What's the Salmon Survival Rate at Each Life Stage?

Duration

- 20-40 min for worksheet activities
- 5 min daily to record mortality, 10 min to calculate overall mortality at different stages
- 1 hour to create visual representation of survivorship

NGSS

- LS1B: Growth and development of organisms
- LS1A Interdependent Relationships in Ecosystems
- LS4B. Natural Selection
- ESS3.A Natural resources
- ESS3.C Human impacts on Earth Systems.

Science and Engineering Practices:

- Obtaining, evaluating, and communicate information
- Analyzing and interpreting data
- Developing and using models.

Materials

- White tray
- Camera
- Internet access
- Salmon bag!
- Art supplies (butcher paper, scissors, hole punch, glue)
- Copies of handouts in this packet

Summary

Students calculate Coho survival rate at different life stages, and compare survival rates across three different rearing environments: rivers, hatcheries, and their own salmon tank.

Objectives

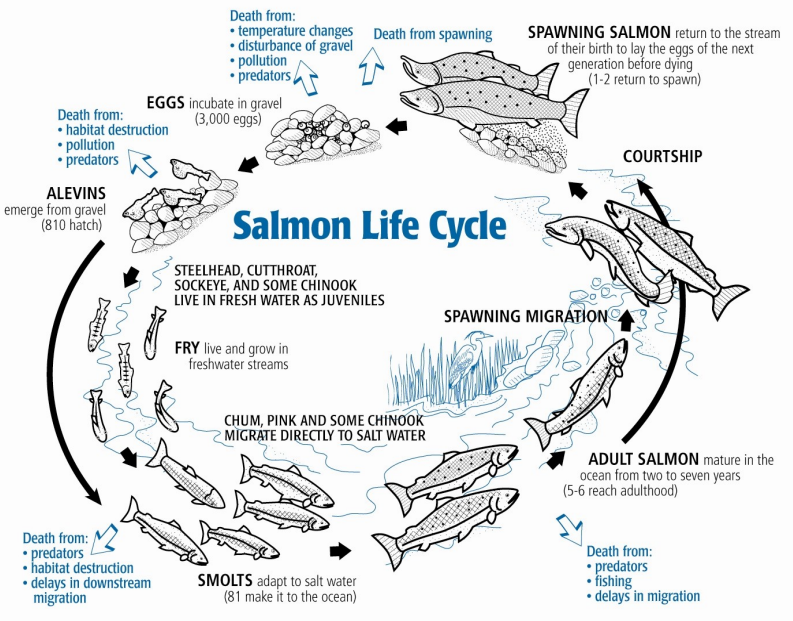
Students will:

- Develop a strategy to confirm the number of eggs in the tank.
- Record daily mortality in the salmon tank, and calculate overall survival rate for egg, alevin, and fry life cycle stages under different rearing conditions (stream, hatchery, and tank).
- Illustrate survivorship with a visual representation / model.
- Evaluate which mortality factors have the biggest influence on survivorship, identify ways to prevent salmon loss, and adopt one stewardship practice as a class to help salmon.

Making Connections

All student participants in Salmon in the Classroom can observe salmon develop from one life stage to the next, and experience the salmon life cycle firsthand. Many students learn to identify these stages by name: eggs, alevin, fry, fingerlings, smolt, adults, spawners. Your class may also be familiar with factors that threaten salmon survival, such as predation, poor water quality conditions, or fishing.

But which life cycle stage is the most fragile? And how are these threats different for wild salmon, versus those raised in a protected hatchery environment? This activity introduces the idea that ***survivorship rates vary depending on the life cycle stage and rearing environment***.



Your Redd Tank

In a river nest of 2000 wild Coho eggs, only 300 survive to become fully developed alevin…

Roughly the same number that's in your tank!

Background

Wild Coho salmon typically lay 2500 eggs in their gravel streambed nests, but only about **15%** of those eggs will survive to hatch and become fully developed alevin. **Rivers and streams are dynamic environments, and wild young salmon at the egg and alevin stages are subject to countless factors that threaten their survival**: predation, silt covering and suffocating the eggs, low dissolved oxygen, pollution, and blockages in the stream.

Wild salmon may be exposed to hazardous conditions before they are even born! Watch the video of these eggs swirling around as adult

Angie Stefani shows us the incubation trays at Lewis River Hatchery. How do **hatcheries** make it easier for eggs to survive? Can predatory birds get inside the incubation rooms?

Hatcheries eliminate those threats by raising eggs and alevin indoors, in very stable and protected environments. S**pawning and raising eggs at a hatchery dramatically increases salmon survival at the early stages,** often with **90%** surviving through the alevin stage.

However, once hatchery-raised fry and smolts are released from their protected existence, they may not fare as well as their wild counterparts. And ultimately, **very few from either environment return to spawn in their natal streams**.

Open the zipper on the spawning salmon to show thousands of "eggs!" Red beads indicate how many survive their incredible journey. Check-out this salmon bag as part of the Salmon Trunk. Just ask!

Procedure

Warm up:

- Do you know how many eggs a Coho lays in its nest? ***It varies by year due to environmental conditions: they might lay 2800 in a good year, or 2200 in a drought year.***
- When a Coho deposits 2500 eggs into a river nest, how many of those will survive to come back and lay their own eggs? ***Very few! In a normal year, we may expect only 1 or 2 to return. Show students your fancy salmon bag! (Left)***
- What are some reasons salmon eggs might not hatch in the wild? ***Some eggs are not fertilized, some get washed away or covered with silt, the water may not have enough oxygen, or eggs may be eaten by birds. (Watch bouncing egg video, above)***
- Do you think those same factors affect eggs raised at a hatchery? Can birds get inside the incubation room? What about once the hatchlings are moved to outside ponds? ***Watch the Lewis River Hatchery video showing egg / alevin incubation trays (above). Hatcheries provide very stable environments for eggs to develop, and many major threats are virtually eliminated. Nets protect fish from predation even in outdoor ponds (aside from the occasional sneaky river otter).***
- How many eggs do you think are in our tank? How many do you think will survive to release day? ***Record student responses!***

Activity:

Part 1. Confirm the number of eggs in the salmon tank.

The first step in calculating survival rate is knowing how many you start with!

- **You were right to be suspicious!** We always tell you that we gave you 250 eggs, but have you ever actually counted them? Neither have we! But we HAVE weighed them!!! As a class or for independent work, have students use the worksheet **"Who wants to help count 14,000 eggs"** and the **"Fish and Egg Disposition Ticket"** to get a better idea of how many eggs are actually in your tank… and how we get around counting all 14,500 of them!

- **"Eggs are more cooperative when it comes to being counted."** Do you ever scream curses on fish release day, when you're trying to catch and count approximately 250 squirming, darting fry out of your tank? SITC teacher Mike Clapp doesn't! Find out how he engages students in egg delivery (below), and try using the **"Aerial Biological Survey of Salmon Eggs in the Tank"** worksheet to do this with your students:

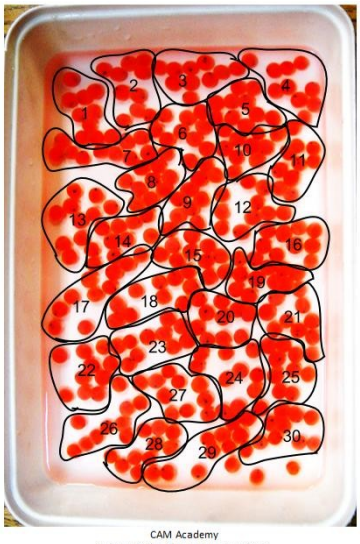
*When I get the eggs back to my classroom, I **first pour them into a container with water and take a picture before releasing them into the tank**. I'll then print out copies of the picture (black & white photo copies work fine) and have students count the number of eggs. It is **interesting to see the different values and strategies students use** to count the eggs in the picture. We'll then compare answers. (Opportunity to do some math analysis - range, mean/median/mode, ...) It is interesting to see just how many eggs we do receive. Inquiring minds want to know!*

*Interestingly, there is an **Oregon Field Guide episode** where they do a similar thing **using aerial photos to count nesting sea birds** on the Oregon Coast.*

*I also **use this information to determine the final number of salmon I release** in the spring. I'll **keep track of eggs that don't develop and the salmon that don't make it.** I'll subtract these from the number of eggs I received to determine my final release total. It is much easier than trying to count the hundreds of salmon when I scoop them out of the tank. The eggs are definitely much more cooperative when it comes to being counted.*

—Mike Clapp, CAM Academy

Watch the first 2:40 of the Oregon Field Guide Episode. Aerial photos in action!



Activity:

Part 2. Calculate survival rates for different life cycle stages and rearing environments.

- **Record daily mortality in the tank** by marking down any eggs, alevin, or fry that that you remove from the tank. You can simply add a "mortality" column to your ATU chart (see **Table 1. Salmon Count and ATU Chart**). Read "**How many Hens does it take to make 14,500 salmon eggs**?" and "**Only the strong survive**" to guide a discussion about what this table would look like if we extended it from the time of egg deposition to returning as a spawner!

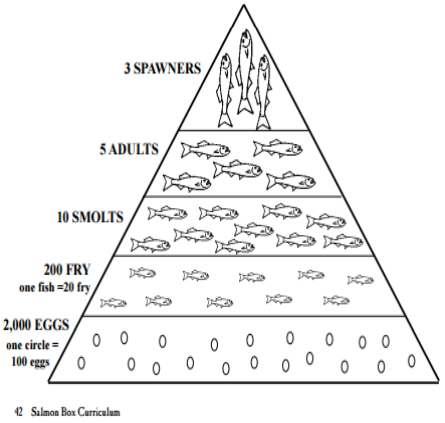
  Watch the intake of the waterfall filter intake, and the powerhead pump for any mortality, since babies may get stuck there. If students find this to be a morbid task, they may be comforted by the fact that at this life stage **survival rates in the tank are much higher than salmon would experience in the wild**!

- Once all the eggs hatch, you can **calculate the survival rate in the tank** for the egg stage (see **10.1 Salmon Survival and Excel sheet** for help). Once all the alevin have buttoned up, you can calculate the survival rate for the alevin. By the time you release the fry, you'll have survival rates for all life stages that your students were able to observe.

- In the meantime, **calculate survival rates for wild and hatchery-raised Coho** using the " **10.1 Salmon Survival**" hand-out. This allows you to see the survival rates of different life cycle stages and different rearing environments, side-by-side.

Part 3. Illustrate survivorship with visual representations.

- Next, have students **create a model or visual representation of this data**. They can **graph rates for wild and hatchery-raised fish** using the "10.0 Salmon Survival" handout, and add their own tank data as it becomes available. Alternately, this could turn into a more creative art project. See "**Natural Survival Pyramid**" for a jumping off point… Get your Martha Stewart on!



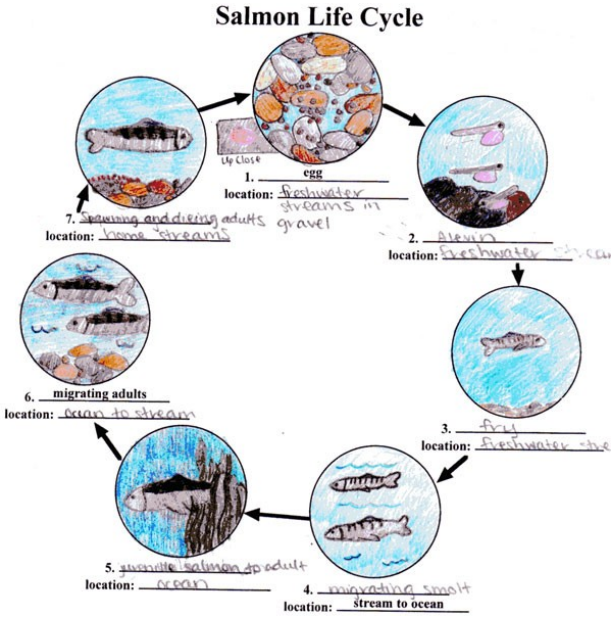
42 Salmon Box Curriculum

Part 4. Identify the mortality factors for each life cycle stage, and ways to help salmon overcome those factors.

- Use the "Salmon Life Cycle" worksheet (courtesy of Mike Clapp!). Students identify salmon "helps and hazards" for each life cycle stage.

- If your students already do a salmon life cycle journal, consider incorporating survival rates at each life stage, hazards to which each life stage is particularly vulnerable, and ways people can help minimize those specific threats.

- Based on their calculations and comparisons, **which threats do students think are the biggest influence on overall salmon survival**? **What stewardship practice might help salmon the most?** Is it different for different life stages? Why is that? Identify one stewardship project to complete as a group: planting trees, improving salmon habitat, and storm drain stenciling have all been done by SITC classes!



Name:_____

Date:_____

Who wants to help count 14,000 eggs???

Each year the Lewis River Hatchery donates over 14,000 Coho eggs to be raised in schools. Eggs for each school are placed inside a knee high stocking, stacked carefully into a cooler, and distributed to about 50 teachers in Clark County. The number of schools in the program and the total number of eggs raised can vary each year.

- Look at the **Fish and Egg Disposition Ticket** (over). What is the total number of eggs picked up from Lewis River Hatchery in 2016?_____

- The total allotment (or number) of eggs is divided amongst all the teachers. This year, 52 schools will receive eggs. How many eggs should each school receive? _____

- Your teacher was told that each school receives about 250 salmon eggs. But your teacher is suspicious… did anyone really count all these eggs? Counting out 14,000 eggs one-by-one would take a LONG time! Can you think of a faster way to divide up the total allotment among the 52 teachers? Describe your idea here:

_____

_____

- Look at the **Fish and Egg Disposition Ticket** again. Hatcheries always keep track of # of fish per pound. This ratio determines when fish can be "planted" or moved to a different location. What is the number of salmon eggs per pound? _____

- Roughly how much does each salmon egg weigh? _____

- How much did each school's stocking weigh? _____

Congratulations! You have just completed the same math problem a hatchery worker does for their job. Next year you can volunteer to help with egg pickup and do the math for us!

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Washington Department of FISH and WILDLIFE

Form 3

FISH AND EGG DISPOSITION TICKET

Washington Department of Fish and Wildlife
Fish Program

FACILITY: Lewis River Hatchery

FACILITY SIGNATURE: [signature]

RECEIVING FACILITY: Columbia Springs

RECEIVING FACILITY SIGNATURE: Katie Workman

TYPE	ID CODE (Appendix A) (Spc: Rc: Stk: BY: BO)	DATE	NUMBER	# PER POUND	POUNDS	SEX / STAGE	CARCASS	CONDITION	PRICE $	PER LB OR EACH	VALUE	?
G	CO:NA:LEWI:IS:H	1/14/16	14,500	1903	7.6	E						
		/ /										
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TICKET VALUE

NOTES

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WDFW 21 Rev. 5/08

Name:_____

Date:_____

Aerial Biological Survey
Of Eggs in the Salmon Tank

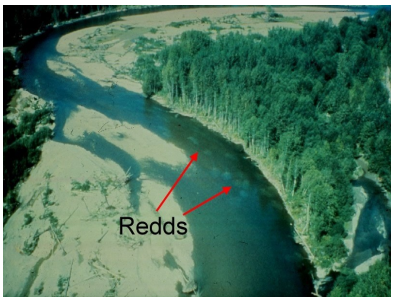
Take a look at the eggs on the gravel of your salmon tank. Be careful not to lift the black covering for more than a few seconds, so that you **don't disturb the developing eggs**.

How many eggs do you think are in the tank? _____
What is most **challenging** about counting the eggs in your tank? _____

_____

Wish you had more time to count? Too hard to see all the way to the back of the tank? Welcome to the world of a field biologist! Biologists often deal with a number of **constraints**, such as time, money, and ability to access what they want to study.

For example, each year seasonal biologists survey the number of **salmon redds**, or nests, in streams to get important information about spawning patterns. Usually these surveys are conducted by someone walking along the stream bank. Sometimes this method is impossible, and instead people conduct **aerial surveys** to count salmon redds from a helicopter. (Drones can capture images of salmon redds, too!)



Aerial surveys are used for all kinds of things in science, including population estimates of whales, nesting seabirds, and even marine debris floating on the ocean's surface!

How can using an aerial photo make a scientist's work easier? _____

_____

- **Look at your aerial photo.** Counting this many eggs might be difficult! Can you come up with any **strategies** to make this easier? _____
- How many eggs do you count in your aerial photo? _____
- What is the class average? _____

CAM Academy

Salmon in the Classroom—2015

https://sites.google.com/a/battlegroundps.org/cam7-8science/cam-7-science/salmon

Table 1. Salmon Count and ATU Chart

Day	Date	AM Temp	PM Temp	Average Temp	Today's Temp Units (Avg temp - 32 F)	Accumulated Temp Units	Dead Salmon Removed	Salmon Count	Notes
Wed	1/13/2016	47F	47F	47F	15	619.5			@ Lewis River Hatchery
Thur	1/14/2016	47F	49F	48F	16	635.5			@ Columbia Springs
Fri	1/15/2016	48F							

How many Hens does it take to make 14,500 salmon eggs???

If you were so inclined, you could complete this chart all the way back to the spawning adults. Hatchery workers fill out daily "Pick Sheets" tracking mortality of eggs, along with temperature units. Lewis River Hatchery knew we needed 14,500 eggs for the SITC school allotment, and they assumed a 10% loss in eggs due to fungus, "blanks," and not surviving the shocking process. They planned to take 15,960 eggs during spawning to get 14,500 eyed eggs. They assumed a fecundity of roughly 2700 eggs per female (or "Hen"), so they planned to use 6 females for our total school allotment. However, eggs counts per female were lower than expected at roughly 2200 eggs per female, so actually **it took 9 Hens to make our allotment this year!**

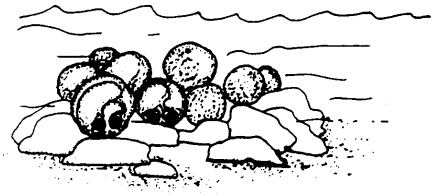
Female spawning salmon are called "Hens" and male spawners are called "Bucks" by hatchery workers, because "Female" and "Male" sound too similar when you're working really fast and throwing fish around in a loud river.

student sheet

Name:

Only the Strong Survive

Use the numbers below to find out how many salmon survived. Use this page for your work.



1. A salmon deposited 5,500 eggs in a redd.

2. Five hundred eggs were not fertilized.

3. Sixty were washed out of the gravel during a flood.

4. Mud from a clearcut eroded into the stream and suffocated one thousand, two hundred.

5. Three hundred alevins died because they could not get enough food.

6. After the alevins developed into fry, six hundred fish were eaten by other fish in the stream.

7. Forty-one were eaten by birds.

8. As they neared the ocean, 260 salmon we caught in a pool where they got too hot because of thermal pollution from a coal-fired power plant.

9. In the ocean, 1,500 were eaten by bigger fish.

10. Seals ate 95.

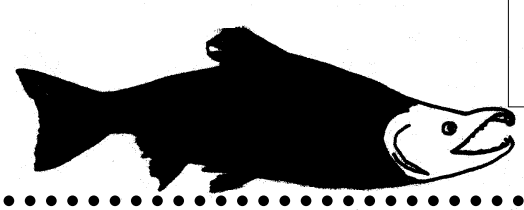
11. Fisherman caught 556.

12. As the salmon returned to their spawning stream, bears ate 180 of them.

13. Three were unable to jump a waterfall.

14. The rest of the salmon spawned.

15. HOW MANY SALMON WERE LEFT TO SPAWN?



Adapted fr om various sour ces, including Fish and Fisheries , B. Mickelson and N. Barr , eds. This unit fr om the Alaska Sea Week Curriculum Series can be obtained by contacting UA-Fairbanks, 304 Eielson Building, Fairbanks, 99775-5040.
(907) 474-6707

HANDOUT 10.1

Salmon Survival

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

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

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

Wild coho salmon survival

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

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

HANDOUT 10.1

Salmon Survival

Wild coho salmon survival (cont'd)

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

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

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

Hatchery coho salmon survival

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

Handout 10.1

Salmon Survival

Hatchery coho salmon survival

1. Use graph paper and coloured pencils or a computer graphing program to create a graph showing the number of survivors at each stage of a natural salmon cycle.
2. Add a graph showing the number of survivors at each stage of a hatchery salmon cycle.
3. What does the difference between the charts show? _____

_____

_____

_____

_____

_____

4. The survival rate is the percentage of the original eggs that remains alive at each stage. You can calculate the survival rate for each stage using this formula:
   (number of survivors) / (number of eggs) x 100
   For example, the survival rate of natural eggs and alevins is 15% (375/2500 x 100).
5. Calculate the survival rate after each stage in the natural life cycle. Add it to the chart.
6. Calculate the survival rate after each stage in the hatchery life cycle. Add it to the chart.

_____

_____

_____

_____

_____

7. At which stage is the difference between the natural and the hatchery survival rate greatest?
8. If salmon lived at the hatchery survival rate, what would happen to the number of salmon?

   Explain your answer. _____

_____

_____

_____

_____

_____

Wild Coho Salmon Survival

Life Stage	Number at beginning	Deaths	Number of survivors	Survival Rate %	Causes of Death
Eggs / Alevin	2500	2125	375	15%	
Fry	375	245	30		
Smolt	30	25.5	4.5		
Adult	4.5	2.5	2		
Spawner	2	2	0		

Hatchery Coho Salmon Survival

Life Stage	Number at beginning	Deaths	Number of survivors	Survival Rate %	Causes of Death
Eggs / Alevin	2500	250	2250		
Fry	2250	450	1689		
Smolt	1689	1530	253		
Adult	253	162	111		
Spawner	111	111	0		

Salmon Tank Coho Survival

Life Stage	Number at beginning	Deaths	Number of survivors	Survival Rate %	Causes of Death
Eggs / Alevin	250??				
Fry					
Smolt					
Adult					
Spawner					

- This alternate version of the “10.1 Salmon Survival” Worksheet allows students to see the survival rate numbers for all 3 rearing environments side-by-side.
- Download editable Excel Sheet here: www.columbiasprings.org/programs/salmon-in-the-classroom/teacher-curriculum-and-resources/

Natural Survival Pyramid

Goal:
•To understand the mathematics behind salmon survival at each life stage

Objectives:

• Create a visual depiction of the number of salmon that survive at each life stage.
• Understand that most salmon eggs will not survive to adulthood.
• Name two natural threats to salmon.
• (for older students) Calculate the percentage of fish that do and do not survive at each life stage.

Materials:

• large sheet of butcher paper
• construction paper (5 colors)
• yard stick
• scissors
• glue
• colored pens
• hole puncher

Background:

Even under ideal conditions, most salmon eggs will never survive to maturity. The fragile eggs die for many reasons: low water temperatures, predation, disease, fungus, lack of fertilization, shifts in gravel, and siltation. Flooding may also wash the eggs away; a drought can cause the eggs to dry up.

Young fish must also compete for food and space, which may act as limiting factors. As streams diminish in the summer, so does available habitat. Water temperatures may rise too high. The fry stage is the toughest; only five percent will survive.

Preparation:

1. Draw a triangle on the butcher paper with sides of 40 inches. Divide the triangle into five sections, as shown.

2. Make the eggs by using a hole punch on colored paper (pink or orange is best). Save the punched out circles to use as eggs.

Procedure:

1. Explain to the students that they will be making a picture that shows how the number of surviving fish becomes smaller and smaller at each life stage. They will start with 2,000 eggs. Make predictions on how many they think will survive.

2. Two thousand circles to represent eggs would be a little much, so one circle will represent 100 eggs. For the same reason, one fry picture will represent 20 fry. Help students calculate how many circles they must use to represent 2,000 eggs. How many fry pictures for 200 fry?

3. Decide on your color coding, for example, orange eggs, green fry, blue smolts, silver adults, red spawners. Have the students count out the eggs and then draw and cut out the other fish forms.

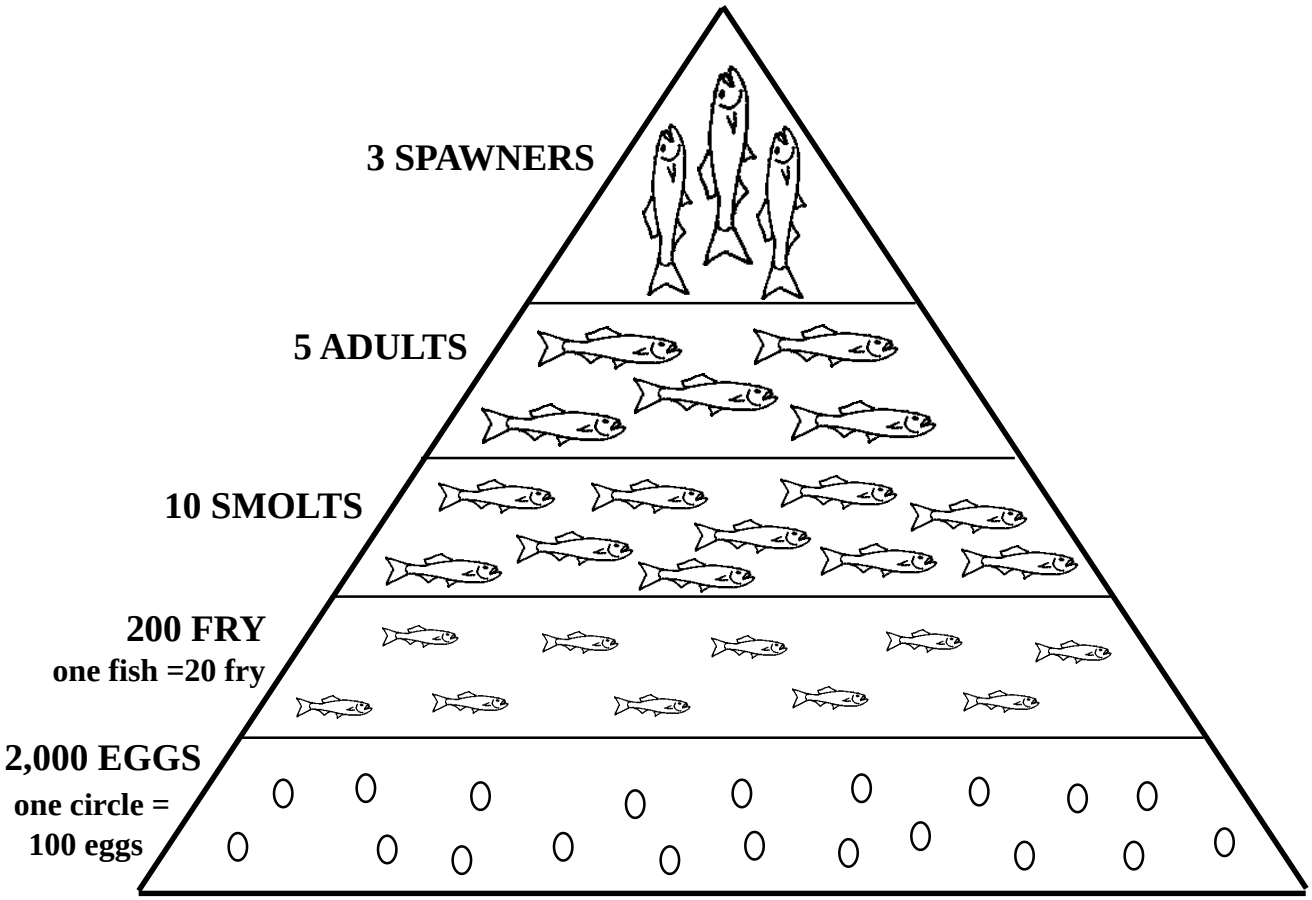
From California's Salmon and Steelhead, Diane Higgins, ed. Lesson contributed by Neil Woodward, Willits, CA

4. Glue the eggs and fish onto the pyramid. Make a key that shows the relationship between color and stage. Also, indicate that 1 circle = 100 eggs and 1 fry picture = 20 fry. Write the number of fish at each stage next to each section, as shown.

5. As you put the pyramid together, discuss why so many of the fish die. What kills them? What would happen if they all lived and returned to spawn? Why does the female fish lay so many eggs? How would survival be affected if the parents were around to somehow protect the young fish?

6. Have older students calculate what percentage of the fish survive through each life stage. What percentage die at each life stage? (90% die as eggs or alevin, 95% of the fry will die before smolting, 50% of the smolts will not reach adulthood, and 40% of the adults will not survive to spawn).

7. A very large salmon may lay as many as 10,000 eggs. Have students figure how many will remain at each life stage, using the same percentages as before.



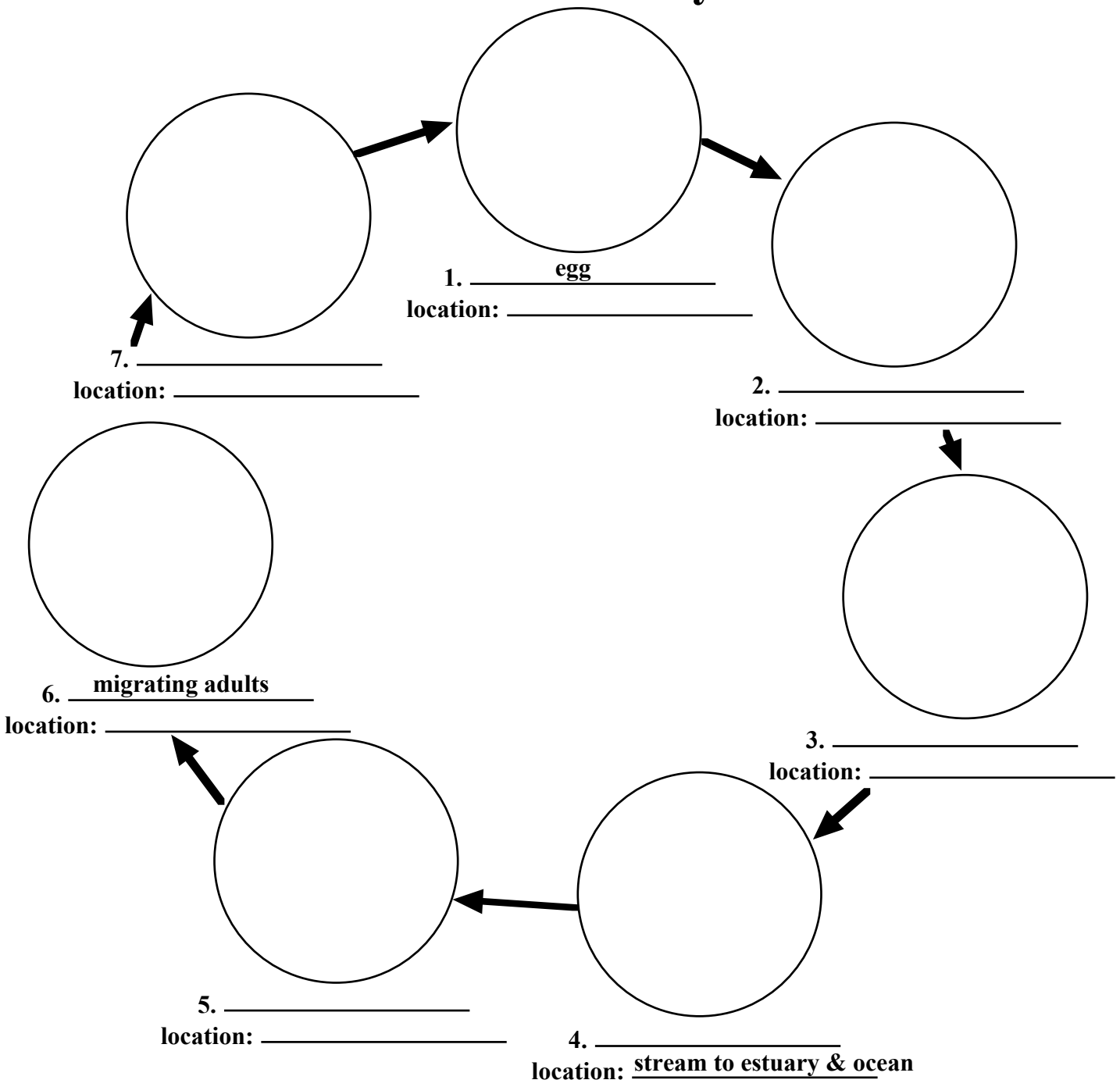
Class: _____ Name _____

Assignment: **Salmon Life Cycle** Date _____

Instructions

1. Label and illustrate (use color) the stages of a Pacific salmon's life cycle.
2. On the back, create a list of salmon helps and hazards.

Salmon Life Cycle



Instructions

In the table below, name the seven stages of a salmon's life. Then, create a list of **environmental** helps (natural events or human actions that benefit salmon or increase their chances of survival) and hazards (natural and manmade threats to survival). There shou be at least one help and one hazard for each stage of the salmon's life. Be specific. If you state a salmon is killed or threatened, tell what (cause of threat), where (location of threat), and how (type of harm). For example: "Salmon smolts are eaten (how) by Caspian terns (what) as they enter the estuary (where)." Or, "Erosion (what) smothers (how) eggs in the stream gravel (where)." Do the same for helps. Be specific. Identify the environmental help and indicate how it benefits the salmon. Example: "Clean (what) streams (where) help fry find food to eat (how). Do not include salmon adaptations like gills, yolk sacs, coloration, ...

Stage	Helps	Hazards
1 **egg**		
2		
3		
4		
5		
6		
7		