SALMON SCIENCE JOURNAL

NAME ____

SCHOOL ____________________________________

SPECIES OF SALMON __________________________

DATE EGGS WERE FERTILIZED __________________

DATE EGGS ARRIVED ___________________________

HATCHERY ___________________________________

FOSS WATERWAY SEAPORT

TACOMA CREATES

SALMON IN THE SCHOOLS SEATTLE

Tacoma

TACOMA PUBLIC SCHOOLS
EVERY STUDENT. EVERY DAY.

The SeaDoc Society
People and science healing the sea

Salmon **Egg** Observations

Draw and label what you **see** when you look at your salmon eggs.

Today's Date________________________

One other thing I noticed is ...

____

____

The eggs remind me of ...

____

____

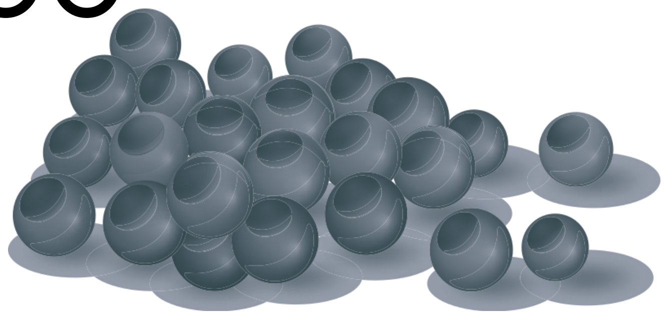
I wonder about...

____

____

I could find answers to my questions by ...

More Salmon Egg Observations



Development Day Number ___________

1. Describe the color and size of the eggs.

____

____

2. The salmon eggs are... (check all that apply)

☐ In bunches

☐ Among the gravel/rocks

3. About how many eggs are in the tank? ★

4. Circle about how many seem to be moving about:

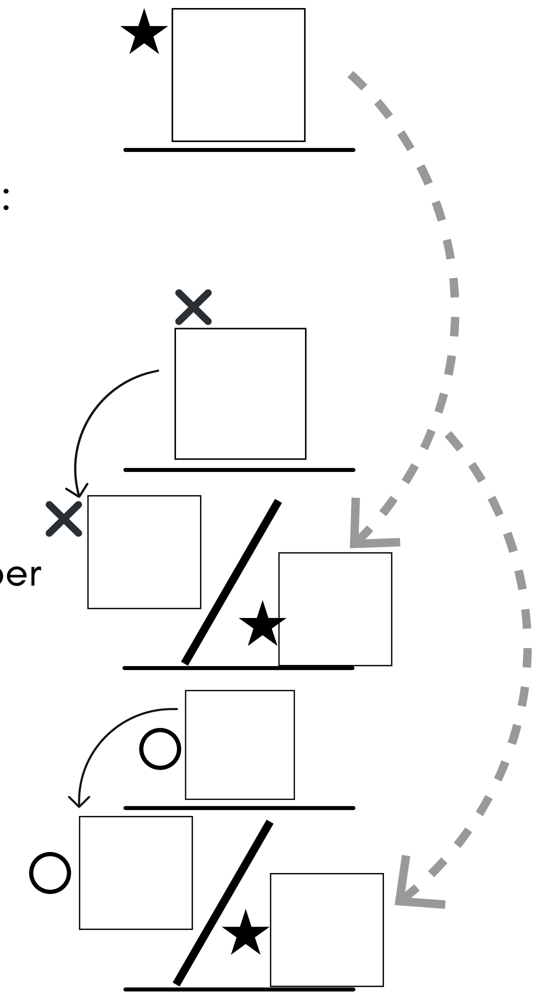
1/4 1/2 3/4 All of them

5. How many eggs (if any) have hatched? ✕
(if too many to count, make an estimate)

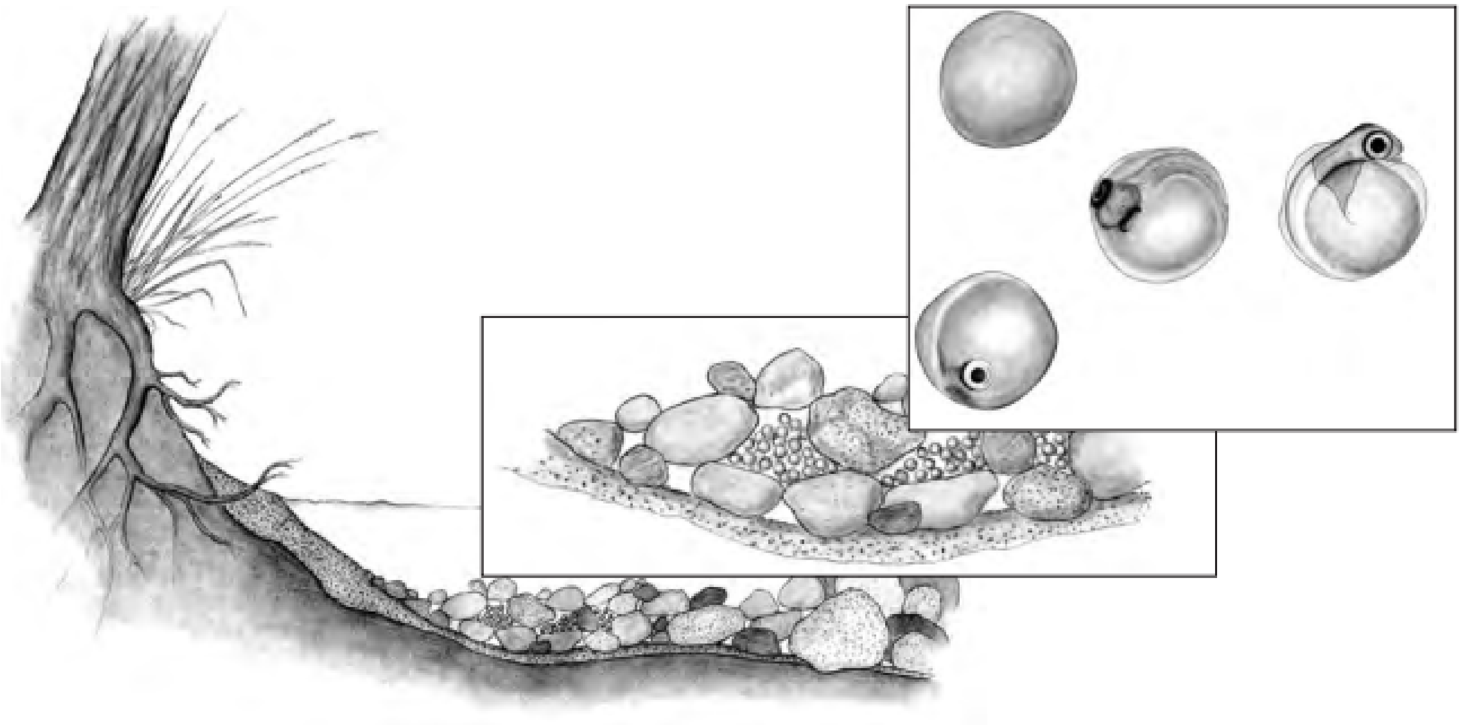
6. What fraction have hatched out of the total number of eggs?

7. How many eggs have died (turned white)? ○

8. What fraction of the total number of eggs have died?



Article 1: 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 eggs.

Salmon eggs are very sensitive—only one in 10 survives 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. (See the box on ATUs.)

Article 1: Salmon Eggs

Salmon biologists use **ATUs** to measure the heat an egg receives. ATU stands for Accumulated Thermal Unit. It is the total heat an egg receives over a period of time. To calculate ATUs, you add the water temperature each day to the total for the previous days. For example, if the water temperature is 8°C on the first day, the ATUs are 8. If the temperature is 8°C again on the second day, the ATUs are 16. If the temperature falls to 6°C on the third day, the ATUs are 22.

The ATUs control the time a salmon takes to develop. Coho salmon, for example, develop as outlined below. (Other salmon species have a slightly different schedule.)

Head and body
50 ATUs
(About 7 to 10 days)

Eyes begin to appear
220 ATUs
(About one month)

The salmon hatches
400 to 500 ATUs
(About two months)

The salmon fry emerges
700 to 800 ATUs
(About three months)

Inside the egg, the developing salmon feeds from a yolk sac. However, the embryo still needs to get oxygen from air dissolved in the water that flows through the gravel. Some oxygen can pass through the wall of the egg. However, if silt covers the gravel under which the egg is buried, oxygen cannot transfer through the egg membrane and the embryo can smother. The embryo can also die if the water flows too slowly and the dissolved oxygen cannot reach the egg.

As development progresses, the embryo begins to move and wiggle around. At a certain point, it releases a chemical that weakens the wall. The embryo breaks through and wiggles out. It will live the next stage of its life in the gravel as an alevin.

Salmon Egg Dependence on Habitat

Focus Questions: What are the dependent relationships of salmon as they develop from eggs to fry in the Salmon Aquarium System and the stream habitat? How do land and water ecosystems affect salmon?

In the table below:

- Describe how the needs of the salmon are met in the Aquarium System and in a stream habitat system
- Then list threats to those needs being met in a stream habitat

Dependent Relationships - Salmon Development Needs

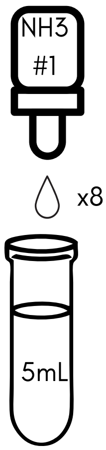
What do salmon need as they hatch and develop into fry?	How their needs are met in the salmon aquarium	How their needs are met in a stream habitat	Threats to the stream that can affect this need being met
Eggs need water temperature 5-9°C (41-48 °F)			
Eggs need oxygen			
Eggs need clean water			

Salmon and Clean Water

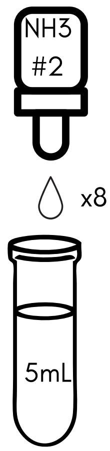
You have been learning about what makes a healthy stream for salmon. In all stages of the salmon development they need clean water. Now it's time to test the water in your tanks!
You will be testing for **ammonia** and **nitrates**.

Instructions for testing **ammonia**:

Step 1: Fill a clean test tube to the 5mL line with water from the tank

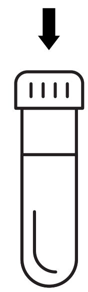


Step 2: Holding the dropper completely upside down, add **8 drops** of Ammonia Solution #1

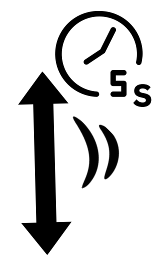


Step 3: Holding the dropper completely upside down, add **8 drops** of Ammonia Solution #2

Step 4: Cap the test tube



Step 5: Shake well for **5 seconds**



Step 6: Wait 5 minutes

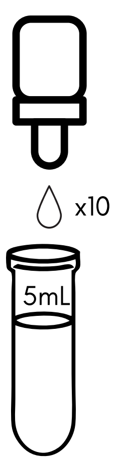
Step 7: Compare the color of the solution to the color chart. The closest color match indicates the ppm of **ammonia**. How much **ammonia** is in the tank?

Step 8: Clean the test tube by rinsing with water. Do not pour the test tube back into the tank.

Instructions for testing **nitrate**:

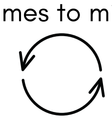
Step 1: Fill a clean test tube to the 5mL line with water from the tank

NO3-
#1

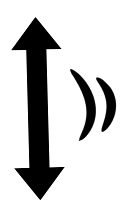


Step 2: Holding the dropper completely upside down, add **10 drops** of Nitrate Solution #1

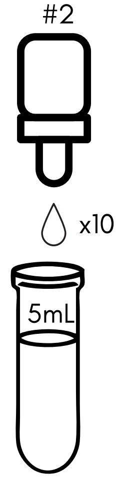
Step 3: Cap the test tube and turn it upside down several times to mix.



Step 4: Vigorously shake the bottle of Nitrate solution #2 for at least 30 seconds **before** adding it to the test tube.

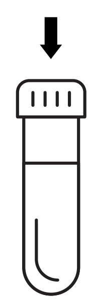


NO3-
#2

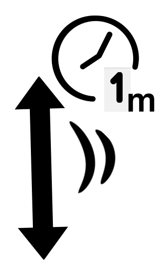


Step 5: Holding the dropper completely upside down, add **10 drops** of Nitrate Solution #2

Step 6: Cap the test tube



Step 7: Shake well for **1 minute**



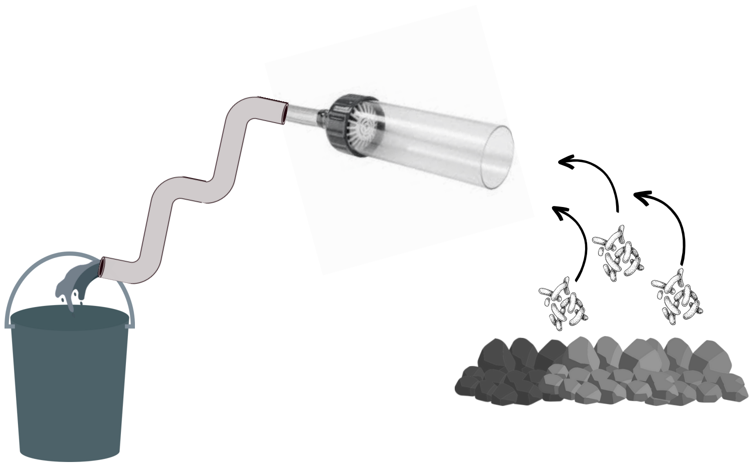
Step 8: Wait 5 minutes

Step 9: Compare the color of the solution to the color chart. The closest color match indicates the ppm of **nitrate**. How much **nitrate** is in the tank?

Step 10: Clean the test tube by rinsing with water. Do not pour the test tube back into the tank.

Salmon and Clean Water

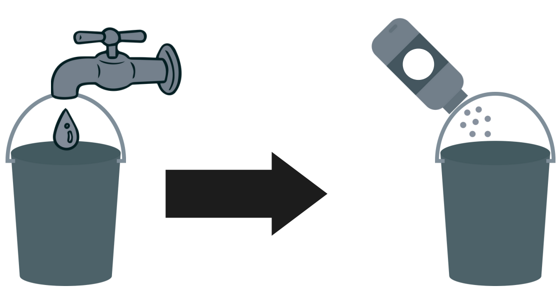
You have been learning about what makes a healthy stream for salmon. In all stages of the salmon development they need clean water. Now it's time to test the water in your tanks!
You will learn how to siphon (clean) the gravel and add new water.



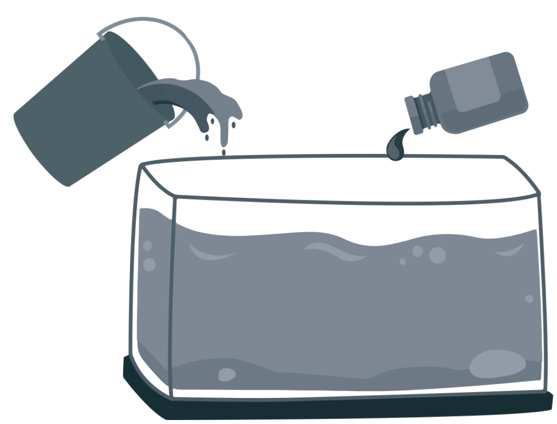
Step 1: clean the gravel, put the dirty water in a bucket

Step 2: dump the dirty water down the sink

If your results from the ammonia or nitrate tests are high, one of the first things you should do is clean the gravel and replace the water. You can do this using the Siphon- this lets you clean up any gross stuff in the gravel and remove some dirty water along with it. Then you can use your buckets to replace the water (with your teacher or Salmon Intern's help!). Just make sure you add de-chlorinator to the bucket **before** you add new water to your tank. Doing this 1-3 times a week will keep your fish healthy and happy!



Step 3: put fresh tap water in the bucket and add the right amount of de-chlorinator



Step 4: put the de-chlorinated water into the tank, and add the right amount of Stability (good bacteria)

Salmon **Alevin** Observations

Draw and label what you **see** when you look at your salmon in the alevin stage

Today's Date___________________________

One other thing I noticed is ...

Do all of the alevin look the same? Describe any differences that you see.

I wonder about...

More Salmon Alevin Observations

Day Number ___________

1. Describe the color, size, and markings of the alevin.

____

____

2. Describe how the alevin move (swim/bounce/float/etc).

____

____

3. Where are they? (check all that apply or write in other observations)

- ☐ bunched up
- ☐ corners of tank
- ☐ next to bubbles
- ☐ in groups next to the glass
- ☐ other: ______________________________

4. Are they bunched by size or behavior? If so, describe.

____

____

5.Shine the flashlight on the salmon alevin for several seconds. What did they do? ______________________________

____

Article 2: Salmon Alevins

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 Alevin Dependence on Habitat

Focus Questions: What are the dependent relationships of salmon as they develop from eggs to fry in the Salmon Aquarium System and the stream habitat? How do land and water ecosystems affect salmon?

In the table below:

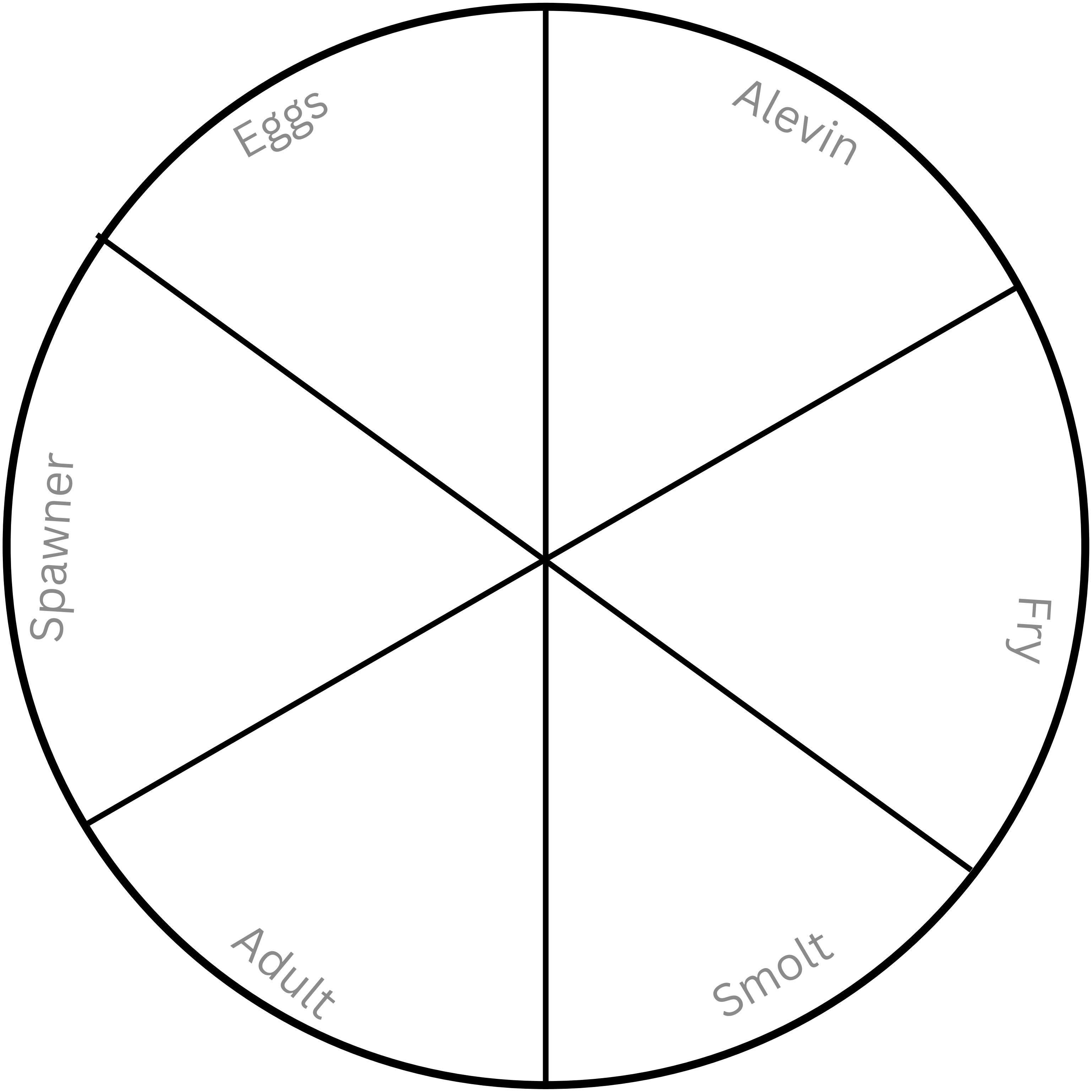
- Describe how the needs of the salmon are met in the Aquarium System and in a stream habitat system
- Then list threats to those needs being met in a stream habitat

Dependent Relationships - Salmon Development Needs

What do salmon need as they hatch and develop into fry?	How their needs are met in the salmon aquarium	How their needs are met in a stream habitat	Threats to the stream that can affect this need being met
Alevin need water temperature 5-14 C (41-57 F)			
Alevin need oxygen			
Alevin need places to avoid light			
Alevin need clean water			

Know your Salmon: Lifecycle

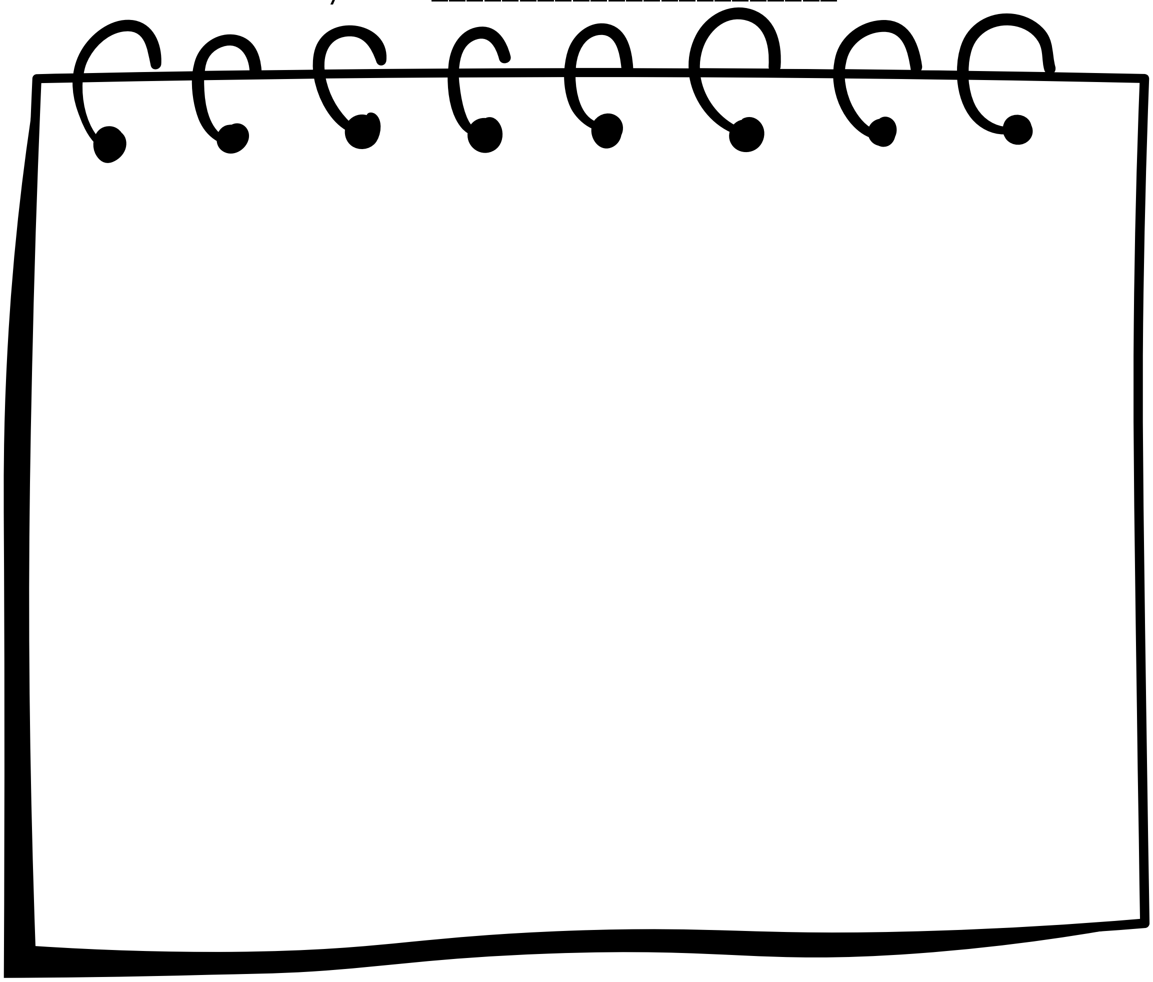
Draw each life stage of salmon in the spaces below.



Salmon **Fry** Observations

Draw and label what you **see** when you look at your salmon in the fry stage.

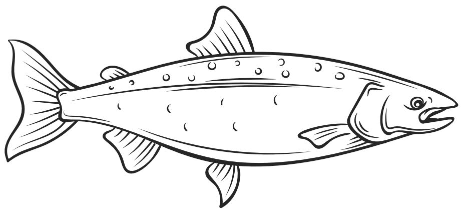
Today's Date________________________



Describe 3 fry behaviors.

Explain how each might help salmon survive in freshwater or saltwater

	Behavior	How it helps salmon survive
1		
2		
3		



More Salmon Fry Observations

Day Number __________

1. Describe the color, size, and markings of the fry.

____

____

2. Are all the sizes mixed or are they bunched by size?

____

____

3. How many fins does each fry have? ____________________

4. Observe how one fry is able to move when it moves different parts of its body. (moves stright ahead? turns direction? darts? holds in place? stops?)

Part of the body the fry moves		What happens
	Big fin on top	
	Pairs of fins on bottom	
	Tail	

5.Describe how the fry behave when fed.

____

____

6. Shine the flashlight on the fry for a few seconds. What did they do?

____

Article 3: Salmon Fry

Illustration: Karen Uldall-Ekman

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

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

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

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

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

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

Article 3: 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.

- Pink and chum spend one to three months in fresh water.
- Chinook, coho and sockeye spend about one year.
- Rainbow trout spend two to three years.

Then, they begin to migrate downstream to the **estuary** where the river meets the ocean. Sometimes, dams or other blockages prevent salmon from travelling to the sea. They remain in lakes and rivers through their entire life cycle, but can continue to produce land-locked offspring.

Salmon Fry Dependence on Habitat

Focus Questions: What are the dependent relationships of salmon as they develop from eggs to fry in the Salmon Aquarium System and the stream habitat? How do land and water ecosystems affect salmon?

In the table below:

- Describe how the needs of the salmon are met in the Aquarium System and in a stream habitat system
- Then list threats to those needs being met in a stream habitat

Dependent Relationships - Salmon Development Needs

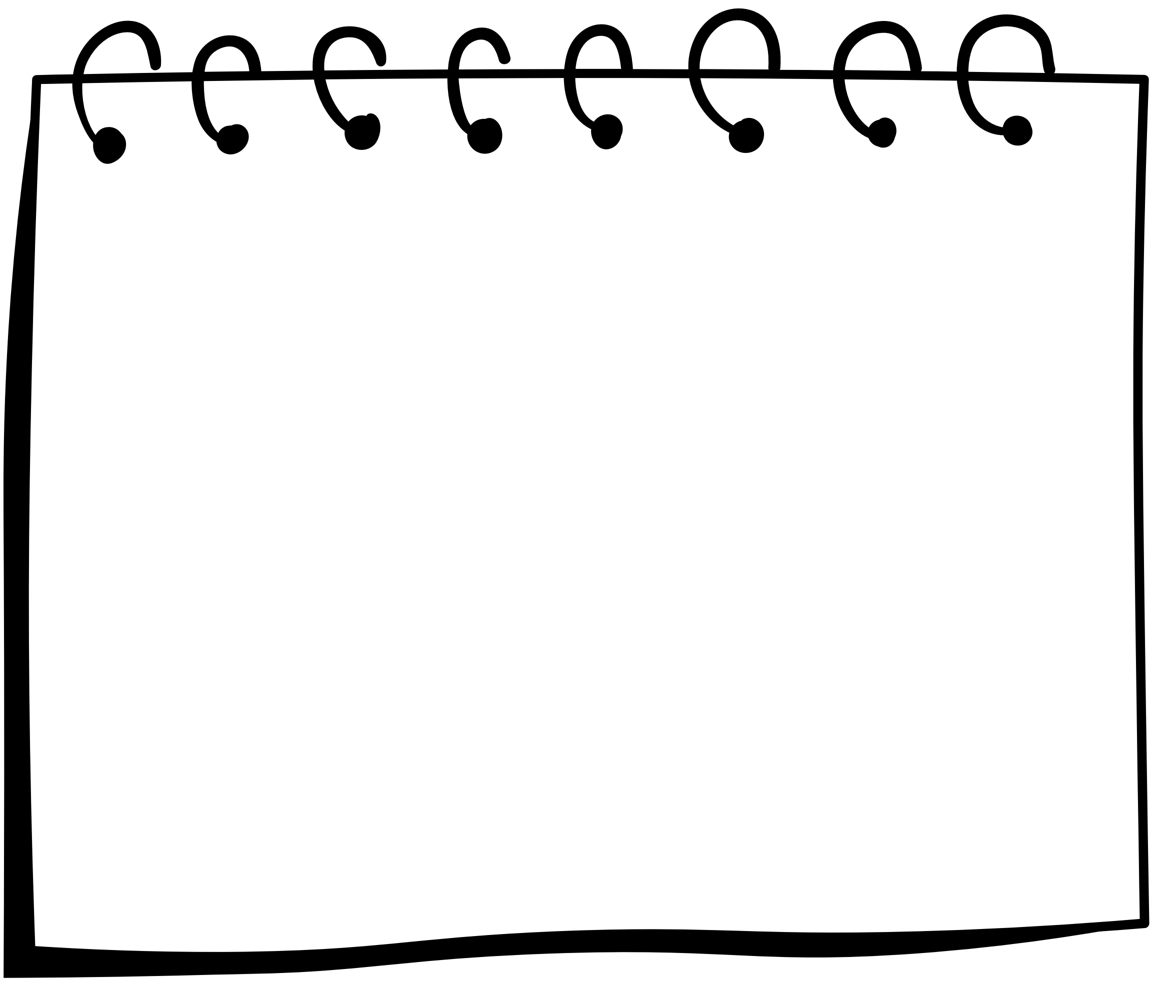
What do salmon need as they hatch and develop into fry?	How their needs are met in the salmon aquarium	How their needs are met in a stream habitat	Threats to the stream that can affect this need being met
Fry need air for buoyancy (floating)			
Fry need to eat			
Fry need oxygen			
Fry need clean water			

Coast Salish Connection: Through Salmon Eyes

"I don't believe in magic. I believe in the sun and the stars, the water, the tides, the floods, the owls, the hawks flying, the river running, the wind talking. They're measurements. They tell us how healthy things are. How healthy we are. Because we and they are the same. That's what I believe in. Those who learn to listen to the world that sustains them can hear the message brought forth by salmon."

BILLY FRANK JR

After watching Salmon Story and reading the quote above by Billy Frank Jr, write or draw how you might “listen to the world that sustains us and hear the message brought forth by the salmon.”



Common tire chemical implicated in mysterious deaths of at-risk salmon

Coho salmon in urban streams have been dying in the U.S. Pacific Northwest

Important vocabulary:

- **Toxicant**- a toxic agent
- **Leach**-to dissolve out by the action of a percolating liquid (running water)
- **Pollution**- the action of polluting especially by environmental contamination with human-made waste
- **Chemical Formula**- an expression in symbols of the composition of a substance (ex: *the formula for water is H2O*)

For decades, something in urban streams has been killing coho salmon in the U.S. Pacific Northwest. Even after Seattle began to restore salmon habitat in the 1990s, up to 90% of the adults migrating up certain streams to spawn would suddenly die after rainstorms. Researchers suspected the killer was washing off nearby roads, but couldn't identify it. "This was a serious mystery," says Edward Kolodziej, an environmental engineer at the University of Washington's (UW's) Tacoma and Seattle campuses.

Online today in Science, researchers led by Kolodziej report the primary culprit comes from a chemical widely used to protect tires from ozone, a reactive atmospheric gas. The **toxicant**, called 6PPD-quinone, **leaches** out of the particles that tires shed onto pavement. Even small doses killed coho salmon in the lab. "It's a brilliant piece of work," says Miriam Diamond, an environmental chemist at the University of Toronto. "They've done a tremendous job at sleuthing out a very challenging problem."
Manufacturers annually produce some 3.1 billion tires worldwide. Tire rubber is a complex mixture of chemicals, and companies closely guard their formulations. Because tire particles are a common component of water **pollution**, researchers have been examining how they affect aquatic life.

After Kolodziej arrived at UW's Center for Urban Waters in 2014, he joined the effort to solve the coho salmon mystery. The group created a mixture of particles from nine tires—some bought new, others provided by two undergraduates who moonlight as mechanics—to mimic what might wash off typical highways. They found several thousand unidentified chemicals in the mixture. Postdoc Zhenyu Tian spent more than 2 years narrowing down the list, separating the molecules based on their electrical charge and other properties. By May 2019, he had narrowed the focus to about 50 unknown chemicals, and then further work revealed the chemical formula of a prime suspect. "If you're looking for an unexplained toxicant that's killing fish, we had the perfect instruments and expertise," Kolodziej recalls.

But what was it? A 2019 report from the Environmental Protection Agency on chemicals in recycled tires mentioned 6PPD, which has a similar **formula**. The final clue was buried in an industry report from 1983, which contained the exact **formula** of 6PPD-quinone, the molecule created when 6PPD reacts with ozone. The team synthesized 6PPD-quinone and found it was highly lethal to coho salmon.
Now, the team is working to understand how the chemical kills fish. Kolodziej and colleagues say other species of fish should also be evaluated for sensitivity. Because you can't buy the molecule, Kolodziej's team is making it. "My lab might even be the only place that actually has this," he says.

The researchers suspect the compound is present on busy roads everywhere. They've found it washes off pavement and into streams in Los Angeles and San Francisco, for example. The simplest solution might be for tire manufacturers to switch to an environmentally benign alternative. But Sarah Amick, vice president of environment, health, safety, and sustainability at the U.S. Tire Manufacturers Association, says it's too early to discuss alternatives. "It's important that additional research be done to validate and verify these results."

Another way to protect salmon is to filter stormwater through soil, but installing enough infiltration basins to treat road runoff before it reaches spawning streams would be very expensive, says co-author Jenifer McIntyre, an ecotoxicologist at Washington State University's Puyallup Research and Extension Center. In the meantime, Kolodziej says he "can't walk along a street without staring at all the skid marks," thinking about tire chemicals, and "wondering what's there."

Resources:

Article: https://www.science.org/content/article/common-tire-chemical-implicated-mysterious-deaths-risk-salmon

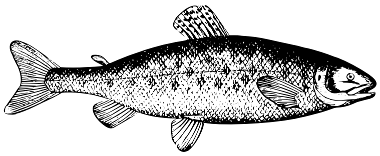
Definitions:

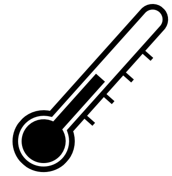
- "Toxicant." Merriam-Webster.com Dictionary, Merriam-Webster, https://www.merriam-webster.com/dictionary/toxicant. Accessed 14 Nov. 2022.
- "Leach." *Merriam-Webster.com Dictionary*, Merriam-Webster, https://www.merriam-webster.com/dictionary/leach. Accessed 14 Nov. 2022.
- "Pollution." *Merriam-Webster.com Dictionary*, Merriam-Webster, https://www.merriam-webster.com/dictionary/pollution. Accessed 14 Nov. 2022.
- "Formula." *Merriam-Webster.com Dictionary*, Merriam-Webster, https://www.merriam-webster.com/dictionary/formula. Accessed 14 Nov. 2022.

Seattle Times Article with video: https://www.seattletimes.com/seattle-news/environment/tire-dust-is-killing-salmon/

Coho photo: https://www.fisheries.noaa.gov/species/coho-salmon-protected

Salmon and Temperature Interaction





Accumulated Thermal (Heat) Units (ATU's)

Date eggs arrived ___________ ATU's when eggs arrived ___________

Instructions: Use the equation below to calculate the number of days to hatch. Then, count from the date the eggs arrived to make a prediction.

$$\frac{\left(\text{ATUs needed to hatch} - \text{ATUs from hatchery (starting ATUs)}\right)}{\text{Average daily temperature °C}} = \text{Number of days until hatching}$$

Use this same equation to find the number of days until your fish develop into fry. Count from the date the eggs arrived again to make another prediction.

Assume your chiller is set to 50°F = 10°C

Remember, this is your **average daily temperature.**

Go to the next page to do your calculations and make predictions.

Coho Salmon need 400-500 ATUs to hatch and 700-800 to develop to fry

Hatching:

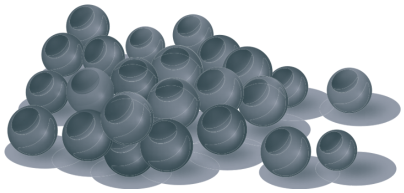
	ATU's needed		Starting ATU's		Avg. Daily Temp.		
Early:	(400	-	☐	) ÷	10	= ________	days
Late:	(500	-	☐	) ÷	10	= ________	days

Fry Development:

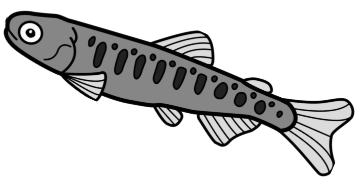
	ATU's needed		Starting ATU's		Avg. Daily Temp.		
Early:	(700	-	☐	) ÷	10	= ________	days
Late:	(800	-	☐	) ÷	10	= ________	days

Using the number of days you calculated above, <u>count</u> from the date the eggs arrived to predict which dates your fish will hatch and develop into fry.

Predicted Hatch dates: ____________ to ____________
Early: Late:

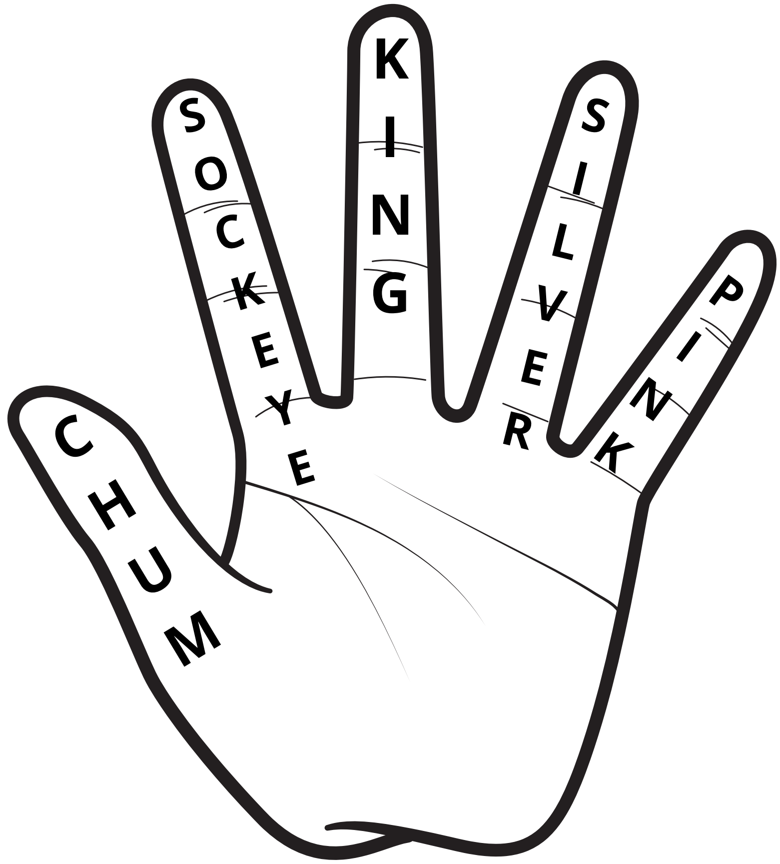


Predicted Fry development dates: ____________ to ____________
Early: Late:



Know the Salmon High Five!

Here is a silly way to remember the 5 species of Pacific salmon plus 2 more anadromous salmonids. Give the Skagit Fisheries Enhancement Group a hand for this handy resource!



Chum rhymes with thumb. Chum are also called **dog** salmon.

You might poke (sock) an eye with your pointer finger. This finger is for sockeye, also known as **red** salmon.

The biggest finger is for the biggest salmon: the king, also known as **Chinook.**

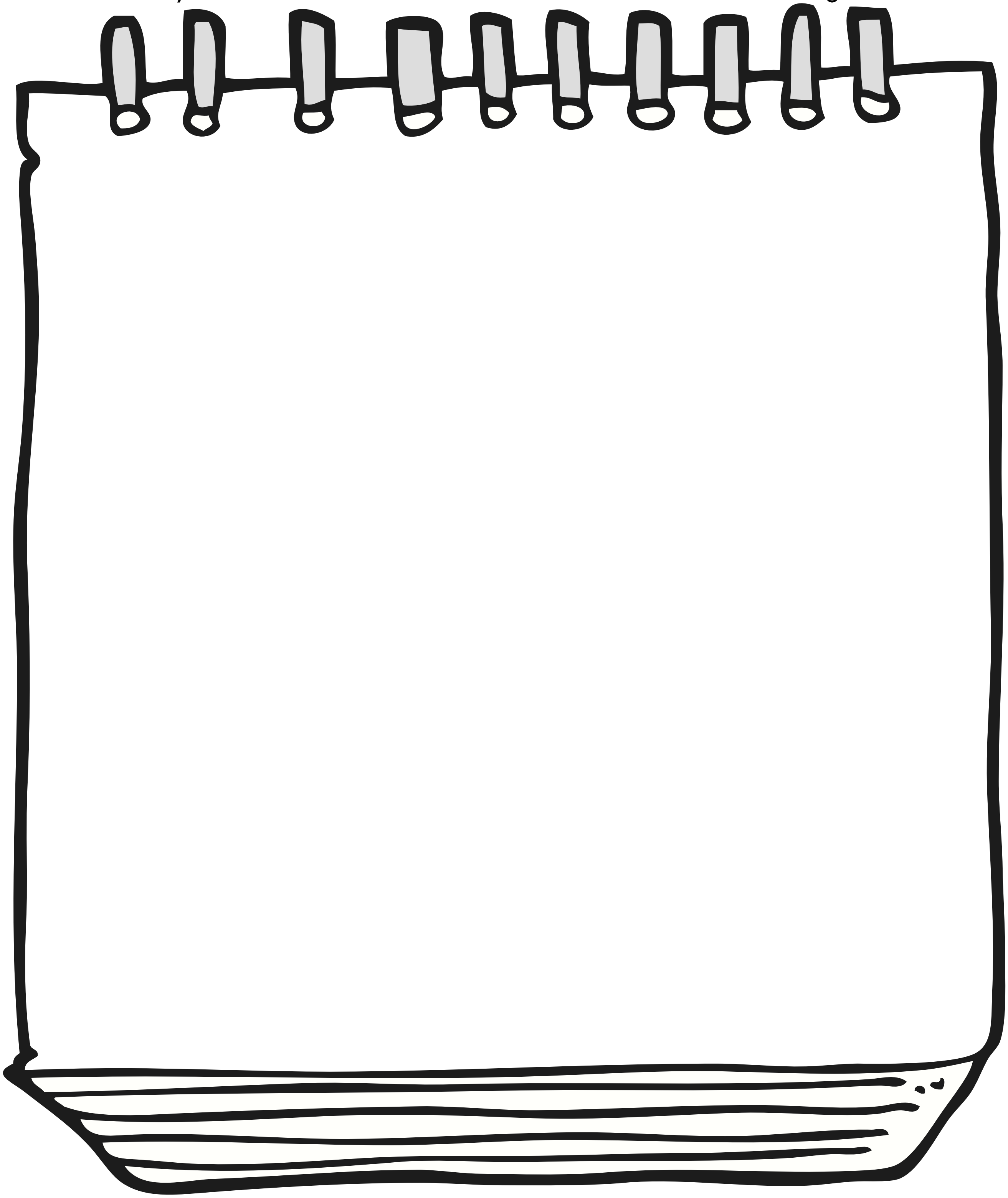
You might wear a silver ring on your ring finger. This is for the silver salmon, or **Coho.**

The pinky finger is for the pink salmon. Also, both the smallest! Pink salmon are also known as **humpies**.

Bonus Salmonids: Use your fist to knock yourself on the head (gently!) for **steelhead** then touch your neck for sea-run **cutthroat**.

Draw the Salmon High Five!

Trace your own hand and create salmon art out of each finger here:



Dream Stream Activity

What does the ideal salmon stream habitat look like?
That depends on the ***riparian zone.***

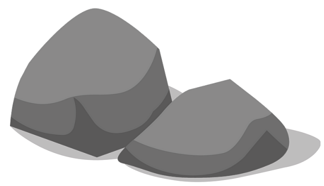
Below are the ingredients for what we call a Dream Stream:

Trees

Salmon like cooler water temperatures, and trees help shade the water. Trees also hold the stream bank in place with their roots. The area of trees and shrubs are a stream is called the ***riparian zone.*** For salmon – bigger riparian zones are better.

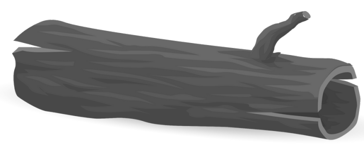
Rocky Stream Bed

Salmon protect their eggs by burying them in gravel nests. Larger rocks create **riffles** that put oxygen into the water which fish need to take into their gills.



Logs and Fallen Trees

Fallen logs create hiding places and slow down water flow so salmon can rest.

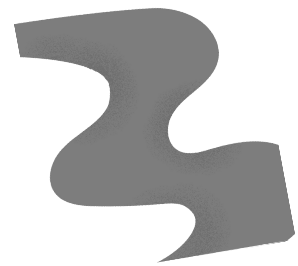


Clear Water

Murky water is a sign that the stream bank is eroding or breaking away. It makes it difficult for salmon to navigate.

Curvy Stream Shape

A stream with lots of bends and turns slows down the flow of water and makes it easier for migrating salmon to swim upstream. A straight channel speeds up water flow and increases stream bank erosion, making water murkier and difficult to swim against.

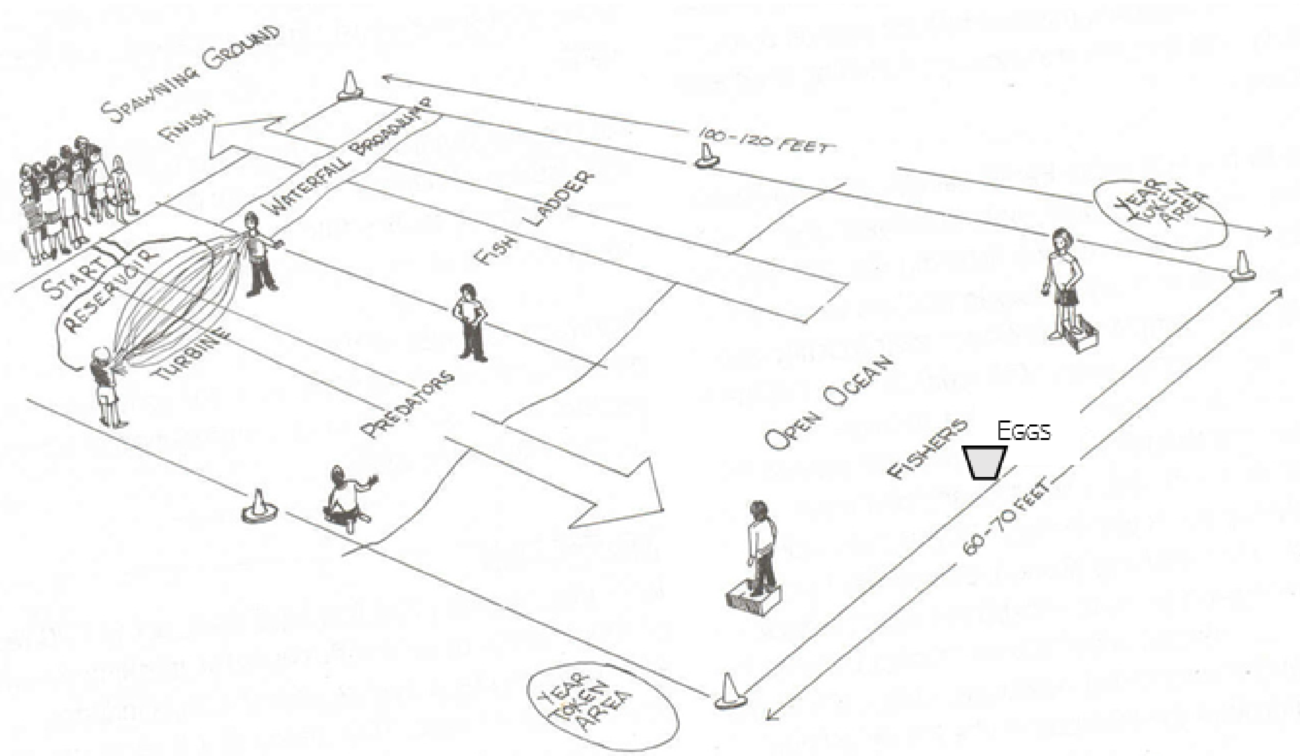


Low Pollution

Salmon become more sensitive to environmental stress when pollution is high. This can include litter, but even more concerning are chemicals like nitrogen fertilizers that run off from lawns and farms.

Now that you know what salmon like, use the next page to draw a salmon's dream stream! Alternatively, you can draw the opposite – a nightmare stream that has all the things that salmon do not like. Happy drawing!

Hooks and Ladders



What were you feeling throughout the game?

Where did you notice salmon losses were the greatest? Where were losses the least?

What seemed realistic about this simulation? What did not?

Tacoma Salmon in the Classroom

Materials provided by:

SALMON IN THE SCHOOLS SEATTLE

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