at the spawning ground the cycle starts again.



Some hazards that are faced by the salmon throughout their lifetime are:

- predators
- dams
- fisherman
- landslides
- erosion
- waterfalls
- fish ladders
- water levels
- temperature
- lack of habitat

Vocabulary:

Limiting Factors: A confining or restricting object, agent, or influence that prevents an organism from migrating or completing the lifecycle.

Alevin: Young fish; after it has hatched but before it emerges from the gravel.

Fry: Small fish, especially young, recently hatched fish.

Smolt: A young salmon two or three years old, when it has acquired its silvery color.

Teaching:

As a warm up, discuss obstacles (limiting factors) in a stream that they think would affect a salmon from migrating. Review the life cycle of a salmon, by asking questions or have laminated cards and have the students place them in the correct order.

The objective of this activity is to teach the students about the life cycle of a salmon, limiting factors for their survival as well as the migration routes. Then compare it to other organisms that migrate and have to overcome obstacles for survival.

Lesson:

For the outside game:

- Create the board game either in the gym or in a field.
- Assign two students turn the jump rope simulating a turbine.
- Assign two students to be predators –have to tag with two hands.
- Assign two students to be fisherman – open sea
- All the rest of the students are salmon

1. The salmon start out at the spawning site in the freshwater rivers and streams.

2. They have to make it through the turbine (jump rope). They cannot go around it, they must go through it. However, if they are touched by the rope then they die and are escorted to the fish ladder, where they kneel and await the migrating salmon.

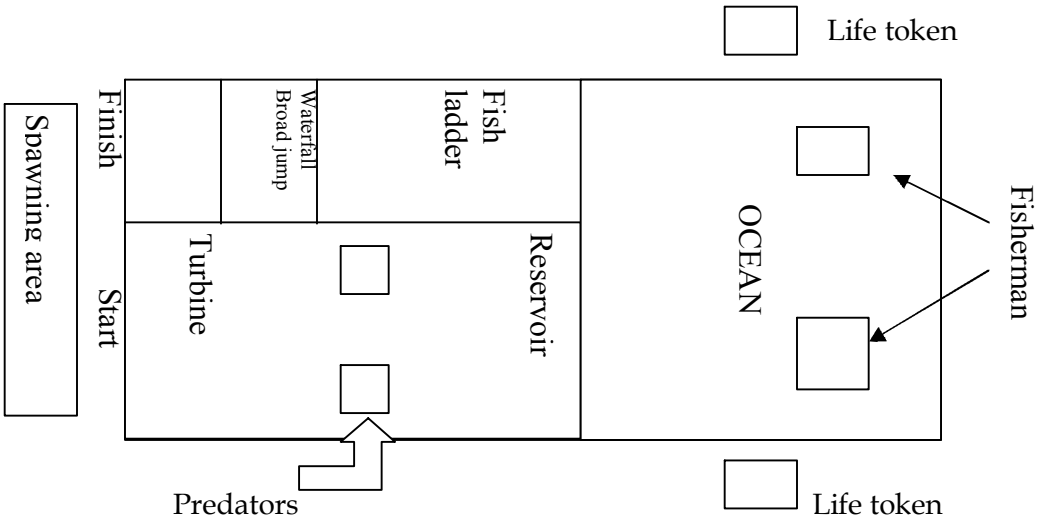
3. After the turbine they must make it through the reservoir without being eaten by predators. **The predators must tag with 2 hands.** If tagged, the predators escort the dead salmon to the fish ladder, where they become part of it.

4. The salmon then arrive in open sea where they have to cross the sea 4 times, picking up one life token at a time. They must dodge the fisherman who again must tag with 2 hands. If the salmon are caught then they will be escorted to the fish ladder by the fisherman.

5. After picking up all four life tokens (simulating 4 years of maturity) they then start migrating back to the streams to spawn. They have to physically go over every student up the fish ladder, simulating the difficulties that a salmon has.

6. Once they pass the fish ladder, there are two obstacles left. One is they have to cross the waterfall broad jump. They have to completely clear it or else are sent back to the bottom of the fish ladder and have to do it again. The two students turning the jump rope, will monitor the waterfall crossing.

7. They then make it back to their spawning area, but there are still predators (the ones that were in the reservoir, move to finish line) looking for food. So they have to make it to the finish area in order to spawn. The game ends when all salmon have either been killed or have made it to the spawning area.



Discussion Questions:

What are the steps of the salmon life cycle?
Why do so few salmon survive?
Give an example of a limiting factor that a salmon faces on the migration route.
Predict how many salmon would return to spawn if you started out with 100 eggs.
How could you create a safer migration route for the salmon?

References:

Project Wet: Hooks and Ladders
Activity Sheet included in this binder

Aquatic Times

Objectives

Students will (1) identify a diversity of issues related to aquatic organisms and habitats, and
(2) Develop their own opinions concerning some issues involving aquatic life and habitats.

Method

Students investigate, write, and produce a newspaper that features aquatic information and issues.

Materials

Research or library resources, current nature magazines (*Ranger Rick*, *National Geographic*, etc.), writing and art materials; OPTIONAL: Cameras/film, tape recorders, computers, video equipment (Educators may want to invite a local newspaper editor or writer to come to the class to discuss the mechanics of newspaper production.)

Background

The production of a newspaper requires an array of skills that include design capabilities, writing, composition, research, and decision making. This activity provides an opportunity for the students to coordinate newspaper production with information, issues, and recommendations about aquatic organisms and their habitats.

Procedure

1. Using an actual newspaper as a model, discuss the various parts of a newspaper. Help the students recognize that in addition to news articles, other departments exist in most newspapers. Comics, sports, editorials, employment opportunities, political cartoons, food and nutrition, entertainment, business, advertisements, weather, obituaries, and many other sections are featured in a newspaper. Ask each student or team of students to choose one section of the newspaper to develop and write.

2. The theme of this newspaper is aquatic animals and plants, aquatic habitats, or aquatic-related issues. Ask the students to gather information and ideas for their chosen section. Show the students how to properly acknowledge and credit any sources they use. NOTE: If using the optional materials listed above, familiarize the students with any resources they can use, such as the tape recorders, computers, software, cameras, and so forth.

3. The articles in the newspaper could be both playful and serious. For example,
- Water Strider Upends at Soap Spill in Stream

Extensions

1. Have an aquatic poster contest.
2. Establish a current events corner about wildlife.
3. Convert the newspaper to a video news format.
4. Visit a local newspaper and offer your articles for submission to the newspaper.

Evaluation

1. Identify three issues involving aquatic animals, aquatic plants, or aquatic habitats.
2. Explain why it is important to accurately report environmental information to others.
3. What are the characteristics of a good environmental reporter?

- Oil Spill Threatens New Hampshire
- Crayfish Die in Silt Avalanche
- Too Many Wells Deplete Local Aquifer
- Snoopy aboard the *Calypso* (cartoon)
- Dear Abalone (advice column)
- Aquatic Recipes
- Tidal Waves in History
- An interview with three grandparents about how local aquatic resources used to be
- Fish Race to Spawning Beds! (sports)

4. Once the students have accumulated their research and begin writing their articles, encourage them to share their work. In this way, interests can merge and different talents can be called on. Keep the students on track, making sure their writing is accurate even though they may have chosen humor or satire as their approach.

5. When most of the articles have been written, assign a small group of students to begin the production phase of the paper. The artwork can be photographs or drawings that illustrate a particular point in the article. Computer graphics can also be used to highlight specific articles. This phase of the newspaper can be produced using a computer, a typewriter, or by students neatly handwriting the articles using a specified column format (3 1/2 or 4 inches wide works well). Most computers have software that includes a newspaper template.

6. Once the newspaper is complete, copies can be made for the class or for distribution throughout the community.

7. Summarize the activity with a discussion of each article or feature, emphasizing what the students learned about aquatic life and habitat from this activity.

Grade Level: 5–8
Subject Areas: Language Arts, Environmental Education
Duration: several sessions or longer
Group Size: small groups or individual activity as part of a class project
Setting: indoors
Conceptual Framework Topic Reference: ITIA, ITIB
Key Terms: newspaper, issue, aquatic
Appendices: Using Local Resources, List of Agencies and Organizations

References: Project Wild Aquatic

Content Standards Extension Examples:

Reading

Listen to, read, and understand a wide variety of informational and narrative text across the subject areas at school and on own, applying comprehension strategies as needed. Increase word knowledge through systematic vocabulary development.

Writing

Pre-write, draft, revise, edit and publish across the subject areas.
Communicate supported ideas across the subject areas, including relevant examples, facts, anecdotes, and details appropriate to audience and purpose that engage reader interest.
Write narrative, expository, and persuasive texts, using a variety of written forms.
Understand and interpret the history of the state of Oregon.
Define and clarify an issue so that its dimensions are well understood.
Acquire and organize materials from primary and secondary sources.
Explain various perspectives on an event or issue and the reasoning behind them.
Identify and analyze an issue.

Geography

Use maps and other geographic tools and technologies to acquire, process and report information from a spatial perspective.
Understand the spatial concepts of location, distance, direction, scale, movement and region.
Compare and analyze physical and human characteristics of places and regions.
Understand how people and the environment are interrelated.

Arts

Apply artistic elements and technical skills to create, present and/or perform works of art for a variety of audiences and purposes.

Economics

Understand that resources are limited.
Research economic impacts of loss on salmon and commercial salmon fishery.

Ideas on how to implement this curriculum into other subject areas:

Read a book or research about the Native Americans and their use of salmon and fish n the watershed.

Identify areas where the Native Americans lived and look at the natural resources in that particular area.

Have the students research the particular issues surrounding salmon, and water. Give each group a separate role and then have them debate it in class.

Have the students create a mural, drawing the migration path of the salmon and the life cycle.

Salmon Life Cycle Game
-Paper, Rock, Scissors-

Stage 1: Egg (Arms over head in circle)

Stage 2: Sac Fry (Arms in front of belly like sac)

Stage 3: Fry (Hands rub belly to show hungry)

Stage 4: Smolt (Superhero pose to out-migrate)

Stage 5: Adult (Jumping to come back to spawning area)

Play paper rock scissors.

Win= move to next stage
Loose= Back to Stage 1: Egg

Play 10-15 rounds.

Review Life Cycle of a Salmon