RIVER MORPHOLOGY AND FRESHWATER SALMON HABITAT

TEACHER'S GUIDE

Photo by Nicole Christiansen

Prepared by Maria Catanzaro and Kyla Sheehan

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PACIFIC SALMON FOUNDATION
320-1385 W 8TH AVE
VANCOUVER, BC,
V6J 4S6

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Photo credit: Nicole Christiansen

OVERVIEW

Students will learn about freshwater habitats for Pacific salmon - delving into what specific habitat types look like, how these habitats function, and how they support salmon. Students will learn how to measure bankfull, wetted width, crown closure percentage, and stream velocity. The goal is to have students think critically about what can affect these habitats, including natural seasonal shifts and climate change impacts to stream velocity. A creative component asks students to create their own diagram of the important habitat elements for Pacific salmon - they can let their imaginations run wild with ideas- drawing, painting or even building a model.

Essential Questions

- How do rivers and streams function? What does river morphology look like?
- What are the functions of each stream component, and how do they benefit Pacific salmon?
- What are the essential habitat needs for Pacific salmon in their freshwater life phase?
- How are freshwater habitat requirements for Pacific salmon impacted seasonally and from climate change?

CURRICULUM REQUIREMENTS:

This lesson educates and engages students in the topic of freshwater habitat features, river morphology and measuring various stream and habitat related components. This lesson fits with the BC Science, Math and Art 7 curriculum. It allows students an opportunity to develop competency in the following areas:

Big Ideas

- Engaging in the arts develops people's ability to understand and express complex ideas.
- Dance, drama, music, and visual arts are unique languages for creating and communicating.

Table 1 – Listed are the curriculum competencies that are covered in this video, and how they are met by the video content and learning exercises.

CURRICULAR COMPETENCIES	CONTENT
Science **Questioning and predicting** • Demonstrate a sustained intellectual curiosity about a scientific topic or problem of personal interest • Make observations aimed at identifying their own questions about the natural world • Identify a question to answer or a problem to solve through scientific inquiry • Formulate alternative "If…then…" hypotheses based on their questions • Make predictions about the findings of their inquiry **Processing and analyzing data and information** • Experience and interpret the local environment • Construct and use a range of methods to represent patterns or relationships in data, including tables, graphs, keys, models, and digital technologies as appropriate • Seek patterns and connections in data from their own investigations and secondary sources	Biology *Survival needs* • Students will learn about the key habitat components that make for a hospitable environment for Pacific salmon. We will discuss habitat components and how Pacific salmon utilize those components to make it through various life stages.

• Use scientific understandings to identify relationships and draw conclusions **Planning and conducting** • Collaboratively plan a range of investigation types, including field work and experiments, to answer their questions or solve problems they have identified • Measure and control variables (dependent and independent) through fair tests • Observe, measure, and record data (qualitative and quantitative), using equipment, including digital technologies, with accuracy and precision • Use appropriate SI units and perform simple unit conversions • Ensure that safety and ethical guidelines are followed in their investigations **Evaluating** • Reflect on their investigation methods, including the adequacy of controls on variables (dependent and independent) and the quality of the data collected • Identify possible sources of error and suggest improvements to their investigation methods • Demonstrate an understanding and appreciation of evidence (qualitative and quantitative) • Consider social, ethical, and environmental implications of the findings from their own and others' investigations	

Communicating ● Communicate ideas, findings, and solutions to problems, using scientific language, representations, and digital technologies as appropriate	
Math Reasoning and analyzing ● Use reasoning and logic to explore, analyze, and apply mathematical ideas ● Estimate reasonably ● Use tools or technology to explore and create patterns and relationships, and test conjectures ● Model mathematics in contextualized experiences Understanding and solving ● Apply multiple strategies to solve problems in both abstract and contextualized situations ● Develop, demonstrate, and apply mathematical understanding through play, inquiry, and problem solving ● Visualize to explore mathematical concepts	*Experimental probability with two independent events* ● students are encouraged to start their 'rubber ducky race' from multiple different spots along the starting line to determine experimentally the location of the thalweg (area of fastest flow). *Discrete linear relations, using tables and graphs &* *Cartesian coordinates and graphing* ● students will create a graph of water velocity over time, plotting data provided by PSF.

Communicating and representing ● Use mathematical vocabulary and language to contribute to mathematical discussions ● Explain and justify mathematical ideas and decisions ● Communicate mathematical thinking in many ways ● Represent mathematical ideas in concrete, pictorial, and symbolic forms	
Art **Exploring and creating** ● Intentionally select and apply materials, movements, technologies, environments, tools, and techniques by combining and arranging artistic elements, processes, and principles in art making ● Create artistic works collaboratively and as an individual using ideas inspired by imagination, inquiry, experimentation, and purposeful play ● Demonstrate an understanding and appreciation of personal, social, cultural, historical, and environmental contexts in relation to the arts **Reasoning and reflecting** ● Examine relationships between the arts and the wider world **Communicating and documenting**	*Manipulation of elements and principles to create meaning in the arts, including but not limited to:* *visual arts: elements of design: line, shape, space, texture, colour, form, value;* *principles of design: pattern, repetition, balance, contrast, emphasis, rhythm, movement, variety, proportion, unity, harmony* ● Homework activity encourages students to use media of their choice to describe the freshwater habitat and its components, using artistic expression to demonstrate understanding of biological topics. *Processes, materials, movements, technologies, tools, strategies, and techniques to support creative works*

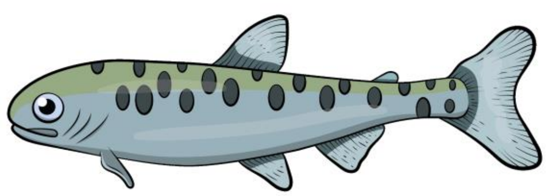
• Adapt learned skills, understandings, and processes for use in new contexts and for different purposes and audiences • Express, feelings, ideas, and experiences through the arts • Experience, document, choreograph, perform, and share creative works in a variety of ways • Demonstrate increasingly sophisticated application and/or engagement of curricular content	• Students are encouraged to think critically about the types of materials, techniques and colours that would best represent each component of the freshwater habitat from their learning, and how best to convey their learning.

ADDITIONAL BACKGROUND FOR TEACHERS

Salmon (written by Sam James)

Pacific salmon hold tremendous ecological, cultural, and economic importance to communities in BC. They provide food for a wide array of animals and even plants, with their carcasses contributing important nutrients to the soil along the river banks when they return to spawn. The cultural, spiritual, and physical well-being of many First Nations communities is dependent on salmon. In addition, the commercial and recreational salmon fishing industries contribute millions of dollars to BC's gross domestic product and generate thousands of jobs. Over time, societal development has had negative effects on wild salmon and their habitats. Natural resource development such as logging and mining has resulted in significant habitat degradation, dams have blocked upriver migrations, and periods of voracious commercial fishing have led to overharvesting. In addition, climate change is altering their food supply and habitat, with warmer rivers and lakes and some systems drying out completely. Every year, more salmon populations are being recognized as being 'at risk'. Salmon populations are dwindling and although there remains much debate as to why and what to do about it, many scientists believe that changes to the marine food chain may be responsible.

There are five species of Pacific Salmon: Sockeye, Pink, Chum, Coho, and Chinook. Each have their own unique life history strategy, but generally, they spend a few months to a few years in streams, rivers, and/or lakes before migrating to sea. There, they will spend 1-4 years either migrating long distances throughout the North Pacific or staying closer to home. They eat mainly zooplankton and smaller fish, known as forage fish. Different species exhibit different feeding preferences: Sockeye, Pink, and Chum salmon are planktivores, consuming more zooplankton, while Chinook and Coho salmon are piscivores, consuming more fish.



River Morphology and Salmon Life Stages

In this lesson, we want students to explore how rivers function and how they support Pacific salmon during their freshwater life stages. There are many habitat features that are important to salmon so they can successfully spawn, grow and find refuge and shelter. The morphology of the river creates these habitat features, and they shift and change naturally (e.g. with seasonal changes in precipitation) as well as through other impacts (e.g. climate change). These habitat features include spawning gravel, glides, riffles, pools, cascades and more. Other habitat components of critical importance include healthy riparian vegetation - which is the vegetation that overhangs the river banks. This vegetation provides shade as well as food sources as insects fall from the vegetation into the river. Trees die and fall, creating complex habitat for salmon as well – the trees and root wads can shift the water flow and create new habitat, as well as shelter and areas of refuge from predation.

Salmon need habitat complexity. Large woody debris like fallen trees and logs in the stream help shift sediment around, creating areas of refuge underneath, and space for new vegetation to grow. The more variety in the habitat, the better!

VOCABULARY

Anadromous: Anadromous fish spend part of their lives in salt water and part in freshwater. Salmon, for instance, are anadromous and start their lives in freshwater, then make their way to the ocean to grow up, then return to freshwater to spawn and complete their life cycle.

Alevin: Juvenile salmon that have just emerged from their egg sacs from the gravel beds of streams, rivers and creeks. Alevin will still have a yolk sac attached to their bodies which provide nutrients as they grow.

Bankfull width: The width of the channel, measured from the level on either bank where the highest level of water would be found. This is essentially the width of the channel during a typical high flow event (i.e. after a big rainfall). The point on either bank is indicated by the start of permanent (rooted) vegetation like grasses, shrubs and trees.

Cascade: Freshwater flowing over a steep drop – a waterfall.

Channel: A wide strait or waterway between two landmasses that lie close to each other.

Erosion: Erosion occurs when sediment is picked up and transported away from a particular site. Erosion occurs naturally, but high erosion events can take away too much beneficial sediment, leaving behind only large rocks.

Estuary: Areas where incoming fresh water (rivers) meet salt water (ocean). Estuaries are unique and highly productive habitats, and are critical areas for juvenile salmon to grow before entering the open ocean and beginning their migration.

Fry: Once the alevin lose their yolk sac, they must leave their gravel nests and enter the river to find food. These salmon that emerge from the gravel are called fry. Fry develop dark bars along the sides of their bodies called parr marks to better camouflage in their new environment.

Glide: A stretch of a channel with smooth, laminar flow (no riffles or pools).

Gradient: Refers to the slope of the channel.

Large Woody Debris (LWD): Trees, logs, large branches or root wads that extend into the bankfull channel and influence the flow or shape of that watercourse. LWD is usually at least 2 meters in length and at least 10 cm thick.

Life Stage: A life stage is a period of the life cycle where an organism has distinct physical characteristics and/or habitat requirements. An example of a salmon life stage is the 'fry' stage.

Mass Wasting: Natural and human-driven events of slope failure. I.e. stream banks and riparian slopes can fail during storms, high flow events, and when vegetation is removed.

Migration: A migration is a long journey that is completed as a normal part of a species life cycle. Salmon smolts travel many kilometers from the freshwater where they are born down to estuaries and out to the ocean. Some salmon species migrate long distances in the ocean as well as they grow. Once they're ready, they start their migration back up those same rivers to spawn.

Pool: A pool is a deep (relative to the average depth of the river) pocket of a river where the water flows at low velocity. A scour pool is a particular type of pool, where water flows against a partial channel obstruction like a piece of large wood, or the channel bank and the sediment buildup behind that structure gets washed out or eroded by the flow. A dammed pool occurs when there is an obstruction that extends across the entire channel width. The pool develops behind the obstruction, as the flow scours away sediment behind it.

Riffle: A relatively shallow area of a river, creek or stream where water flows over rocks near the surface. The flow of the water over these rocks is audible.

Riparian: The vegetated area adjacent to the channel. This riparian area provides many ecosystem functions like regulating the temperature of the channel by shading out the sun, adding organic matter and nutrients from falling leaves/branches, and contributing terrestrial invertebrates (insects) to the channel.

River: A large natural course of flowing freshwater that extends from inland to meet an ocean/sea at the coastline or lake or channelized fresh watercourse.

Smolt: Fry transform into smolts when they are ready to begin their migration downstream into the open ocean. Smolts undergo physiological changes like losing their parr marks and slowly change to be more silver in colouring, as well as changing internally to prepare for the salt water environment.

Spawning Gravel/Redds: Redds are the nests of spawning fish like Pacific salmon. Adult salmon select areas in their natal streams where the substrate (sediment) is suitable for them to lay their eggs. Depending on the species and their preferences for gravel size, water depth and water flow, we can describe their ideal spawning grounds and identify areas where there are appropriate beds of spawning gravel.

Substrate: In this video, we refer to the floor of the river and the substrate or 'bed materials' of which it is made up. The substrate is usually described as the type of material or size of sediment, e.g. sand, rock, cobble.

Thalweg: The deepest part of the channel, which also happens to be where the flow will be fastest. The thalweg is not always in the centre of the channel, and often is skewed to one side when channels bend or curve.

Velocity: The speed at which something or someone travels. In this case, we refer to the stream velocity, or the speed at which the water is moving, usually measured in meters per second (m/s).

Watershed: The area over which freshwater drains over the landscape to reach its final destination (the ocean or sea).

Wetted Width: The width of the channel, measured from the point on either bank where the water level sits at the time it is recorded.

Windfall: Trees or other vegetation falling over during a high wind event - downed trees from windfall often end up in the river as large woody debris.

Photo credit: Maria Catanzaro

OUTLINE

PSF Biologists, Kyla Sheehan and Maria Catanzaro, will guide students through a lesson about freshwater habitats for Pacific Salmon. Students will learn about the components of a river or stream, and the benefits or impacts that they provide to Pacific Salmon. Below is an outline of the topics covered, key content in each topic, as well as potential questions for teachers to ask. Kyla and Maria ask some of these questions in the video, which would be ideal times for you to pause the video and do a round of think, pair, share with the students before continuing.

Table 2 - A guide to accompany video playing. Includes opportunities to pause for learning; including guiding questions and answers for the educator.

<table>
<tr><th>TOPIC</th><th>CONTENT</th><th>POTENTIAL QUESTIONS</th></tr>
<tr>
<td>Where can you find salmon?</td>
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- Quick overview of salmon life cycle and which habitat type each life stage uses
- Focus in on the freshwater habitat and give more details on the life stages that use this habitat

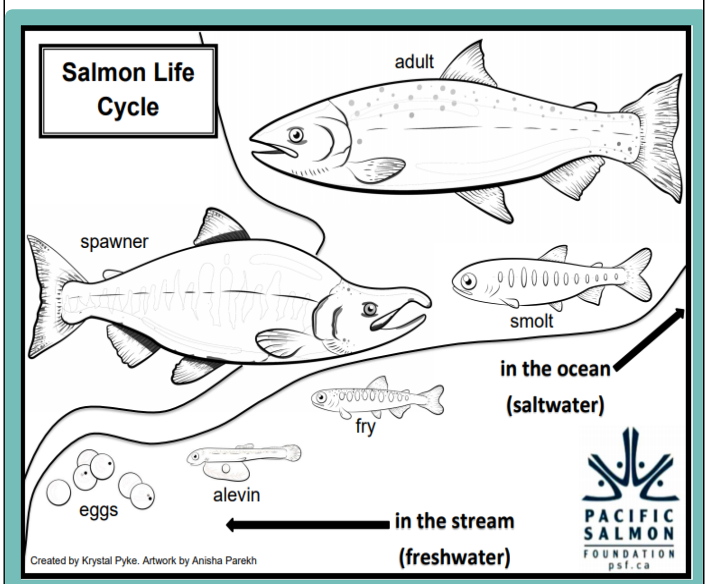

Figure 1 - The salmon life cycle.
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Pause at the end of slide 2 to discuss

Q: Why do salmon spend part of their lives in freshwater and part in the ocean

A: Because the ocean provides more food, allowing them to grow bigger. If you look at kokanee (land-locked sockeye salmon in lakes), they don't grow anywhere near as big as their migrating counterparts! Also salmon choose to spawn in nutrient-poor streams and rivers since these habitats typically cannot support year-round predator populations big enough to heavily reduce numbers of salmon.
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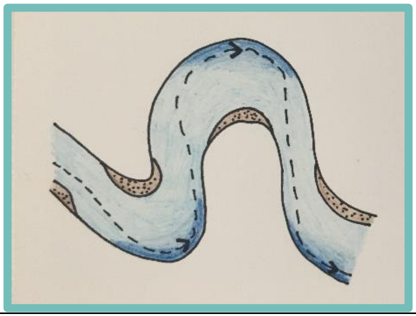
Components of freshwater habitat: *Riffles*	• How to identify a riffle: fast flowing water that you can hear moving over rocks at the surface of the waterway • How salmon use this habitat: salmon spawning habitat if substrate is appropriate, helping to aerate the water around the eggs.	

Components of freshwater habitat: *Pools*	• How to identify a pool: areas of relatively deep water, usually created when water flows around an obstruction like LWD or boulders, scouring away the sediment to make that area of the stream deeper.
	• How salmon use this habitat:
	  • juveniles: nursery habitat where salmon can grow! Pools with riparian cover or LWD provide nutrients, shade, and protection from predators
	  • adults: rest habitat during migration to spawning grounds	

Components of freshwater habitat: *Glide*	• How to identify a glide: a stretch of smooth, fast flowing water with no rocks protruding the surface. • How salmon use this habitat: smooth migration straights!	
Components of freshwater habitat: *Cascade*	• How to identify a cascade: steep, sharp drops in a stream (gradient > 4%), or a stepped riffle of bedrock or emergent cobble or boulders in channels. • How salmon use this habitat: cascades are obstacles along the migration course, but salmon can jump really far to get over them!	**Pause at the end of slide 8 to discuss** Q: What are cascades a potentially dangerous part of a salmon's migration? A: To continue on their migration upstream, salmon have to jump out of the water to get over cascades. When they do this, they

		are vulnerable because there are often predators like bears and eagles waiting to grab them out of the stream!
Stream Width: Bankfull Width & Wetted Width	• Bankfull width is measured from each edge of the channel where rooted vegetation starts. This signifies the high water mark, or the maximum amount of water that is in the stream during a normal flow cycle. • Wetted width is measured across the stream at the surface of the water. This represents the amount of water in the stream at the time of measurement. • How salmon use this habitat: the more water in the stream, the more habitat is available to the fish, but with more water, there is typically higher flow which could be hard for juveniles to navigate through.	**Pause at the end of slide 11 to discuss** Q: When do you think the water level in a stream would reach bankfull width? Does this happen all the time? What would cause the water level to rise to this level? Does the water level ever get higher than bankfull? A: The stream level will reach bankfull width during high flow events. These occur on a regular basis after a heavy rainfall. During very intense storms or slide events, the water level will surpass the bankfull level and overflow the banks, causing flooding. Q: Let's say that we measure the wetted width as 6.2m, and the bankfull width as 6.5m. What is the difference (in cm) between the bankfull width and wetted width in this case?* A: difference = 30 cm (0.3m) *This question involves unit conversions. Students could work out this problem by converting each measurement from m to cm.

Components of freshwater habitat: *Thalweg*	• How to identify the thalweg: The thalweg is an imaginary line in a river that follows the path of the deepest water flow. This is also where the force of the water is strongest, so it is where erosion is happening. The thalweg is not always in the centre of the river.  **Figure 2** – The thalweg, depicted as the dotted line in this stream. Illustration by Maria Catanzaro.	**Pause at the end of slide 13 to discuss** Q: What impact would it have on our data if we only measured stream velocity from the thalweg? A: Our results would show an overestimation of the stream's average velocity. We need to measure at different points across the stream to get the average velocity of the stream.
Components of freshwater habitat: *Gradient*	• Gradient is the steepness of a slope, and usually describes the steepness as a percentage. The higher the percentage, the steeper the gradient of the river! Gradient is related to how FAST the water flows downstream, and gravity is the force that pulls the water down the slope.	**Pause at the end of slide 14 to discuss** Q: What influence might the gradient of a stream have on salmon habitat? A: Gradient is related to how FAST the water flows downstream, so if salmon are migrating up the stream, it might be more difficult for them to swim against the current at a higher gradient. As we have discussed, high gradient areas of a stream might also be cascades where salmon will have to jump to get past them! They expend more effort when they have to face challenges like this.

Field Activity: Measuring Stream Velocity	● Setting up a racecourse on a section of the waterway helps us to explore how water velocity changes throughout the cross section of the stream. ● With a friend, set up a 10m long racecourse on the waterway and use a stopwatch to test how long it takes for your rubber ducky to cross the finish line from different points across the starting line.	**Pause at the end of slide 15 (field activity) to discuss** Q: How do we identify where the thalweg is? A: The thalweg is where the ducky traveled the fastest - this was the first (?) place that Maria released the ducky, slightly away from the middle of the stream. There was a pool on the closest side of the stream where some duckies slowed down, but they traveled quickly on a glide near the middle of the stream. Q: Can you name some of the habitat features that you saw in the video? A: riffles, pool, LWD, glide, riparian vegetation
Student Activity: Graphing Velocity	**Activity (Slide 17)** ● Stream velocity was measured every hour for 24 hours. ● Educators: see the 'Measuring Velocity' supplementary materials to guide this activity.	

Components of freshwater habitat: *Substrate/Bed Materials*	• The sediment (rocks, silt, clay, boulders, sand) at the bottom of the stream is called the substrate. We often refer to the substrate as 'bed materials'. • How salmon use this habitat: the composition of the bed materials, as well as the amount of turbidity (or suspended particles) tells us about the health of the habitat for salmon. Each species of Pacific salmon have a preference for the size of bed materials that are suitable for building their redds and laying their eggs.	**Pause at the end of slide 18 to discuss** Q: Does substrate change over time, or does it stay put? What factors might influence the movement of the substrate? Bed materials will shift around depending on the force of the flowing water. Animals will also influence the movement of particles. When Pacific salmon dig in the substrate to create their redds, smaller particles will loosen and be carried away by the flowing water. During high flow events, certain sizes of particles will be picked up and carried downstream. New materials can also enter the stream from upland areas when the rain carries particles over earth surfaces, or when erosion or mass wasting events like landslides occur.
Components of freshwater habitat: *Riparian Areas*	• Riparian zones are the areas of vegetation within 20 m on either side of a river or other moving water. Riparian areas can be made up of grasses, shrubs, trees, or a mixture. • How riparian areas provide habitat for salmon: The roots of these plants hold onto the soil and provide stability to the banks of the river. Without riparian vegetation, streams can get pretty warm – riparian trees and overhanging vegetation shade the river and provide cover for salmon and other animals in the stream! Insects like to live in the riparian soils and on the riparian plants – these can be yummy snacks for	**Pause at the end of slide 20 to discuss** Q: What does the percentage of crown closure tell us about the habitat? Does it change in different parts of the stream? Crown closure provides an estimate of the amount of cover or shade provided by the trees and shrubs in the riparian area. A high percentage of crown closure will stay cooler during sunny days, making the habitat safer for Pacific salmon. Crown cover will change depending on the type

	salmon swimming by! Overhanging trees also drop their leaves and other debris into the stream - this adds nutrients for aquatic insects and other small organisms to eat!	and amount of vegetation in the riparian zone. It can change throughout the watershed!
Components of freshwater habitat: *Large Woody Debris*	• LWD are logs, branches, whole trees or root wads that fall into the stream from the adjacent riparian areas, or have been moved by the flow of the water from somewhere upstream. LWD is usually at least 2 meters in length and at least 10 cm thick. • How does LWD benefit salmon habitat: Salmon like a lot of LWD! LWD helps to create those habitat components that we talked about earlier by changing the course of the water's flow! When water flows around obstructions like LWD, the force of the water erodes the sediment in some areas, and drops off sediment in others. This creates scour pools and lots of complexity just by diverting the flow! Larger pieces of wood can also act as a place for riparian vegetation to grow, stabilize banks and can shelter parts of the stream, providing cover for fish in pools and riffles. This can shade them from the hot sun and even give them places to hide from predators.	**Pause after slide 21 - opportunity for field trip or watershed walk** Q: Look around your local stream. Do you see any LWD? Where do you think it could have come from? A: Live or dead trees can crash over and enter the stream from the riparian areas during storms (windfall) or in landslide events where the soil beneath them gives out and slides downhill (mass wasting events). Sometimes you'll see logs that look like they have been cut - those logs might have come into the stream after being cut down for logging activities.
Wrap-Up/ Homework Activity	**Activity(Slide 22)** To show what they have learned from Video #1, have students draw/paint a picture, build a model, etc. of a stream reach showing all of the elements we discussed. Encourage students to think critically about the way they want to present their learnings, and what materials, techniques	

	and colours will best represent each component of the habitat.

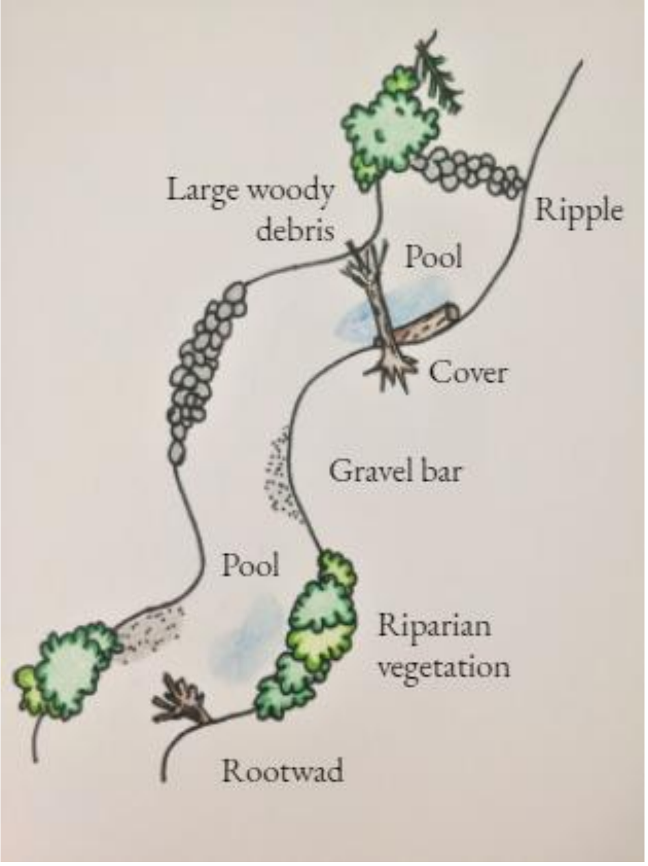


Figure 3 – Stream habitat components that provide good habitat for salmon, including large woody debris (LWD), pools, ripples/riffles, gravel bars for spawning, and riparian vegetation. Illustration by Maria Catanzaro.

ACTIVITY: GRAPHING STREAM VELOCITY OVER TIME

Objectives

Students will plot the given data of stream velocity over time. The data represent stream flow over one day, monitored every hour.

Materials Needed

Either graph paper and pencil, or excel spreadsheet. Data provided.

Essential Questions

1. What are some reasons why stream velocity might change over one day?
2. Revisit the streamwidth exercise - what do you think you would see if you measured the wetted width every hour and graphed it with stream velocity?
3. How might velocity change over the course of a whole week?

Procedure

- Look at the data as a class - explain how each line will be one data point e.g. 0.14 m/s at 7:00am
- review how the graph will be laid out:
    - x-axis = time
    - y-axis = velocity or flow
    - what are the units for the y-axis? = m/s

ACTIVITY: HOMEWORK ASSIGNMENT

Objectives

Students will show what they learned about freshwater salmon habitat by either drawing/painting a picture, building a model, or some other creative approach.

Materials Needed

Desired art supplies.

Elements that should be included/shown

1. Riffle
2. Pool
3. Glide
4. Riparian area
5. Large Woody Debris (LWD)
6. Cascade
7. Bankfull width
8. Wetted Width

Procedure

Have students create a representation of a stream reach, showing and labeling as many of the components of that habitat listed above as possible!

Example Assignment

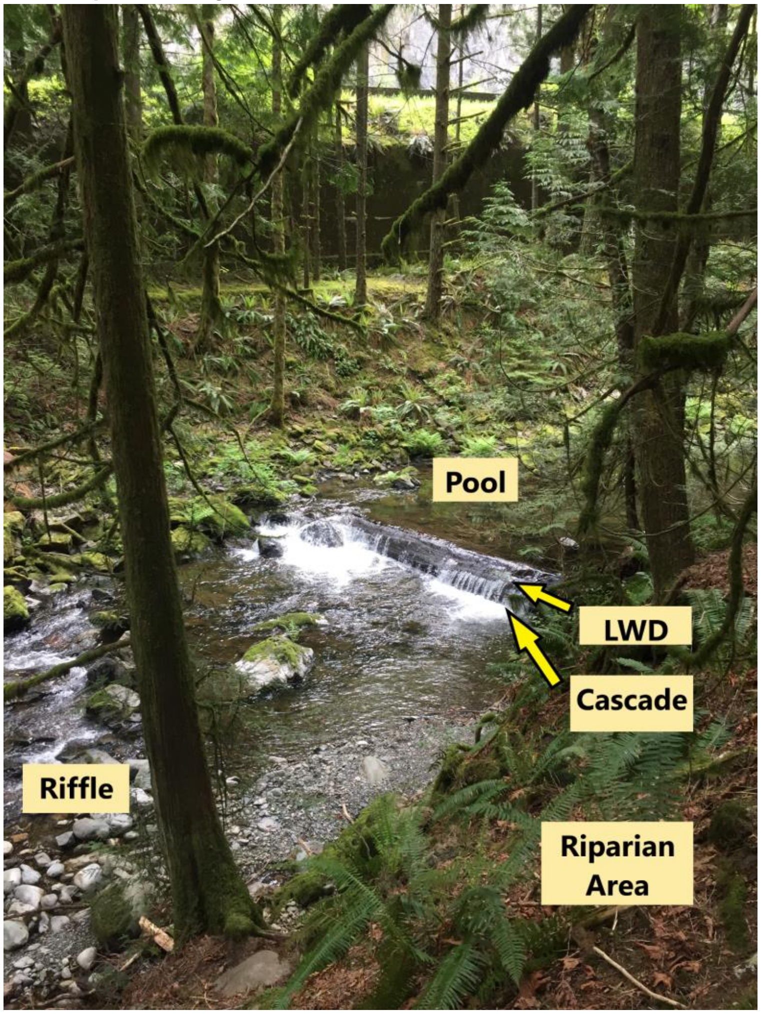


Photo credit: Kyla Sheehan

DATA SOURCES

Velocity data attached, collected by PSF.

MEDIA

1. Drawings by Anisha Parekh

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