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Lummi Youth Riparian Education Program

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Lummi Youth Riparian Education Program

Written by Western Washington University Environmental Education student Kirsten Moore based on the Nooksack Salmon Enhancement Association's (NSEA) Students for Salmon program for a grant written by Lummi Natural Resources

Kirsten Moore **Spring 2012**

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HONORS THESIS

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KIRSTEN MOORE

Active Minds Changing Lives

Lummi Youth Riparian Education Program

A series of educational activities to be performed at Marietta Slough in order to fulfill the educational component of the grant written by Lummi Natural Resources

As defined by the grant, "Lummi Youth" includes students grades 3-12. The following lesson plans are aligned to the Washington State Learning Standards for grades 3, 4-5, and 6-8, with the intention of involving students grades 9-12 in leadership/mentor roles.

The lesson plans are similar from grade level to grade level, primarily varying in topics and depth of discussion. My hope for this program is that it becomes sustainable so that students may monitor water quality and health of the riparian area from year to year, noting changes and delving into a deeper level of understanding of the role the riparian area holds in creating healthy habitat for salmon and thus drawing the connection between the health of the natural environment and that of their own culture.

Community Salmon Fund Full Proposal Project Narrative

Instructions: Save this document on your computer and complete the narrative in the format provided. The final narrative should not exceed six (6) pages; do not delete the text provided below. Once complete, upload this document into the on-line application as instructed.

1. **Project Information:** Please provide the following information about your project:
   Project site latitude / longitude: 122 36'30.5W 48 47'38.4N
   Watershed name & WRIA #: Nooksack WRIA1
   Body of water affected: Smuggler's Slough; Bellingham Bay; Lummi Bay
   Project type (choose one: Restoration, Design & Development, Creative Partnerships, or Previous CSF Project Maintenance): Restoration

2. **Legal Permission:** *Do you have legal permission to be on the project site? Please explain.*

   Yes, project will occur entirely on the Lummi Reservation or Lummi Nation lands, where Lummi youth will be the main participants.

3. **Project Need:** *Describe the salmon habitat conservation need or problem this project will address. Is this need/problem mentioned as a priority in any watershed plans or assessments? Describe how the project is consistent with the local salmon recovery plan. Discuss how this project will encourage landowners, local businesses and community groups to become engaged in salmon habitat conservation and stewardship, or stimulate creativity and leadership among various constituencies to address conservation needs.*

Degradation of the Estuary and Nearshore Waters:

Like most western coastal watersheds, the landscape of the Nooksack River floodplain changed dramatically following the arrival of Euro-Americans in the late 1800s. Early maps and written accounts of the Nooksack River estuary (1860) describe the river discharging into Lummi Bay. The conversion to farmland involved the installation of drainage ditches, construction of dikes, clearing of logjams, and other actions to create a permanent separation of the river's two deltas. In the 1920s, a reclamation project that built levees along the lower Nooksack River was initiated. These levees restrict mainstem discharge into the Lummi River and down to Lummi Bay, and as wetlands conversion continued, eventually disconnected this distributary channel from its estuarine floodplain with its own series of levees. The diking and draining of wetlands in the Lummi Bay delta and the resulting loss of natural hydrology, salt marsh, and tidal riparian habitats has resulted in heavy compaction of the floodplain, filling of relict channels, and sporadic colonization by invasive species.

The Smuggler's Slough channel, once functioning as a migratory pathway for fish and a route for tidal exchange between the estuary's two deltas, has been effectively disconnected from the estuary by a series of levees built along several miles of river channel and a seawall built across the front of the Lummi Bay delta. These levees were built for agriculture reclamation of the tidelands in the 1930s. Smuggler's Slough functions as the primary drainage path between lower river farmlands and Lummi Bay, connected to miles of agriculture ditches and emptying through five tidegates built across its mouth.

The diverse salt marshes and estuaries of the Red River and Nooksack Deltas and the greater Lummi Nation shorelines are threatened by a dangerous invader- the aggressive salt-tolerant *Spartina* grasses. There are four species of invasive *Spartina* in Puget Sound, with *Spartina anglica* by far the most widespread; it has been found in all North Puget Sound counties as well as British Columbia, and is known to be established in both of the river deltas on the Lummi Reservation. *S. anglica* was introduced to the Puget Sound in 1961 for erosion control and cattle forage. It spreads rapidly into a variety of shoreline habitats, including mud flats, mashes, and cobble and sand beaches. Once established, it rapidly displaces native vegetation and disrupts shellfish habitat and salmon foraging areas (Thompson, 1991). Due to the severe ecological effects this dangerous weed can have, Washington State has been aggressively controlling *Spartina* for over a decade.

Importance of the Estuary to Salmonid Stock Recovery:

Habitat degradation is considered the leading cause for the decline of WRIA-1 salmonid populations (WRIA-1 Salmonid Recovery Plan 2005). Current habitat conditions are substantially less productive than historical conditions.

In the Nooksack basin, it is clear that abundances of several salmonid stocks have diminished substantially from historical levels as the land use in the watershed has intensified. Estimated historic abundances of early-timed (spring) Chinook in the Nooksack basin were 26,000 and 13,000, respectively, for North Fork/Middle Fork Nooksack (NF/MF) and South Fork Nooksack (SF) Chinook stocks (Mobrand Biometrics, unpublished data). The estimates are also reflected in catch records and observations (Lummi Natural Resources data). Recent escapements of wild fish for the two early populations averaged 170 fish (NF/MF) and 210 fish (SF) between 1997 and 2004 (Fisheries co-managers, unpublished data). This represents a 99.3% and 98.3% reduction in the number of NF/MF and SF spring Chinook fish returning to the river to spawn. Only 3 of 19 salmonid stocks identified in Water Resource Inventory Area (WRIA) 1 by Washington State Salmonid Stock Inventories are currently considered healthy: North Fork Nooksack fall chum, Samish fall chum, and North Fork/Middle Fork Nooksack pink salmon (WDFW, 2002; Blakely et al. 2000; WDFW 1998).

Many of these stocks have been significantly depleted; bull trout in WRIA 1 constitute a component of the Coastal-Puget Sound Distinct Population Segment (DPS), listed as Threatened (64 FR 58910, Nov. 1, 1999), and both early South Fork Nooksack Chinook and early North Fork/Middle Fork Nooksack Chinook stocks are considered essential for recovery of the Puget Sound ESU, and have been listed (64 FR 14308, Mar. 24, 1999). Further, Puget Sound/Strait of Georgia Coho salmon, including Nooksack Coho, is a species of concern, and NOAA Fisheries has listed Puget Sound steelhead as Threatened. Because the Nooksack basin represents such an important component of the Puget Sound diversity for ESA-listed Chinook salmon, it has become a major focus for salmon recovery. The populations of these fish are small and highly vulnerable to disturbance and because these anadromous salmon species exhibit unique life history strategies that require diverse habitat for successful production and maintenance. There is a great need to preserve and restore their habitats.

WRIA1 Priority

Acquisition and restoration of tidally influenced estuary wetlands is a top priority of the area's fish, wildlife, and natural resource scientists from Washington Department of Ecology, Washington Department of Fish and Wildlife, the Nooksack and Lummi Indian Nations, Whatcom County, the Natural Resource Conservation Service, and Ducks Unlimited. The WRIA-1 Salmon Recovery Board, comprised of science and policy representatives from the Lummi Nation, Nooksack Indian Tribe and Whatcom County, committed to comprehensive watershed protection and restoration, has prioritized Nooksack River estuary restoration in the Salmonid Recovery Plan (2005). This project is listed on the recovery board's most recent three-year project matrix.

Nooksack River estuarine habitat recovery and restoration was initiated in 1998 by the Lummi Indian Business Council (LIBC) as part of the Nooksack Estuary Recovery Project through LIBC Resolution 98-62. In response to the Resolution, the Seattle District of the U.S. Army Corps of Engineers conducted a Section-22 Planning Study in 2000 (USACE 2000) to develop and evaluate possible restoration alternatives for estuary recovery. This evaluation, though producing several restoration project ideas and alternatives, did not profile natural habitat-forming processes or provide a general habitat assessment of the study area. The LIBC Natural Resources (LNR) department initiated a more detailed habitat assessment to understand the linkages between historic and current conditions and the implications for salmon recovery. In 2005, the tribe completed a full habitat assessment of the Nooksack River estuary that includes additional restoration project concepts. Reconnecting the Smuggler's Slough channel and restoring tidal wetlands on the Lummi delta ranked highest of all projects prescribed in the study.

Habitat Conservation Objectives/Benefits: *List the tangible salmon restoration objectives and benefits of the project on the local and watershed levels (e.g. re-establish riparian forest along 2,000 linear feet of Salmon Creek; increase in-stream habitat complexity of Salmon Creek through installation of 25 pieces of large woody debris). Where appropriate, note how these outcomes and benefits address priorities identified in the local recovery plan.*

The projects short term goal is improve and protect habitat conditions for endangered Chinook salmon, bull trout, and steelhead trout; and chum, Coho, sockeye, and pink salmon by restoring 47 acres of floodplain habitat, protecting 53.8 miles of nearshore habitat for migrating adults and juveniles, including 1600 acres of prime eelgrass habitat. Lummi youth will be trained on the identification of *Spartina*, but will not be participating in regular monitoring. LNR staff will be monitoring for invasive *Spartina* as part of their regular tasks. When areas of high density of *Spartina* are located, Lummi youth will be utilized to remove these plants.

The parcel targeted for restoration on the northwest corner of Ferndale Road and Marine Drive (Figure 1) will be acquired by April 30, 2011. The current owners have harvested all of the poplar trees and sediment erodes off the property and onto the road during rainstorms. Continuing to re-establish riparian areas in the estuary that were previously converted for agriculture will increase habitat diversity, providing sources of nutrients and food resources for salmonids, macroinvertebrates and other terrestrial species.

These outcomes are directly in line with the WRIA1 Salmonid Recovery plan, where the first habitat objective is to "Protect and restore freshwater, estuarine, and nearshore marine habitat, including water quantity and water quality conditions, in WRIA 1 sufficient to meet recovery goals for WRIA 1 salmonid populations."

5. **Community Involvement Objectives/Benefits:** *List the community involvement objectives and the stewardship and educational benefits of the project (e.g. recruit 75 volunteers from Harbor City to participate in bi-weekly planting parties; open up access to 2.5 miles of interpretive trails in Harbor City Park). Community involvement can include: (a) engaging large numbers of the community (e.g. school groups, community groups, large planting parties) in restoration projects through volunteering and stewardship; and/or (b) engaging a smaller number of key landowners (e.g. farmers, business owners, etc.) in restoration activities and including a clear plan for how their involvement will encourage participation of a broader segment of that community through dissemination. Please also describe your organization's prior experience (if any) working with the target community.*

We will engage at least 50 Lummi Youth from grades 3-12 in various aspects of monitoring, planning, restoration and data analyzing in the Smuggler's Slough project area. Grades 7-12 will focus on the monitoring, planning, and data analyzing aspects, with riparian restoration elements. These youth will learn how to plan a riparian restoration project, learning about appropriate plants, soil types, importance of water quality and native macroinvertebrates. They will then learn proper planting techniques and apply protective beaver devices. They will then learn how to monitor survival rates, take water quality measurements and identify macroinvertebrates. A core group of high school youth (around 5) will be recruited to also train and educate younger youth in restoration activities. This will help to pass on knowledge of natural resources within the Lummi Nation community. It will also build skills in education and supervision and enable these young adults become future leaders in Lummi Natural Resources. Youth in grades 3-6 will be involved with some basic level monitoring (simple water quality kits and macroinvertebrate identification) and planting of trees.

Engaging youth in Lummi Natural Resource restoration projects is new, starting in January 2010 with a 22 acre site within our Smuggler's Slough project area. Partnering with the Nooksack Salmon Enhancement Association, the Lummi Youth Academy and the Northwest Indian College we utilized over 100 volunteers of all ages, including the local community and Lummi youth in the planting and protecting of a variety of native plants and shrubs. These plants are showing at least an 80% survival rate.

6. **Methodology**: *Describe how each activity identified previously in your proposal will be implemented. Also, explain how the activities relate to established local plans (management, conservation, recovery, etc.), as well as the habitat conservation and community involvement objectives described above.*

Lummi Youth Grades 3-6:
Using section 4 of NSEA's Students for Salmon handbook, we will work with the Lummi Youth Academy and NSEA to teach grades 3-6 about the importance of water quality, and how to identify native plants and macroinvertebrates. In the field, students will collect a sample of stream water and measure it for temperature, turbidity, dissolved oxygen,

and pH. As this information is collected and written on the Water Quality Data Sheet, students, and instructors will discuss the ranges for each parameter that are the best for salmon. For macroinvertebrates, instructor and student volunteer helpers will collect macroinvertebrates from the stream. Using a large net called a kick net, or surber sampler, two to three people will carefully collect the macroinvertebrate sample. The sample will be brought back to the station and split into three or four shallow trays. Students will work in pairs on each tray to find their insects. One insect is chosen, placed into ice cube trays, and each student is asked to sketch in their journals, noting # of legs, # of tails, movement, antennae, mouthparts, suction cups, and gills. They are then showed how to use the dichotomous key to identify their bug. Students will be taught about indicator species and use the macroinvertebrate index to figure out which tolerance rating their insect has.

To help them learn about native plants, students will participate in a walk where they will become the teachers, teaching their classmates about one specific native plant or an aspect of the riparian zone (for example, large woody debris). Along an area previously restored, information cards will be placed by various plants. Students will be asked to locate a card, learn about the plant. The first student will walk through the area to the second student where he/she will teach student #1 about their plant/element. Then Student #1 moves on to the third student and continues down the line until he/she has learned about and taken notes on all of the plants. Once Student #1 has finished at #3 and moved to #4, student #2 can begin rotating through. It works best to have student teaching be one-on-one, especially for shy students or students who don't normally socialize with each other. When student #1 has completed the rotation he/she will return to their plant/element station and wait for student #2 who will be the first to learn from them. The rest of the students will soon follow in this pattern. By the end of the station each student should have learned about each plant/element and have taught everyone else about theirs.

Lummi Youth Grades 7-12:
Using NSEA's Streamside Science handbook, students will learn about the importance of water quality, macroinvertebrates and riparian cover for salmonid growth and survival. At sites selected by LNR staff, students will be learn how to measure water temperature, dissolved oxygen levels, pH levels, salinity, and turbidity using a variety of different pieces of equipment, including thermometers, water quality testing kits, and turbidity tubes.

Using the macroinvertebrate ID key, instructors will talk about the different types of insects that the students will expect to see in the stream and introduce the concept of indicator species. Students will be split into three groups, and each group will be asked to collect and sort insects by type. Each species are counted and sketched; water quality samples are taken. Students are asked to compare water quality and macroinvertebrate results and determine if the insects are a good indicator of poor vs. good water quality.

For the planting site, students will (1) understand the structural relationship between native vs. non-native plants and the stream ecosystem, create a site map use math to calculate area and density of vegetation (2) understand what defines soil types (3) determine drainage characteristics of site based on soil types (4) use their data on water quality, vegetation and soil types to create a riparian restoration plan including a list of plants to be planted and (5) photo-document the site. Students will be given a "Native Plants to Western Washington" packet as a reference, while a tour is taken of a previously restored site to identify various types of plants. They will also be given an ID card on the most common invasive plants in Whatcom County. Students will then be asked to take a count of the plants at the restoration site, and determine a plant density. The area will be marked off and a detailed map created. Soil separates and types will be discussed and students asked to determine the soil type for the restoration site, by taking 10-20 samples within a measured plot area. To develop a planting plan, students will be asked to record current sunlight, soil types/drainage, other aspects to consider, identification of invasive species to remove, and 3 tree types that will grow well.

All Students:
Finally, each student will be taught by LNR, NSEA and LYA staff on how to plant trees. This area will be previously staked out as part of the planting plan developed by older Lummi students.

Lummi youth will receive formal training from People for Puget Sound that includes information about *Spartina*, identification techniques, and control of infestations. Each youth will be provided a laminated ID card, "Identifying Spartina in Puget Sound and Georgia Basin" with detailed instructions on how to identify the plant. People for Puget Sound staff will also train the youth in proper removal and disposal. Digging is a low-impact way to control infestations and People for Puget Sound has 10 years experience working with volunteers to eradicate *Spartina* in this way.

By assisting in the restoration of a 47 acre parcel adjacent to Smuggler's Slough and helping to removal invasive Spartina in key salmonid habitat areas, we will be helping to meet WRIA1 Salmonid Recovery plan objective of protecting and restoring nearshore and estuarine habitat. In addition, by teaching Lummi students about the natural resources in the area they live in, this meets both a WRIA1 strategy of using education and outreach to increase awareness of human impacts to salmonids, foster land stewardship, and encourage behavior changes to reduce impacts. Education and outreach is also part of the implementation strategy for the plan.

7. **Evaluation/Monitoring:** *Describe in detail your strategy for managing and evaluating project results, including specifics on how success will be defined and measured. Describe in detail your monitoring plan, including those activities that will take place after completion of this grant. If possible, identify how post-grant monitoring will be funded.*

Project results will be evaluated by number of students recruited for the volunteer effort, how many acres/# of trees are planted, and acres/shoreline protected from invasive Spartina. Documents, including sketches of insects, planting area, notes about plants, and basic graphs will be reviewed to determine how much information was absorbed by the student and how interested they were in the activity. Those that either speak up or show the most potential for science based work will be recruited to teach subsequent classes in the activity.

For the past 15 years, we have developed and revised our own vegetation monitoring protocols. However since the Smuggler Slough project is a highly regarded project in the Puget Sound, we are developing a more stringent plan that can build off of existing monitoring data. Scientists and funders both would like to know if hydrology will improve in the area, and ultimately are the Chinook utilizing the habitat? What conditions seem to be the most critical in the Smuggler Slough ecosystem for growth and survival? Unfortunately, these questions and plan were not thought of when the project was first conceived, but our current staff members have more experience with statistically significant monitoring plans and will work with others (such as Eric Beamer from the Skagit River System Cooperative) to help us with this plan. For *Spartina* monitoring, we will follow the protocols and adapt as necessary (conferring with People for Puget Sound) to conditions on the Lummi Reservation.

Since this project is proposed to be self sustaining, in that the students themselves become teachers of future students, we will utilize equipment obtained with this grant to continue monitoring at this site to help inform plantings at other sites. In addition, we are partnering with the Northwest Indian College to monitor macroinvertebrates and water quality. A local avid bird surveyor has also volunteered his time to set up transects to monitor birds in the project area.

8. **Proposed Partnerships:** *Briefly list the proposed partners and the roles that they will play in implementing the project. (Note: a project partner is any group, agency, organization or individual that contributes to the project outcomes in a substantial way and is closely involved in the completion of the project.)*

The Nooksack Salmon Enhancement Association (NSEA) has developed several programs for youth and has worked with us to coordinate volunteer activities including working with Lummi youth. These programs include the Streamside Science Program and the Students for Salmon Program. They will be the primary coordinators for grades 9-12, with LNR staff assisting.

The Lummi Youth Academy (LYA) has been working to engage youth in science activities, including last year's planting project at Smuggler's Slough. The students planted and installed protection devices (beaver cages) around the planted trees. LNR staff will coordinate with LYA to teach younger students about macroinvertebrates, identifying plants (both native and nonnative), simple water quality monitoring, and planting trees in the 47 acre parcel.

People for Puget Sound (PPS) will train Lummi youth on the identification of invasive *Spartina* and simple removal techniques. LNR staff will be monitoring nearshore areas for *Spartina* and will work with the youth in areas with safe access to remove *Spartina.* PPS has developed a *Spartina* manual and from 2007-2010, volunteer kayakers surveyed almost 300 miles of shoreline from and located over 530 square meters of Spartina in Puget Sound.

9. **Dissemination:** *Describe how the results of the project (including monitoring results) will be actively disseminated to the appropriate audiences. Please specifically state how you will work with local media outlets, neighboring landowners, partner organizations, and others to disseminate information on the project before, during, and after the proposed activities.*

Results of the project will be reported in the Lummi Nation newspaper, Squol Quol and via a presentation at the First Salmon ceremony. Results of monitoring will be relayed in reports for this grant, but also related Smuggler's Slough grants. We will also work with NSEA to highlight this project in their quarterly newsletter, on the NSEA and LNR websites, and through contacts at the local newspaper, the Bellingham Herald.

10. **Project Team:** List key individuals and describe their qualifications relevant to implementation of this project.

Jill Komoto, LNR Restoration Program Manager has spent the past five years working with the Native Hawaiian community, including youth in the State of Hawai'i in water quality monitoring, education and outreach activities and biological monitoring. She is the primary author of several volunteer handbooks for Hawaii including a water quality manual and community projects handbook. She has over 25 years combined experience in managing budgets and projects, with a Masters in Environmental Science and Management, focusing on coastal and marine resources, as well as a B.A in Business, focusing on Accounting.

Eric Stover, LNR Restoration Project Scientist is the project manager for the Smugglers Slough project and recently oversaw the completion of Phase I. He also has extensive GIS experience and has provided GIS services for People for Puget Sound Spartina monitoring project. During his time with People for Puget Sound, he served as project manager for several estuary restoration projects in the San Juan Islands, overseeing community volunteers.

Frank Bob, Restoration Assistant is a 16-year veteran of the Lummi Natural Resources department and is the lead for riparian restoration projects. He provides the layout and plant lists for these projects, consulting with staff and funding agencies. Frank has also started the first volunteer program last year at Smugglers Slough and coordinates activities with NSEA, the Lummi Youth Academy, and the Northwest Indian College.

11. **Other (Optional):** *Provide any further information important for the review of this proposal.*

The Smugglers Slough Restoration Project is a part of a larger habitat restoration effort in the Nooksack River estuary, with full implementation leading to the reconnection of the river to a large part of its estuarine floodplain. Restored habitats include estuarine emergent and palustrine wetlands, and fresh and salt water tidal channel habitats at the mouth of the Nooksack River. The project will also improve fish passage from Bellingham Bay to Lummi Bay into restored habitat historically used by ESA-listed Chinook salmon, bull trout, and steelhead trout; and chum, Coho, sockeye, and pink salmon, during their physiological transitioning, feeding, and rearing life stages.

Future aspects of this program will include cultural lessons, connecting Lummi elders with Lummi youth to pass along traditional ecological knowledge as well as local land use history, and a regular volunteer monitoring program.

The Habitat Restoration department of the LNR has completed numerous habitat improvement projects and habitat assessments throughout the Nooksack Watershed. Progress toward achieving the expected outputs and outcomes have been documented in work products, performance reports identified in the grant agreements, and final performance reports. In the past 12 years, Lummi Natural Resources has completed the work noted below:

- 161 instream habitat structures built, including 34 engineered logjams,
- Preservation of 597 acres of habitat,
- 495 acres of riparian stand treatment along 91.5 miles of stream,
- 176 miles of forest road abandonment and storm proofing
- 8 fish blockages removed to open up 12 miles of stream habitat

Contacts

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Nathaniel Davis	Northwest Indian College (science outreach coordinator)	360.392.4271	ndavis@nwic.edu
Matt McGarth	Lummi Youth Build (director)		MattM@lummi-nsn.gov

Lesson Plans

Grade 3

1. *Water Quality: A Quest in Chemistry*
2. *Macroinvertebrates: Messengers of our Waterways*
3. *Native Plants: Each One Teach One*

Water Quality: A Quest in Chemistry (Grade 3)

Lesson Adapted by Kirsten Moore

Subject

Science

Objectives

1. At the stream site, students will carry out a series of water quality measurements using scientific tools and scientifically record the data
2. Students will measure different chemical parts of a stream and recognize that the combination of these parts come together to determine its quality.
3. Students will understand how these measurements relate to the heath of their stream system and the surrounding ecosystem.
4. Students will discuss the importance of a healthy stream to the life within the stream and the systems surrounding the stream, especially in regards to salmon.

Materials

1. Student field journal
2. Student writing utensil
3. Clip-boards
4. Dissolved Oxygen test kit
5. pH test kit/pH test strips
6. Thermometer
7. 3 example turbidity bottles
8. Turbidity chart

Size/Setting/Duration

12-15 students/Marietta Slough/~50 minutes

Background

The water quality station enables students to measure and observe the health of their stream. Students will learn how dissolved oxygen, pH, water temperature, and turbidity affect salmon survival.

Water quality affects salmon's ability to survive in their freshwater habitat. By testing various chemical qualities of the stream, we can determine the stream's health.

When it comes to **temperature**, Salmon survive best in water **5-20°C** (40-68°F). A water temperature higher than 20°C (68°F) or lower than 5°C (40°F) can kill or lower the chances of survival for fish.

Turbidity is a measurement of water clarity and is measured by the amount of sediment present in the water (clear, slightly silty, or muddy/brown). Sediment in the water can damage fish gills and make it hard for fish to see or breathe in their freshwater habitat. Sediment also suffocates salmon eggs.

pH stands for "parts hydrogen" and is a measure of the concentration of hydrogen in a solution on a scale of 1 - 14. Depending on the concentration, the solution will be acidic (lemon juice - pH 2), basic (ammonia - pH 12), or neutral (rainwater - pH 7). Salmon have a limited pH range in which they can live. A neutral pH of **7** is best for salmon; however, salmon will survive in a range from 6.5-8.5.

Dissolved oxygen (DO) is a measure of the amount of oxygen in the water; we measure this because salmon need to breathe oxygen from the water through their gills. Dissolved oxygen is measured in parts per million (ppm). Salmon need a DO concentration of at least 6 ppm in order to survive. However, salmon will tolerate a DO concentration as low as 4 ppm, but this inhibits their chances of survival greatly. The colder the water is, the more oxygen it can hold. This is one reason that salmon love cold water so much!

Activity

Lummi high school students will lead 3rd graders through four streamside stations. The students will collect water samples and run the aforementioned water quality tests on the samples.

1. (0:00-0:05) Once everyone is at the stream site, wait for the attention of the students.

Introduce the stream and have the students take a moment to observe the stream and the surrounding environment. Explain the course of the stream, verbally illustrating its path through farmland and eventual destination in Bellingham Bay. Have students brainstorm why water quality in this stream and Bellingham Bay matter (shellfish, salmon, riparian environment, stream health, species nesting, etc.). Emphasize the connectedness of the various characteristics of the stream and how all of these characteristics come together to form the entire stream system. Ask students what they think a "stream system" might include based on what they already know about the functioning of systems.

2. (0:05-0:07) Divide students into four groups of 3-4. Assign each group to a high school leader. Each high school leader will be an expert on one type of testing (temperature, turbidity, pH, DO). See *High School Leaders* handout for the specific roles the high school students will assume.

3. (0:07-0:45) Rotate groups through the different water quality testing stations, allowing approximately 10 minutes for each rotation.

Temperature: Explain why the temperature of the stream is important to the health of the stream and the health of salmon (see *Background Information*). Have students feel the temperature of the stream with their hand and hypothesize whether the temperature falls within the ideal range. Select a volunteer to take the actual temperature of the water and have students record the measurement in their field journals. Have students discuss what might change the temperature of the water. Warm it up? Cool it down?

Turbidity: Ask students what they think "turbidity" is. After hearing responses clear up any misconceptions and ask why turbidity matters to stream health. Have students hypothesize whether or not the water is turbid at the sample site. Explain how the tool they will be testing turbidity with works. Select a volunteer (a student who has not volunteered at previous testing stations) to collect the water sample and run the test. Have students record their measurement in their field journals. Facilitate discussion based on their findings. What might make a stream more turbid? Less turbid?

pH: Explain the pH scale and how pH is a measure of acidity. A base has a pH < 7 and is the opposite of an acid which has a pH > 7; something that is neutral is not basic or acidic and has a pH of 7. Have students prove their understanding of this concept by having them brainstorm examples of basic substances and acidic substances. Explain to students that water should have a neutral pH but that certain substances such as fertilizers and cleaners can alter this pH. Have students discuss what activities upstream might affect the pH at the testing site (fertilizers and pesticides from farming, runoff from roads and homes, etc.). Select a volunteer (a student who has not volunteered at previous testing stations) to collect the water sample and run the test. As the student is running the test explain how the pH measuring tool works. Have students record their findings in their field journals. Ask why salmon would or would not be happy in this stream based on what they found.

Dissolved Oxygen (DO): Ask students what they need to survive. When oxygen or air comes up, emphasize the importance of this substance for fish too! Even though they live in water, they still need oxygen! We call oxygen that is in water "dissolved oxygen." Ask students to look at the ripples or faster moving parts of the stream and ask how they think oxygen can get into the water. Explain how the DO measuring tool works and select a volunteer (a student who has not volunteered at previous testing stations) to collect the water sample and run the test. Have students record their findings in their field journals. Ask students to use what they now know about DO to describe what kind of stream salmon would like.

4. (0:45-0:50) Brief Assessment: Bring the students back together and review the ideal stream parameters for salmon. Discuss human and natural impacts to the stream and how those might affect these parameters. See EALRS below for key points to include.

Component	Grade Level Expectation	Evidence of Learning
EALR 1: Systems (SYS) **Role of each part in a system** **A.** A system is a group of interacting parts that form a whole. **B.** A whole object, plant, or animal may not continue to f__ t o__ the same way if some of its parts are missing.	Learn to think systematically about how the parts of objects, plants, and animals are connected and work together. Understand that an object, plant, or animal is more than the sum of its parts.	-Students will measure different chemical parts of a stream and recognize that the combination of these parts come together to determine its quality. -Students will learn that if these chemical parts fall outside of a given range, the stream can no longer function to its fullest ability.
EALR 2: Inquiry (INQ) **Conducting investigations** **A. Question—** Scientific *investigations* are *designed* to gain knowledge about the natural world. **B. Investigate—** A scientific *investigation* may include making and following a plan to accurately observe and describe objects, events, and organisms; make and record measurements, and *predict* outcomes. **D. Investigate—** Simple instruments, such as magnifiers, thermometers, and rulers provide more information than scientists can obtain using only their unaided senses. **F. Explain—** Scientists develop explanations, using *observations (evidence)* and what they already know about the world. Explanations should be based on *evidence* from *investigations.* **G. Communicate Intellectual Honesty—** Scientists make the results of their *investigations* public, even when the results contradict their expectations.	Learn to conduct different kinds of investigations. Although students may not yet be able to plan investigations alone, they can carry out investigations in collaboration with other students and support from the teacher. Actions may include observing and describing objects, events, and organisms, classifying them and making and recording measurements. Students should also display their data using various tables and graphs, make inferences based on evidence, and discuss their results with other students.	-Students will form questions regarding the health of the stream system and the surrounding riparian system. -Students will investigate the stream to gain knowledge toward their questions. -Students will record their investigations in their field journals. -Students will use instruments, such as a dissolved oxygen test kit, a pH test kit, a thermometer, and turbidity test kit to further investigate the qualities of the stream. -Students will discuss their findings as a group and record them in their field journals.
EALR 3: Application (APP) **Solving problems** **D.** *Tools* help scientists see more, measure more accurately, and do things that they could not otherwise accomplish. **E.** Successful *solutions* to problems often depend on selection of the best *tools* and materials and on previous experience.	Develop the ability to design a solution to a simple problem, using an elementary version of the technological design process.	-Students will use tools, such as a dissolved oxygen test kit, a pH test kit, a thermometer, and turbidity test kit to further investigate the qualities of the stream. -Students will draw conclusions from their findings to create solutions to improve the quality of the stream.
EALR 4: Earth Systems, Structures and Processes (ES2) ***Water and Weather*** **A.** Water plays an essential role	Learn that water exists in various locations and plays an essential role in Earth systems, including shaping land forms and weather.	-Students will discuss the importance of a healthy stream to the life within the stream and the systems surrounding the stream, especially in regards to

in Earth *systems*		salmon.
EALR 4: Ecosystems **(LS2)** ***Changes in Ecosystems*** **A.** *Ecosystems* support all life on the planet, including human life, by providing food, fresh water, and breathable *air*. **C.** Some changes in *ecosystems* occur slowly and others occur rapidly. Changes can affect life forms, including humans. **D.** Humans impact *ecosystems* in both positive and negative ways. Humans can help improve the health of *ecosystems* so that they provide *habitats* for plants and animals and resources for humans over the long term. For example, if people use fewer resources and recycle waste, there will be fewer negative impacts on natural *systems*.	Learn that ecosystems include plant and animal populations as well as nonliving resources. Plants and animals depend both on each other and on the nonliving resources in their ecosystem to survive. Ecosystems can change through both natural causes and human activities. These changes might be good or bad for the plants and animals that live in the ecosystem, or have no effect. Humans can protect the health of ecosystems in a number of ways.	-Students will understand that certain chemical qualities of the stream determine the health of the stream system as well as the surrounding ecosystem. -Students will discuss different changes (good and bad) to the riparian system and how they affect the ecosystem as a whole.

Macroinvertebrates: Messengers of the Waterways (Grade 3)

Lesson adapted by Kirsten Moore

Subject

Science

Objectives

1. Students will collect and identify macroinvertebrates from their stream, noting special characteristics that allow them to survive.
2. Students will understand feeding methods of different species of macroinvertebrates and how these allow them to serve a special role in the stream: scrapers, shredders, strainers, and predators.
3. Students will learn how to use macroinvertebrate ratings to determine the health of their stream.
4. Students will interpret how the biotic and abiotic components affect diversity and water quality.

Materials

1. Student field journal
2. Student writing utensil
3. White trays
4. Hand lenses, magnifying classes
5. Thermometer in a jar of freshly collected stream water
6. Catchment nets
7. Macroinvertebrate dichotomous key (laminated)
8. Additional bug/insect/macroinvertebrate identification books

Size/Setting/Duration

12-15 students/Marietta Slough/~50 minutes

Background

Macroinvertebrates are animals that are large enough to see with the unaided eye and have no backbone. These animals include: insects, worms, snails, crayfish, leeches, clams, mussels, etc. These aquatic insects live in the stream at different stages of their lives (larvae or nymph and adult). Macroinvertebrates can tell us a lot about the stream's water quality without ever having to do pH, DO, or water temperature tests. The species of macroinvertebrates present in a stream can also be used to indicate the quality of the water.

Some macroinvertebrates cannot survive in polluted water while others can survive or even thrive in polluted water. In other words, macroinvertebrates vary in their tolerance for pollutants, nutrient conditions, and range of temperature and dissolved oxygen. Macroinvertebrates are good indicators because: they are sensitive to physical changes in their habitat, they do not travel long distances in their lifetime like some fish can, they cannot easily escape changes in the water quality, and they are easy to collect in the stream.

Most aquatic macroinvertebrates make their home in rocks, leaves and the sediment of streambeds. These organisms have many special adaptations, allowing them to live in demanding environments. Macroinvertebrates that live in riffles and fast-moving water may have features that help them hold on to rocky or hard substrates, such as hooked feet, suction cups, and flat bodies. Macroinvertebrates that live in muddy substrates may have adaptations for a low oxygen environment.

While it is best to allow students to use their own knowledge and observations to draw their own conclusions as to where macroinvertebrates might be found, some background information can be shared to point students in the right direction. Students may then go out in the creek to test their hypotheses based on this background knowledge. Shave the following points with the students. (1) The area of the stream from which you are collecting should have at least a moderate rate of flow; if it is stagnant, limited oxygen may reduce macroinvertebrates' chances for survival. (2)

Since macroinvertebrates need oxygen, look for them in places in the stream where oxygen is most likely present (i.e. riffles). (3) Vegetated banks and rocks provide safe shelter. (4) Rocky stream bottoms allow for air pockets and safe places for macroinvertebrates to live. (5) Look where there is food! Macroinvertebrates can be found in areas that have vegetation along stream banks, because leaves drop in the water providing food when they decompose. Also look in quiet eddy waters where detritus and other organic material accumulate.

The presence of macroinvertebrates in the stream is not only important as an indicator of the stream's health, but is necessary for salmon to be able to thrive. These tiny insects are a prime food choice for fry (baby salmon that have just hatched) and provide the salmon with a source of nutrition and energy for their trip back out to the ocean.

Activity

1. (00:00-00:04) After the students have gathered around the macroinvertebrate collection station, transition from water quality testing (previous station) to macroinvertebrates. Explain that there are multiple ways to determine a stream's health: we can measure physical and chemical components of the water (as we did in water quality testing) or we can observe what kind of life exists in the stream system.
2. (00:04-00:10) Gather the students' attention, by asking whether the stream is healthy or not. Students should reference prior activity in measuring water quality. After taking a poll, tell the students they will have the chance to confirm their answer by see what some bugs have to show us. Explain that one way to observe the health of a stream is to actually look at what, or *'who'* is living in the stream. Whether you like bugs or not, the more kinds of insects we find living in a stream, the healthier it is!
3. (00:10-00:12) These insects are called, "Macroinvertebrates!" Pass the dichotomous keys around to the students, explaining how to use them.
4. (00:12-00:15) *Macro-Dance:* To introduce the different types of macroinvertebrates, teach students the macro-dance. Explain the different macro dance moves. Macroinvertebrates have no backbones, so dance as if you didn't have a spine! The next four dance moves are the types of macroinvertebrates. Macroinvertebrates obtain their energy by eating, just like we do. Macroinvertebrates are divided into categories, based on *how* they eat: the shredder shreds its food, so to represent the shredder, move like a robot with karate chopping arms; the strainer strains its food out of the water, so to dance like a strainer, make disco eye movements, but over the mouth; the scraper scrapes its food off of rocks and vegetation, to represent this, claw the air in front of you; and the predator stalks and hunts its prey, to be like a predator, make a big clap like clapping jaws! Have students practice their favorite dance moves, saying the type they are mimicking.
5. (00:15-00:40) *Looking at Macro-invertebrates! White trays, nets, hand lenses/magnifying glasses, and the dichotomous keys will be used in this portion of the lesson.* Before handing out the equipment, remind the students that we want to respect the environment and the insects we are temporarily removing from their homes. Proceed by demonstrating how to take a macroinvertebrate collection. This introduction to sampling is vital and will help reinforce the proper procedures for performing these tasks in their groups. Lower the net into the water, and carefully clean the rocks in front of the net so the macroinvertebrates flow with the stream into the net. Tell the students to pick a 2 foot area to sample from to prevent disturbing the entire stream. Once the samples have been collected in the net, fill the white tray with a layer of water, and empty collected debris and macroinvertebrates in the tray. Stress that the insects need water to live. Move trays to a flat spot so debris can settle.
Before releasing the students to their own work, identify hazards around the creek (steep embankments, slippery rocks, fast moving cold water), and remind students they must stay in

control while working (refrain from throwing rocks/debris in the creek, walk carefully around the stream and the other groups, and stay within pre-determined boundaries).

Divide the students into 4 groups and distribute a net, a white tray, magnifying glasses and a key to each group; supervise student groups in sampling practices.

When a group finds a macroinvertebrate have them do their best to identify it. Remind students of the characteristics to look for while identifying macroinvertebrates (referencing the Stream Macroinvertebrate Identification Charts). Have students circle the insects they found in the journals.

Instructors can facilitate inquiry-based learning while the students are collecting, analyzing and recording their findings in their field journals. Through questioning and instruction, help students correct any misconceptions.

6. (00:40-00:45) Brief Assessment: ask one member of each group to give the identifying characteristics of the macroinvertebrates they found.

Conclusion: summarize the group findings, main understandings, and designate the remaining time to stewardship orientated questions that will encourage students to think broadly about what they learned and to apply locally in their community. Especially emphasize how activities upstream might affect the downstream system the students have been observing. Have the students plot their location on a map of the watershed to provide a visual and generate discussion on land use within the watershed. See EALRS listed below for key points to emphasize.

7. (00:45-00:50) Carefully release macroinvertebrates ~10 feet upstream from the sample site. Lower the tray into the flow of water before emptying. All materials should be clean of organic matter and water. If students are releasing the, ensure they respect the organisms.

EALR Information 2-3 Macroinvertebrates: Messengers of our Waterways

Component	Grade Level Expectation	Evidence of Learning
EALR 1: Systems (SYS) ***Role of each part in a system*** **A.** A system is a group of interacting parts that form a whole. **E.** Similar parts may play different roles in different objects, plants, or animals.	Learn to think systematically about how the parts of objects, plants, and animals are connected and work together. Understand that an object, plant, or animal is more than the sum of its parts.	-Students will explain how one part of a system depends upon other parts of the same system. For example, students will be able to explain how activities upstream effect the system downstream -Students will understand feeding methods of different species of macroinvertebrates: scrapers, shredders, strainers, and predators
EALR 2: Inquiry (INQ) ***Conducting investigations*** **A. Question—** Scientific *investigations* are *designed* to gain knowledge about the *natural world*. **B. Investigate—** A scientific *investigation* may include making and following a plan to accurately observe and describe objects, events, and *organisms*; make and record measurements, and *predict* outcomes. **C. Infer—** *Inferences* are based on *observations*. **D. Investigate—** Simple instruments, such as *magnifiers*, *thermometers*, and rulers provide more information than scientists can obtain using only their unaided senses. **E. Model—** *Models* are useful for understanding *systems* that are too big, too small, or too dangerous to study directly. **F. Explain—** Scientists develop explanations, using *observations (evidence)* and what they already know about the world. Explanations should be based on *evidence* from *investigations*. **G. Communicate Intellectual Honesty—** Scientists make the results of their *investigations* public, even when the results contradict their expectations.	Learn to conduct different kinds of investigations. Although students may not yet be able to plan investigations alone, they can carry out investigations in collaboration with other students and support from the teacher. Actions may include observing and describing objects, events, and organisms, classifying them and making and recording measurements. Students should also display their data using various tables and graphs, make inferences based on evidence, and discuss their results with other students.	-Students will observe and investigate the riparian area and stream life in order to gain knowledge about the stream health and surrounding natural environment. -Students will make inferences as to the system's health based on their observations. -Students will use magnifiers, thermometers, and rulers to contribute to the information they gather based on the presence of certain macroinvertebrates as they determine the health of the stream. -Students will use a dichotomous key to identify organisms. -Students will plot their location on a map of the watershed and relate their activities to effects on the watershed. -Students will share their findings as a group at the end of the lesson.
EALR 3: Application (APP) ***Solving problems*** **B.** Scientific ideas and discoveries can be applied to solving problems. **D.** *Tools* help scientists see more, measure more accurately, and do things that they could not otherwise accomplish.	Develop the ability to design a solution to a simple problem, using an elementary version of the technological design process.	-Students will be able to determine the health of the stream through scientific identification and categorization of macroinvertebrates and then apply their findings by brainstorming ideas of how water quality problems can be solved. -Students will use magnifiers, thermometers, and rulers to contribute to the information they gather based on the presence of certain macroinvertebrates as they determine the health of the stream. -Students will use a dichotomous key to identify organisms.

EALR 4: Energy: Transfer, Transformation, and Conservation (PS3) ***Forms of Energy*** **A.** *Heat*, light, *motion*, electricity, and sound are all forms of *energy*.	Have an intuitive understanding of energy concepts. For example, energy is needed to get things done; humans get energy from food.	-Students will relate the different feeding habits of the macroinvertebrates to different ways to obtain energy.
EALR 4: Earth Systems, Structures and Processes (ES2) ***Water and Weather*** **A.** Water plays an essential role in Earth *systems*	Learn that water exists in various locations and plays an essential role in Earth systems, including shaping land forms and weather.	-Through the conclusion element of this lesson, students will make the connection that water in the stream connects inland systems to marine systems and the events along the stream that effect the water are important to every part of the stream.
EALR 4: Structures and Functions of Living Organisms (LS1) ***Life Cycles*** **B.** Animals have *life cycles* that include being born; developing into juveniles, adolescents, then adults; reproducing (which begins a new cycle); and eventually dying. The details of the *life cycle* are different for different animals.	Learn that all plants and animals have life cycles. They also compare the life cycles of a few common animals to see how they are similar and how they are different, and learn about the life cycles of plants. Focus should be on observable characteristics of how plants and animals change over time.	-Students will collect and study macroinvertebrates and make the connection that macroinvertebrates are a different life stage of insects they see flying in the air in the summer.
EALR 4: Ecosystems (LS2) ***Changes in Ecosystems*** **A.** *Ecosystems* support all life on the planet, including human life, by providing food, fresh water, and breathable *air*. **C.** Some changes in *ecosystems* occur slowly and others occur rapidly. Changes can affect life forms, including humans. **D.** Humans impact *ecosystems* in both positive and negative ways. Humans can help improve the health of *ecosystems* so that they provide *habitats* for plants and animals and resources for humans over the long term. For example, if people use fewer resources and recycle waste, there will be fewer negative impacts on natural *systems*.	Learn that ecosystems include plant and animal populations as well as nonliving resources. Plants and animals depend both on each other and on the nonliving resources in their ecosystem to survive. Ecosystems can change through both natural causes and human activities. These changes might be good or bad for the plants and animals that live in the ecosystem, or have no effect. Humans can protect the health of ecosystems in a number of ways.	-Students will understand that the presence of macroinvertebrates depends on food, clean water, and air which are provided by the ecosystem. -Students will discuss different changes (good and bad) to the riparian system and how they affect the ecosystem as a whole.
EALR 4: Biological Evolution (LS3) ***Variations of Inherited Characteristics*** **A.** There are *variations* among the same kinds of plants and animals. **B.** The offspring of a plant or animal closely resembles its parents, but close inspection reveals differences. **C.** Sometimes differences in *characteristics* give individual plants or animals an advantage in surviving and reproducing.	Learn about variations in inherited characteristics. That is, when plants and animals reproduce, the offspring closely resemble their parents. But the offspring are not exactly the same as their parents. Variations among animals and plants can help them survive changing conditions. Those plants and animals unable to survive and reproduce become extinct. This topic engages students in looking closely at plants and animals and noticing similarities and subtle differences. It also lays the foundation for later study of Evolution and of Earth History.	-Students will observe and record presence of various life stages of different aquatic insects. -Students will gauge the health of the stream based on the presence of certain macroinvertebrates and their characteristics that allow them to thrive in the given environment.

Native Plants: Each One Teach One (Grade 3)

Lesson adapted by Kirsten Moore

Subject

Science

Objectives

1. Students will learn the names and unique characteristics of several native plants.
2. Students will describe the organisms and their observations and record these in their field journals.
3. Students will use the information and knowledge gained through their observations to effectively explain and communicate their findings to their classmates, reinforcing what they have learned.
4. Students will learn how the riparian zone helps keep streams healthy
5. Students will teach their peers about one native plant or element of the riparian zone.

Materials

1. Student Field Journal
2. Student writing utensil (Colored pencils are fun!)
3. *Riparian Zone Cards* (provided by NSEA)

Size/Setting/Duration

12-15 students/Marietta Slough/~45 minutes

Background

This activity is based on the philosophy that people learn and remember something the best when they teach it. At this station, students will participate in an activity where they will become the teachers, teaching their classmates about one specific native plant or an aspect of the riparian zone (for example, large woody debris).

Scout out the area before you do the lesson and identify your teaching stops. Place *Riparian Zone Cards* on the appropriate plants or near corresponding concepts (large woody debris). Each station should be fairly close to the others so that all students are within sight during the activity.

Activity

1. (0:00-0:05) Tell students that they will be studying native plants and teaching each other about their importance to the riparian zone. Instead of you doing all the teaching, they get to help out by becoming teachers for their classmates. They'll each study one native plant, becoming "experts" on its cultural and environmental significance. Start by refreshing the concept of a riparian zone for the students, asking them what makes a healthy one. Clarify the concept that even though we've been focusing on the stream with the water quality testing and macroinvertebrate collection, the riparian zone includes the surrounding terrestrial environment as well. Pose the question: "How do trees help keep the stream's water clean, cold, and clear?" They should come up with: roots stabilize the banks; leaves feed bugs, bugs feed fish; large woody debris provides places for fish to hide; and shade.
2. (0:05-0:10) Set boundaries for the students and tell them they will be searching for bright orange and green cards. There should be one card per student. Instruct the students to stay by their card once they find one, study the information listed on the card, and to fill out their *Each One Teach One* worksheets in the Student Journal. Before releasing students to find the cards, provide an example of a mini lesson that each student should prepare for his or her plant.
3. (0:10-0:15) Once the students have found a card allow five minutes to fill out their *Each One Teach One* worksheets in the Student Journal. Make

sure they understand that they'll be teaching what they learn, so they should put answers into their own words and be ready to share by showing and telling! As the students study their plant/element and fill out their journal, go around and offer your excitement and knowledge about each one.

4. (0:15-0:45) Gather students together once they've completed their worksheets. Begin walking the trail, pausing at each plant with a card to have the corresponding student teach about it. Students should share 2-3 interesting facts about that plant or element in their lesson. Encourage student teachers to show the plant while they share (if they are talking about how soft the leaves are - invite the other students to feel the leaves). Students learning should take notes on and sketch each plant as the go (space provided on back of worksheet).

Component	Grade Level Expectation	Evidence of Learning
EALR 1: Systems (SYS) Role of each part in a system **A.** A <u>*system*</u> is a group of interacting parts that <u>*form*</u> a whole. **B.** A whole object, plant, or animal may not continue to <u>*function*</u> the same way if some of its parts are missing. **C.** A whole object, plant, or animal can do things that none of its parts can do by themselves.	Learn to think systematically about how the parts of objects, plants, and animals are connected and work together. Understand that an object, plant, or animal is more than the sum of its parts.	-Students will identify native plants and, based on informational cards attached to the plants, teach classmates the role each plant has in the riparian system.
EALR : n iry ( ) Cond cting investi ations **A. Question—** Scientific <u>*investigations*</u> are *designed* to gain knowledge about the <u>*natural world*</u>. **B. Investigate—** A scientific *investigation* may include making and following a plan to accurately observe and <u>*describe*</u> objects, events, and <u>*organisms*</u>; make and record measurements, and *predict* outcomes. **F. Explain—** Scientists develop explanations, using *observations (<u>evidence</u>)* and what they already know about the world. Explanations should be based on *evidence* from *investigations*. **G. Communicate Intellectual Honesty—** Scientists make the results of their *investigations* public, even when the results contradict their expectations.	Learn to conduct different kinds of investigations. Although students may not yet be able to plan investigations alone, they can carry out investigations in collaboration with other students and support from the teacher. Actions may include observing and describing objects, events, and organisms, classifying them and making and recording measurements. Students should also display their data using various tables and graphs, make inferences based on evidence, and discuss their results with other students.	-Students will "investigate" plants based on their own observations combined with information given on pre-made cards. -Students will describe the organisms and their observations and record these in their field journals. -Students will use the information and knowledge gained through their observations to effectively explain and communicate their findings to their classmates.
EALR 4: Str ct res an F nctions of Livin Or anisms (LS1) *Life Cycles* **A.** Plants have <u>*life cycles*</u> that include sprouting, growing to full size, forming fruits and flowers, shedding seeds (which begins a new cycle), and eventually dying. The details of the *life cycle* are different for different plants.	Learn that all plants and animals have life cycles. They also compare the life cycles of a few common animals to see how they are similar and how they are different, and learn about the life cycles of plants. Focus should be on observable characteristics of how plants and animals change over time.	-Students will record the presence of various life stages of riparian plants.
EALR 4: Ecosystems (LS2) *Changes in Ecosystems* **B.** All *ecosystems* change over	Learn that ecosystems include plant and animal populations as well as nonliving resources. Plants and animals depend both on each	-Students will note and discuss possible environmental changes that impact riparian areas and what effects these changes might

time as a result of natural causes (e.g., storms, floods, volcanic eruptions, fire). Some of these changes are beneficial for the plants and animals, some are harmful, and some have no *effect*. **D.** Humans impact *ecosystems* in both positive and negative ways. Humans can help improve the health of *ecosystems* so that they provide *habitats* for plants and animals and resources for humans over the long term. For example, if people use fewer resources and recycle waste, there will be fewer negative impacts on natural *systems*.	other and on the nonliving resources in their ecosystem to survive. Ecosystems can change through both natural causes and human activities. These changes might be good or bad for the plants and animals that live in the ecosystem, or have no effect. Humans can protect the health of ecosystems in a number of ways.	hold on the system. -Students will note and discuss human impacts on the riparian area and what effects these impacts might hold on the system. -Students will differentiate between positive, negative, and neutral effects.
EALR 4: Biological Evolution (LS3) ***Variations of Inherited Characteristics*** **A.** There are *variations* among the same kinds of plants and animals. **B.** The offspring of a plant or animal closely resembles its parents, but close inspection reveals differences. **C.** Sometimes differences in *characteristics* give individual plants or animals an advantage in surviving and reproducing.	Learn about variations in inherited characteristics. That is, when plants and animals reproduce, the offspring closely resemble their parents. But the offspring are not exactly the same as their parents. Variations among animals and plants can help them survive changing conditions. Those plants and animals unable to survive and reproduce become extinct. This topic engages students in looking closely at plants and animals and noticing similarities and subtle differences. It also lays the foundation for later study of Evolution and of Earth History.	-Students will identify plants in various life stages and teach peers about the characteristics of the plant that allow it to survive and thrive in a riparian system.

Lesson Plans

Grades 4-5

1. *Water Quality: A Quest in Chemistry*
2. *Macroinvertebrates: Messengers of our Waterways*
3. *Native Plants: Each One Teach One*

Water Quality: A Quest in Chemistry (Grades 4 and 5)

Lesson Adapted by Kirsten Moore

Subject

Science

Objectives

1. Students will measure different chemical parts of a stream and recognize that the stream system is a subsystem of the watershed.
2. At the stream site, students will carry out a series of water quality measurements using scientific methods and scientifically record the data.
3. Students will understand how these measurements relate to the heath of their stream system and the surrounding ecosystem.

Materials

1. Student field journal
2. Student writing utensil
3. Clip-boards
4. Dissolved Oxygen test kit
5. pH test kit/pH test strips
6. Thermometer
7. 3 example turbidity bottles
8. Turbidity chart

Size/Setting/Duration

12-15 students/Marietta Slough/~50 minutes

Background

The water quality station enables students to measure and observe the health of their stream. Students will learn how dissolved oxygen, pH, water temperature, and turbidity affect salmon survival.

Water quality affects salmon's ability to survive in their freshwater habitat. By testing various chemical qualities of the stream, we can determine the stream's health.

When it comes to **temperature**, Salmon survive best in water 5-20°C (40-68°F). A water temperature higher than 20°C (68°F) or lower than 5°C (40°F) can kill or lower the chances of survival for fish.

Turbidity is a measurement of water clarity and is measured by the amount of sediment present in the water (clear, slightly silty, or muddy/brown). Sediment in the water can damage fish gills and make it hard for fish to see or breathe in their freshwater habitat. Sediment also suffocates salmon eggs.

pH stands for "parts hydrogen" and is a measure of the concentration of hydrogen in a solution on a scale of 1 - 14. Depending on the concentration, the solution will be acidic (lemon juice - pH 2), basic (ammonia - pH 12), or neutral (rainwater - pH 7). Salmon have a limited pH range in which they can live. A neutral pH of **7** is best for salmon; however, salmon will survive in a range from 6.5-8.5.

Dissolved oxygen (DO) is a measure of the amount of oxygen in the water; we measure this because salmon need to breathe oxygen from the water through their gills. Dissolved oxygen is measured in parts per million (ppm). Salmon need a DO concentration of at least 6 ppm in order to survive. However, salmon will tolerate a DO concentration as low as 4 ppm, but this inhibits their chances of survival greatly. The colder the water is, the more oxygen it can hold. This is one reason that salmon love cold water so much!

Activity

Lummi high school students will lead 4th-5th graders through four streamside stations. The students will collect water samples and run the aforementioned water quality tests on the samples.

1. (0:00-0:05) Once everyone is at the stream site, wait for the attention of the students. Introduce the stream and have the students take a moment to observe the stream and the surrounding environment. Explain the course of the stream, verbally illustrating its path through

farmland and eventual destination in Bellingham Bay. Have students brainstorm why water quality in this stream and Bellingham Bay matter (shellfish, salmon, riparian environment, stream health, species nesting, etc.). Emphasize the connectedness of the various characteristics of the stream and how all of these characteristics come together to form the entire stream system. Ask students what they think a "stream system" might include based on what they already know about the functioning of systems. Also, ask students to hypothesize whether or not this is a healthy stream. Have them record their answers in their field journals.

2. (0:05-0:07) Divide students into four groups of 3-4. Assign each group to a high school leader. Each high school leader will be an expert on one type of testing (temperature, turbidity, pH, DO). See *High School Leaders* handout for the specific roles the high school students will assume.

3. (0:07-0:45) Rotate groups through the different water quality testing stations, allowing approximately 10 minutes for each rotation. As students are working through the different stations, wander between groups, encouraging students to think how the technology of water quality testing has opened communication between all who depend on a stream system.

Temperature: Explain why the temperature of the stream is important to the health of the stream and the health of salmon (see *Background Information*). Have students feel the temperature of the stream with their hand and hypothesize whether the temperature falls within the ideal range. Select a volunteer to take the actual temperature of the water and have students record the measurement in their field journals. Have students discuss what might change the temperature of the water. Warm it up? Cool it down?

Turbidity: Ask students what they think "turbidity" is. After hearing responses clear up any misconceptions and ask why turbidity matters to stream health. Have students hypothesize whether or not the water is turbid at the sample site. Explain how the tool they will be testing turbidity with works. Select a volunteer (a student who has not volunteered at previous testing stations) to collect the water sample and run the test. Have students record their measurement in their field journals. Facilitate discussion based on their findings. What might make a stream more turbid? Less turbid?

pH: Explain the pH scale and how pH is a measure of acidity. A base has a pH < 7 and is the opposite of an acid which has a pH > 7; something that is neutral is not basic or acidic and has a pH of 7. Have students prove their understanding of this concept by having them brainstorm examples of basic substances and acidic substances. Explain to students that water should have a neutral pH but that certain substances such as fertilizers and cleaners can alter this pH. Have students discuss what activities upstream might affect the pH at the testing site (fertilizers and pesticides from farming, runoff from roads and homes, etc.). Select a volunteer (a student who has not volunteered at previous testing stations) to collect the water sample and run the test. As the student is running the test explain how the pH measuring tool works. Have students record their findings in their field journals. Ask why salmon would or would not be happy in this stream based on what they found.

Dissolved Oxygen (DO): Ask students what they need to survive. When oxygen or air comes up, emphasize the importance of this substance for fish too! Even though they live in water, they still need oxygen! We call oxygen that is in water "dissolved oxygen." Ask students to look at the ripples or faster moving parts of the stream and ask how they think oxygen can get into the water. Explain how the DO measuring tool works and select a volunteer (a student who has not volunteered at previous testing stations) to collect the water sample and run the test. Have students record their findings in their field journals. Ask students to use what they now know about DO to describe what kind of stream salmon would like.

4. (0:45-0:55) Brief Assessment: Bring the students back together and review the ideal stream parameters for salmon. Have each group

share their findings and talk about differences in the results. Ask students why it is important to have repeated trials in data collection. Discuss human and natural inputs to the stream and how those might affect these parameters/stream output. Students should be able to infer that erosive activities take place upstream. See EALRS below for key points to include.

EALR Information 4-5 **Water Quality: A Quest in Chemistry**

Component	Grade Level Expectation	Evidence of Learning
EALR 1: Systems (SYS) ***Complex Systems*** **A.** *Systems* contain *subsystems*.	Learn that systems contain smaller (sub-) systems, and that systems are also parts of larger systems. The same ideas about systems and their parts learned in earlier grades apply to systems and subsystems. In addition, students learn about inputs and outputs and how to predict what may happen to a system if the system's inputs are changed.	-Students will measure different chemical parts of a stream and recognize that the stream system is a subsystem of the watershed.
EALR 2: Inquiry (INQ) ***Planning Investigations*** **A. Question—** Scientific *investigations* involve asking and answering *questions* and comparing the answers with *evidence* from the real world. **B. Investigate—** Scientists plan and conduct different kinds of *investigations*, depending on the *questions* they are trying to answer. Types of *investigations* include systematic *observations* and descriptions, *field studies*, *models*, and *open-ended explorations* as well as *controlled experiments*. **D. Investigate—** *Investigations* involve systematic collection and recording of relevant *observations* and data. **E. Investigate—** Repeated *trials* are necessary for *reliability*. **H. Communicate—** Scientists communicate the results of their *investigations* verbally and in writing. They review and ask *questions* about the results of other scientists' work. **I. Intellectual Honesty—** Scientists report the results of their *investigations* honestly, even when those results show	Learn to plan an investigation, which involves first selecting the appropriate kind of investigation to match the question being asked.	-Students will observe and investigate the riparian area and stream life in order to gain knowledge about the stream health and surrounding natural environment. They will gather evidence from the real world in the form of water quality testing to answer their questions. -Students will investigate the stream's health through observations, field studies, and controlled experiments. -Students will record their observations and data in their field journals. -Students will recognize the importance of multiple water quality collections to the reliability of their findings. -Students will share their findings as a group at the end of the lesson.

their predictions were wrong or when they cannot *explain* the results.		
EALR 3: Application (APP) ***Different Technologies*** **G.** Science and technology have greatly improved food quality and quantity, transportation, health, sanitation, and communication.	Learn to distinguish between science and technology and to work individually and collaboratively to produce a product of their own design. They learn that people in different cultures use different materials and technologies to meet their same daily needs and increase their understanding of tools and materials. Students also develop their abilities to define problems that can be solved by modifying or inventing technologies, to create and test their designs, and to communicate what they learned. These capabilities help students understand the value of science and technology to meet human needs and provide them with valuable skills for everyday life.	-Students will discuss how science and our growing knowledge of water quality and stream health have helped to develop conversation between those whose activities impact the system upstream and those who live and use the stream.
EALR 4: Earth Systems, Structures and Processes (ES2) ***Formation of Earth Materials*** **C.** *Erosion* is the movement of Earth materials by forces such as *wind*, moving water, ice forming, and *gravity*. **F.** *Erosion* plays an important role in the formation of soil, but too much *erosion* can wash away fertile soil from *ecosystems* and farms.	Learn how Earth materials change and how they can be used for various purposes. People use many of these materials as resources to meet their needs. One of the most important Earth resources is soil, since people depend on fertile soil to grow food. The processes that produce soils offer an excellent opportunity for students to understand how Earth materials change gradually over time.	-Students will discuss how erosion upstream effects water quality downstream. -Students will discuss activities that cause erosion. -Students will be able to connect their results from the turbidity test to potential erosion upstream.
EALR 4: Ecosystems (LS2) ***Food Webs*** **A.** An *ecosystem* includes all of the *populations* of living organisms and nonliving physical factors in a given area. Living organisms depend on one another and the nonliving physical factors in their *ecosystem* to help them survive. **C.** Some changes in *ecosystems* occur slowly and others occur rapidly. Changes can affect life forms, including humans. **D.** *Ecosystems* can change slowly or rapidly. Big changes over a short period of time can have a major impact on the *ecosystem* and the *populations* of plants and animals living there. **F.** People affect *ecosystems* both positively and negatively.	Learn how ecosystems change and how these changes affect the capacity of an ecosystem to support populations. Some changes in ecosystems are caused by the organisms themselves. The ability of any organism to survive will depend on its characteristics and behaviors. Humans also play an important role in many ecosystems and may reduce negative impacts through thoughtful use of natural resources.	-Students will understand that healthy water quality parameters depend on other living organisms and the nonliving physical environment. -Students will discuss different changes (positive, negative, natural, and anthropogenic) to the riparian system and how they affect the ecosystem as a whole.

Macroinvertebrates: Messengers of the Waterways (Grades 4-5)

Lesson adapted by Kirsten Moore

Subject

Science

Objectives

1. Students will observe the stream system's macroinvertebrate subsystem and learn how different macrolnvertebrates have different roles within the larger stream system.
2. Students will learn how to use macroinvertebrate ratings to determine the health of their stream.
3. Students will observe and investigate the riparian area and stream life in order to gain knowledge about the stream health and surrounding natural environment.
4. Students will interpret how the biotic and abiotic components affect diversity and water quality.

Materials

1. Student field journal
2. Student writing utensil
3. White trays
4. Hand lenses, magnifying classes
5. Thermometer in a jar of freshly collected stream water
6. Catchment nets
7. Macroinvertebrate dichotomous key (laminated)
8. Additional bug/insect/macroinvertebrate identification books

Size/Setting/Duration

12-15 students/Marietta Slough/~50 minutes

Background

Macroinvertebrates are animals that are large enough to see with the unaided eye and have no backbone. These animals include: insects, worms, snails, crayfish, leeches, clams, mussels, etc. These aquatic insects live in the stream at different stages of their lives (larvae or nymph and adult). Macroinvertebrates can tell us a lot about the stream's water quality without ever having to do pH, DO, or water temperature tests. The species of macroinvertebrates present in a stream can also be used to indicate the quality of the water.

Some macroinvertebrates cannot survive in polluted water while others can survive or even thrive in polluted water. In other words, macroinvertebrates vary in their tolerance for pollutants, nutrient conditions, and range of temperature and dissolved oxygen. Macroinvertebrates are good indicators because: they are sensitive to physical changes in their habitat, they do not travel long distances in their lifetime like some fish can, they cannot easily escape changes in the water quality, and they are easy to collect in the stream.

Most aquatic macroinvertebrates make their home in rocks, leaves and the sediment of streambeds. These organisms have many special adaptations, allowing them to live in demanding environments. Macroinvertebrates that live in riffles and fast-moving water may have features that help them hold on to rocky or hard substrates, such as hooked feet, suction cups, and flat bodies. Macroinvertebrates that live in muddy substrates may have adaptations for a low oxygen environment.

While it is best to allow students to use their own knowledge and observations to draw their own conclusions as to where macroinvertebrates might be found, some background information can be shared to point students in the right direction. Students may then go out in the creek to test their hypotheses based on this background knowledge. Shave the following points with the students. (1) The area of the stream from which you are collecting should have at least a moderate rate of flow; if it is stagnant, limited oxygen may reduce macroinvertebrates' chances for survival. (2)

Since macroinvertebrates need oxygen, look for them in places in the stream where oxygen is most likely present (i.e. riffles). (3) Vegetated banks and rocks provide safe shelter. (4) Rocky stream bottoms allow for air pockets and safe places for macroinvertebrates to live. (5) Look where there is food! MAcroinvertebrates can be found in areas that have vegetation along stream banks, because leaves drop in the water providing food when they decompose. Also look in quiet eddy waters where detritus and other organic material accumulate.

The presence of macroinvertebrates in the stream is not only important as an indicator of the stream's health, but is necessary for salmon to be able to thrive. These tiny insects are a prime food choice for fry (baby salmon that have just hatched) and provide the salmon with a source of nutrition and energy for their trip back out to the ocean.

Activity

1. (00:00-00:04) After the students have gathered around the macroinvertebrate collection station, transition from water quality testing (previous station) to macroinvertebrates. Explain that there are multiple ways to determine a stream's health: we can measure physical and chemical components of the water (as we did in water quality testing) or we can observe what kind of life exists in the stream system.
2. (00:004-00:10) Have the students complete the stream observation questions in their field journals. Questions are as follows:
   - Look at the stream banks. Do you observe lots of plant life or little plant life?
   - How many different plants can you count around the stream?
   - Look up. Is there canopy cover from trees?
   - Is the water clear, brown, or green?
   - Collect water in a clear jar. Are there free flowing sediments (dirt and plant matter) in the water?
   - Are there logs, branches or boulders in the stream? How many?
   - Feel the temperature of the water. Is it warm or cold?
   - Check the temperature of the water with a thermometer and record it.
   - Do believe this stream is healthy? Explain your reason for this answer.
3. (00:10-00:15) Gather the students' attention, by asking whether the stream is healthy or not. Students should reference prior activity in measuring water quality. After taking a poll, tell the students they will have the chance to confirm their answer by see what some bugs have to show us. Explain that one way to observe the health of a stream is to actually look at what, or *'who'* is living in the stream. Whether you like bugs or not, the more kinds of insects we find living in a stream, the healthier it is!
4. (00:15-00:20) These insects are called, "Macroinvertebrates!" Pass the dichotomous keys around to the students, explaining how to use them. *Macro-Dance:* To introduce the different types of macroinvertebrates, teach students the macro-dance. Explain the different macro dance moves. Macroinvertebrates have no backbones, so dance as if you didn't have a spine! The next four dance moves are the types of macroinvertebrates. Macroinvertebrates obtain their energy by eating, just like we do. Macroinvertebrates are divided into categories, based on *how* they eat: the shredder shreds its food, so to represent the shredder, move like a robot with karate chopping arms; the strainer strains its food out of the water, so to dance like a strainer, make disco eye movements, but over the mouth; the scraper scrapes its food off of rocks and vegetation, to represent this, claw the air in front of you; and the predator stalks and hunts its prey, to be like a predator, make a big clap like clapping jaws! Have students practice their favorite dance moves, saying the type they are mimicking.
5. (00:20-00:40) *Looking at Macro-invertebrates! White trays, nets, hand lenses/magnifying glasses, and the dichotomous keys will be used in this portion of the lesson.* Before handing out the equipment, remind the students that we want to respect the environment and the insects we are temporarily

removing from their homes. Proceed by demonstrating how to take a macroinvertebrate collection. This introduction to sampling is vital and will help reinforce the proper procedures for performing these tasks in their groups. Lower the net into the water, and carefully clean the rocks in front of the net so the macroinvertebrates flow with the stream into the net. Tell the students to pick a 2 foot area to sample from to prevent disturbing the entire stream. Once the samples have been collected in the net, fill the white tray with a layer of water, and empty collected debris and macroinvertebrates in the tray. Stress that the insects need water to live. Move trays to a flat spot so debris can settle.

Before releasing the students to their own work, identify hazards around the creek (steep embankments, slippery rocks, fast moving cold water), and remind students they must stay in control while working (refrain from throwing rocks/debris in the creek, walk carefully around the stream and the other groups, and stay within pre-determined boundaries).

Divide the students into 4 groups and distribute a net, a white tray, magnifying glasses and a key to each group; supervise student groups in sampling practices.

When a group finds a macroinvertebrate have them do their best to identify it. Remind students of the characteristics to look for while identifying macroinvertebrates (referencing the Stream Macroinvertebrate Identification Charts). Have students circle the insects they found in the journals.

Instructors can facilitate inquiry-based learning while the students are collecting, analyzing and recording their findings in their field journals. Through questioning and instruction, help students correct any misconceptions.

6. (00:40-00:45) Brief Assessment: ask one member of each group to give the identifying characteristics of the macroinvertebrates they found.

Conclusion: summarize the group findings, main understandings, and designate the remaining time to stewardship orientated questions that will encourage students to think broadly about what they learned and to apply locally in their community. Especially emphasize how activities upstream might affect the downstream system the students have been observing. Have the students plot their location on a map of the watershed to provide a visual and generate discussion on land use within the watershed. Spend some amount of time discussing how science and our growing knowledge of water quality and stream health have helped to develop conversation between those whose activities impact the system upstream and those who live and use the stream. *ee L listed below for key points to emphasize.*

7. (0:45-0:50) Carefully release macroinvertebrates ~10 feet upstream from the sample site. Lower the tray into the flow of water before emptying. All materials should be clean of organic matter and water. If students are releasing the, ensure they respect the organisms.

Component	Grade Level Expectation	Evidence of Learning
EALR 1: Systems (SYS) ***Complex Systems*** **A.** *Systems* contain *subsystems*.	Learn that systems contain smaller (sub-) systems, and that systems are also parts of larger systems. The same ideas about systems and their parts learned in earlier grades apply to systems and subsystems. n addition, students learn about inputs and outputs and how to predict what may happen to a system if the system's inputs are changed.	-Students will observe the stream system's macroinvertebrate subsystem and learn how different macroinvertebrates have different roles within the larger stream system.
EALR 2: Inquiry (INQ) ***Planning Investigations*** **A. Question—** Scientific *investigations* involve asking and answering *questions* and comparing the answers with *evidence* from the real world. **B. Investigate—** Scientists plan and conduct different kinds of *investigations*, depending on the *questions* they are trying to answer. Types of *investigations* include systematic *observations* and descriptions, *field studies*, *models*, and *open-ended explorations* as well as *controlled experiments*. **D. Investigate—** *Investigations* involve systematic collection and recording of relevant *observations* and data. **E. Investigate—** Repeated *trials* are necessary for *reliability*. **H. Communicate—** Scientists communicate the results of their *investigations* verbally and in writing. They review and ask *questions* about the results of other scientists' work. **I. Intellectual Honesty—** Scientists report the results of their *investigations* honestly, even when those results show their *predictions* were wrong or when they cannot *explain* the results.	Learn to plan an investigation, which involves first selecting the appropriate kind of investigation to match the question being asked.	-Students will observe and investigate the riparian area and stream life in order to gain knowledge about the stream health and surrounding natural environment. They will gather evidence from the real world to answer their questions. -Students will investigate the stream's health through observations of macroinvertebrate populations. -Students will record their observations and data in their field journals. -Students will recognize the importance of multiple macroinvertebrate collections to the reliability of their findings. -Students will share their findings as a group at the end of the lesson.
EALR 3: Application (APP) ***Different Technologies*** **G.** *Science* and technology have greatly improved food quality and quantity, transportation, health, sanitation, and communication.	Learn to distinguish between science and technology and to work individually and collaboratively to produce a product of their own design. They learn that people in different cultures use different materials and technologies to meet their same daily needs and increase their understanding of tools and materials. Students also develop their abilities to define problems that can be solved by modifying or inventing technologies, to create and test their designs, and to communicate what they learned.	-Students will discuss how science and our growing knowledge of water quality and stream health have helped to develop conversation between those whose activities impact the system upstream and those who live and use the stream.

	These capabilities help students understand the value of science and technology to meet human needs and provide them with valuable skills for everyday life.	
EALR 4: Energy: Transfer, Transformation, and Conservation (PS3) ***Heat, Light, Sound, and Electricity*** **B.** *Energy* can be *transferred* from one place to another.	Build on their intuitive understanding of energy and learn how heat, light, sound, and electrical energy are generated and can be transferred from place to place.	-Students will relate the different feeding habits of the macroinvertebrates to different ways to obtain energy.
EALR 4: Earth Systems, Structures and Processes (ES2) ***Formation of Earth Materials*** **C.** *Erosion* is the movement of Earth materials by forces such as *wind*, moving water, ice forming, and *gravity*. **F.** *Erosion* plays an important role in the formation of soil, but too much *erosion* can wash away fertile soil from *ecosystems* and farms.	Learn how Earth materials change and how they can be used for various purposes. People use many of these materials as resources to meet their needs. One of the most important Earth resources is soil, since people depend on fertile soil to grow food. The processes that produce soils offer an excellent opportunity for students to understand how Earth materials change gradually over time.	-Students will discuss how erosion upstream effects water quality downstream. -Students will discuss activities that cause erosion.
EALR 4: Structures and Functions of Living Organisms (LS1) ***Structures and Behaviors*** **A.** Plants and animals can be sorted according to their structures and behaviors. **B.** Plants and animals have different structures and behaviors that serve different *functions*. **C.** Certain structures and behaviors enable plants and animals to respond to changes in their *environment*.	Learn that plants and animals have different structures that work together to respond to various internal and external needs.	-Students will collect and observe different macroinvertebrates with different tolerances, behaviors, and structures that allow them to thrive.
EALR 4: Ecosystems (LS2) ***Food Webs*** **A.** An *ecosystem* includes all of the *populations* of living organisms and nonliving physical factors in a given area. Living organisms depend on one another and the nonliving physical factors in their *ecosystem* to help them survive. **B.** Plants make their own food using *energy* from the sun. Animals get food by eating plants and/or other animals that eat plants. Plants make it possible for animals to use the energy of sunlight. **C.** Some changes in *ecosystems* occur slowly and others occur rapidly. Changes can affect life *forms*, including humans. **D.** *Ecosystems* can change slowly or rapidly. Big changes over a short period of time can have a major impact on the *ecosystem*	Learn how ecosystems change and how these changes affect the capacity of an ecosystem to support populations. Some changes in ecosystems are caused by the organisms themselves. The ability of any organism to survive will depend on its characteristics and behaviors. Humans also play an important role in many ecosystems and may reduce negative impacts through thoughtful use of natural resources.	-Students will understand that the presence of macroinvertebrates depends on other living organisms and the nonliving physical environment. -Students will learn different ways through which macroinvertebrates obtain their energy -Students will discuss different changes (positive, negative, natural, and anthropogenic) to the riparian system and how they affect the ecosystem as a whole.

and the *populations* of plants and animals living there. **F.** People affect *ecosystems* both positively and negatively.		
EALR 4: Biological Evolution (LS3) ***Heredity and Adaptation*** **A.** In any ecosystem, some populations of organisms thrive and grow, some decline, and others do not survive at all. **B.** Plants and animals inherit many characteristics from their parents. Some inherited *characteristics* allow *organisms* to better survive and reproduce in a given *ecosystem*. **C.** Sometimes differences in characteristics give individual plants or animals an advantage in surviving and reproducing.	Learn that some differences in inherited characteristics may help plants and animals survive and reproduce. Sexual reproduction results in offspring that are never identical to either of their parents and therefore contributes to a species' ability to adapt to changing conditions. Heredity is a key feature of living plants and animals that enables changes in characteristics to be passed on and for species to change over time.	-Students will be introduced to the idea of macroinvertebrates as an indicator species. Indicator species have special characteristics that either allow them to thrive or die in given environmental conditions. These characteristics are inherited. -Students will be able to relate stream health to the macroinvertebrate populations they find thriving in the stream environment.

Native Plants: Each One Teach One (Grades 4-5)

Lesson adapted by Kirsten Moore

Subject

Science

Objectives

1. Students will learn the names and unique characteristics of several native plants.
2. Students will recognize the plants and terrestrial system of a riparian area as a subsystem of the entire riparian system.
3. Students will record characteristics of both invasive and native species that give them survival advantages.
4. Students will teach their peers about one native plant or element of the riparian zone, reinforcing what they have learned.

Materials

1. Student Field Journal
2. Student writing utensil (Colored pencils are fun!)
3. *Riparian Zone Cards* (provided by NSEA)

Size/Setting/Duration

12-15 students/Marietta Slough/~45 minutes

Background

This activity is based on the philosophy that people learn and remember something the best when they teach it. At this station, students will participate in an activity where they will become the teachers, teaching their classmates about one specific native plant or an aspect of the riparian zone (for example, large woody debris).

Scout out the area before you do the lesson and identify your teaching stops. Place *Riparian Zone Cards* on the appropriate plants or near corresponding concepts (large woody debris). Each station should be fairly close to the others so that all students are within sight during the activity.

Activity

1. (0:00-0:05) Tell students that they will be studying native plants and teaching each other about their importance to the riparian zone. Instead of you doing all the teaching, they get to help out by becoming teachers for their classmates. They'll each study one native plant, becoming "experts" on its cultural and environmental significance. Start by refreshing the concept of a riparian zone for the students, asking them what makes a healthy one. Clarify the concept that even though we've been focusing on the stream with the water quality testing and macroinvertebrate collection, the riparian zone includes the surrounding terrestrial environment as well. Pose the question: "How do trees help keep the stream's water clean, cold, and clear?" They should come up with: roots stabilize the banks; leaves feed bugs, bugs feed fish; large woody debris provides places for fish to hide; and shade.
2. (0:05-0:10) Set boundaries for the students and tell them they will be searching for bright orange and green cards. There should be one card per student. Instruct the students to stay by their card once they find one, study the information listed on the card, and to fill out their *Each One Teach One* worksheets in the Student Journal. Before releasing students to find the cards, provide an example of a mini lesson that each student should prepare for his or her plant.
3. (0:10-0:15) Once the students have found a card allow five minutes to fill out their *Each One Teach One* worksheets in the Student Journal. Make sure they understand that they'll be teaching what they learn, so they should put answers into their own words and be ready to share by showing and

telling! As the students study their plant/element and fill out their journal, go around and offer your excitement and knowledge about each one.

4. (0:15-0:45) Gather students together once they've completed their worksheets. Begin walking the trail, pausing at each plant with a card to have the corresponding student teach about it. Students should share 2-3 interesting facts about that plant or element in their lesson. Encourage student teachers to show the plant while they share (if they are talking about how soft the leaves are - invite the other students to feel the leaves). Students learning should take notes on and sketch each plant as the go (space provided on back of worksheet).

Component	Grade Level Expectation	Evidence of Learning
EALR 1: Systems (SYS) ***Complex Systems*** **A.** *Systems* contain *subsystems*.	Learn that systems contain smaller (sub-) systems, and that systems are also parts of larger systems. The same ideas about systems and their parts learned in earlier grades apply to systems and subsystems. In addition, students learn about inputs and outputs and how to predict what may happen to a system if the system's inputs are changed.	-Students will recognize the plants and terrestrial system of a riparian area as a subsystem of the entire riparian system.
EALR 2: Inquiry (INQ) ***Planning investigations*** **B. Investigate—** Scientists plan and conduct different kinds of *investigations*, depending on the *questions* they are trying to answer. Types of *investigations* include systematic *observations* and descriptions, *field studies*, *models*, and *open-ended explorations* as well as *controlled experiments*. **D. Investigate—** *Investigations* involve systematic collection and recording of relevant *observations* and data. **H. Communicate—** Scientists communicate the results of their *investigations* verbally and in writing. They review and ask *questions* about the results of other scientists' work. **I. Intellectual Honesty—** Scientists report the results of their *investigations* honestly, even when those results show their *predictions* were wrong or when they cannot *explain* the results.	Learn to plan an investigation, which involves first selecting the appropriate kind of investigation to match the question being asked.	-Students will "investigate" plants based on their own observations combined with information given on pre-made cards. -Students will describe the organisms and their observations and record these in their field journals. -Students will use the information and knowledge gained through their observations to effectively explain and communicate their findings to their classmates.
EALR 4: Structures and Functions of Living Organisms (LS1) ***Structures and Behaviors*** **A.** Plants and animals can be sorted according to their structures and behaviors. **B.** Plants and animals have different structures and behaviors that serve different *functions*. **C.** Certain structures and behaviors enable plants and animals to respond to changes in their *environment*.	Learn that plants and animals have different structures that work together to respond to various internal and external needs.	-Students will record the structures and behaviors of various riparian plants and how these allow the plants to function and respond to changes in their environment.
EALR 4: Ecosystems	Learn how ecosystems change and how these changes affect the	-Students will note and discuss possible environmental changes

(LS2) ***Food Webs*** **C.** Some changes in *ecosystems* occur slowly and others occur rapidly. Changes can affect life forms, including humans. **D.** *Ecosystems* can change slowly or rapidly. Big changes over a short period of time can have a major impact on the *ecosystem* and the *populations* of plants and animals living there. **F.** People affect *ecosystems* both positively and negatively.	capacity of an ecosystem to support populations. Some changes in ecosystems are caused by the organisms themselves. The ability of any organism to survive will depend on its characteristics and behaviors. Humans also play an important role in many ecosystems and may reduce negative impacts through thoughtful use of natural resources.	that impact riparian areas and what effects these changes might hold on the system. -Students will note and discuss human impacts on the riparian area and what effects these impacts might hold on the system. -Students will differentiate between positive, negative, and neutral effects.
EALR 4: Biological Evolution (LS3) ***Heredity and Adaptation*** **A.** In any ecosystem, some populations of organisms thrive and grow, some decline, and others do not survive at all. **B.** Plants and animals inherit many characteristics from their parents. Some inherited *characteristics* allow *organisms* to better survive and reproduce in a given *ecosystem*. **C.** Sometimes differences in characteristics give individual plants or animals an advantage in surviving and reproducing.	Learn that some differences in inherited characteristics may help plants and animals survive and reproduce. Sexual reproduction results in offspring that are never identical to either of their parents and therefore contributes to a species' ability to adapt to changing conditions. Heredity is a key feature of living plants and animals that enables changes in characteristics to be passed on and for species to change over time.	-Students will identify plants and be able to recognize which species thrive in the riparian area. -Students will learn and then teach their peers about characteristics that allow the plants to survive and reproduce. -In their field journals, students will record characteristics of both invasive and native species that give them survival advantages.

Lesson Plans

Grades 6-8

1. *Water Quality: A Quest in Chemistry*
2. *Macroinvertebrates: Messengers of our Waterways*
3. *Native Plants: Each One Teach One*

Water Quality: A Quest in Chemistry (Grades 6-8)

Lesson Adapted by Kirsten Moore

Subject

Science

Objectives

1. Students will measure different chemical parts of a stream using scientific methods and recognize that the stream system is but a subsystem of the watershed.
2. Students will scientifically record the data.
3. Students will understand how these measurements relate to the heath of their stream system and the surrounding ecosystem.
4. Students will discuss different changes (positive, negative, natural, and anthropogenic) to the riparian system and how they affect their water quality results and the ecosystem as a whole.

Materials

1. Student field journal
2. Student writing utensil
3. Clip-boards
4. Dissolved Oxygen test kit
5. pH test kit/pH test strips
6. Thermometer
7. 3 example turbidity bottles
8. Turbidity chart

Size/Setting/Duration

12-15 students/Marietta Slough/~50 minutes

Background

The water quality station enables students to measure and observe the health of their stream. Students will learn how dissolved oxygen, pH, water temperature, and turbidity affect salmon survival.

Water quality affects salmon's ability to survive in their freshwater habitat. By testing various chemical qualities of the stream, we can determine the stream's health.

When it comes to **temperature**, Salmon survive best in water **5-20°C** (40-68°F). A water temperature higher than 20°C (68°F) or lower than 5°C (40°F) can kill or lower the chances of survival for fish.

Turbidity is a measurement of water clarity and is measured by the amount of sediment present in the water (clear, slightly silty, or muddy/brown). Sediment in the water can damage fish gills and make it hard for fish to see or breathe in their freshwater habitat. Sediment also suffocates salmon eggs.

pH stands for "parts hydrogen" and is a measure of the concentration of hydrogen in a solution on a scale of 1 - 14. Depending on the concentration, the solution will be acidic (lemon juice - pH 2), basic (ammonia - pH 12), or neutral (rainwater - pH 7). Salmon have a limited pH range in which they can live. A neutral pH of **7** is best for salmon; however, salmon will survive in a range from 6.5-8.5.

Dissolved oxygen (DO) is a measure of the amount of oxygen in the water; we measure this because salmon need to breathe oxygen from the water through their gills. Dissolved oxygen is measured in parts per million (ppm). Salmon need a DO concentration of at least 6 ppm in order to survive. However, salmon will tolerate a DO concentration as low as 4 ppm, but this inhibits their chances of survival greatly. The colder the water is, the more oxygen it can hold. This is one reason that salmon love cold water so much!

Activity

The students will rotate through four different stations, collecting water samples and running the aforementioned water quality tests on the samples.

1. (0:00-0:05) Once everyone is at the stream site, wait for the attention of the students. Introduce the stream and have the students

take a moment to observe the stream and the surrounding environment. Explain the course of the stream, verbally illustrating its path through farmland and eventual destination in Bellingham Bay. Have students brainstorm why water quality in this stream and Bellingham Bay matter (shellfish, salmon, riparian environment, stream health, species nesting, etc.). Emphasize the connectedness of the various characteristics of the stream and how all of these characteristics come together to form the entire stream system. Ask students what they think a "stream system" might include based on what they already know about the functioning of systems.

2. (0:05-0:07) Divide students into four groups of 3-4. Assign each group to a high school leader. Each high school leader will be an expert on one type of testing (temperature, turbidity, pH, DO).

3. (0:07-0:45) Rotate groups through the different water quality testing stations, allowing approximately 10 minutes for each rotation.

Temperature: Explain why the temperature of the stream is important to the health of the stream and the health of salmon (see *Background Information*). Have students feel the temperature of the stream with their hand and hypothesize whether the temperature falls within the ideal range. Select a volunteer to take the actual temperature of the water and have students record the measurement in their field journals. Have students discuss what might change the temperature of the water. Warm it up? Cool it down?

Turbidity: Ask students what they think "turbidity" is. After hearing responses clear up any misconceptions and ask why turbidity matters to stream health. Have students hypothesize whether or not the water is turbid at the sample site. Explain how the tool they will be testing turbidity with works. Select a volunteer (a student who has not volunteered at previous testing stations) to collect the water sample and run the test. Have students record their measurement in their field journals. Facilitate discussion based on their findings. What might make a stream more turbid? Less turbid?

pH: Explain the pH scale and how pH is a measure of acidity. A base has a pH < 7 and is the opposite of an acid which has a pH > 7; something that is neutral is not basic or acidic and has a pH of 7. Have students prove their understanding of this concept by having them brainstorm examples of basic substances and acidic substances. Explain to students that water should have a neutral pH but that certain substances such as fertilizers and cleaners can alter this pH. Have students discuss what activities upstream might affect the pH at the testing site (fertilizers and pesticides from farming, runoff from roads and homes, etc.). Select a volunteer (a student who has not volunteered at previous testing stations) to collect the water sample and run the test. As the student is running the test explain how the pH measuring tool works. Have students record their findings in their field journals. Ask why salmon would or would not be happy in this stream based on what they found.

Dissolved Oxygen (DO): Ask students what they need to survive. When oxygen or air comes up, emphasize the importance of this substance for fish too! Even though they live in water, they still need oxygen! We call oxygen that is in water "dissolved oxygen." Ask students to look at the ripples or faster moving parts of the stream and ask how they think oxygen can get into the water. Explain how the DO measuring tool works and select a volunteer (a student who has not volunteered at previous testing stations) to collect the water sample and run the test. Have students record their findings in their field journals. Ask students to use what they now know about DO to describe what kind of stream salmon would like.

4. (0:45-0:50) Brief Assessment: Bring the students back together and review the ideal stream parameters for salmon. Discuss human and natural impacts to the stream and how those might affect these parameters. See EALRS below for key points to include.

EALR Information 6-8 — Water Quality: A Quest in Chemistry

Component	Grade Level Expectation	Evidence of Learning
EALR 1: Systems (SYS) ***Inputs, Outputs, Boundaries, and Flows*** **A.** Any system may be thought o a onta n g subsystems a d a be g subsystem o l rger *system*. **D.** In an open system, matter flows into and out of the *system*. In a closed system, energy may flow into or out of the *system*, but *matter* stays within the *system*. **F.** The *natural* and designed world is complex; it is too large and complicated to *investigate* and comprehend all at once. Scientists and students learn to define small portions for the convenience of *investigation*. The units of *investigation* can be referred to as *"systems."*	Learn how to use systems thinking to simplify and analyze complex situations. Systems concepts that students learn to apply at this level include choosing system boundaries, determining if a system is open or closed, measuring the flow of matter and energy through a system, and applying systems thinking to a complex societal issue that involves science and technology.	-Students will measure different chemical parts of a stream and recognize that the stream system is but a subsystem of the watershed. -Students will connect activities upstream to water quality at the test site; likening this relation to inputs and outputs and recognizing the sample site as an open system. -Students will recognize that their water quality investigation only tells part of the stream system's story.
EALR 2: Inquiry (INQ) ***Questioning and Investigating*** **A. Question—** Scientific inquiry involves asking and answering *questions* and comparing the answer with what scientists already know about the world. **C. Investigate—** Collecting, analyzing, and displaying data are essential aspects of all *investigations*. **F. Explain—** It is important to distinguish between the results of a particular *investigation* and general conclusions drawn from these results. **H. Intellectual Honesty—** Science advances through openness to new *ideas*, honesty, and legitimate skepticism. Asking thoughtful *questions*, querying other scientists' explanations, and evaluating one's own thinking in response to the *ideas* of others are abilities of scientific inquiry.	Learn to revise questions so they can be answered scientifically and then to design an appropriate investigation to answer the question and carry out the study. Students learn to think critically and logically to make connections between prior science knowledge and evidence produced from their investigations. Students can work well in collaborative teams and communicate the procedures and results of their investigations, and are expected to critique their own findings as well as the findings of others.	-Students will question whether or not the stream is a healthy habitat for salmon. After investigating water quality they will answer their question based on what scientists already know about the salmon's tolerances. -Students will collect data and analyze and display their findings in their field journals. -Students will recognize that their findings are but one investigation and that the conclusions they draw from these results are general. -Students will discuss their results and be encouraged to question their findings and consider what variables might have played a part in determining their findings.
EALR 4: Ecosystems (LS2) ***Flow of Energy through Ecosystems*** **D.** *Ecosystems* are continuously changing. Causes of these changes include nonliving *factors* such as the amount of light, range of temperatures, and availability of water, as well as living *factors* such as the disappearance of different	Learn to apply key concepts about ecosystems to understand the interactions among organisms and the nonliving environment. Essential concepts include the process of photosynthesis used by plants to transform the energy of sunlight into food energy, which is used by other organisms, and possible causes of environmental change. Students also learn to investigate environmental issues and to use science to evaluate	-Students will discuss different changes (positive, negative, natural, and anthropogenic) to the riparian system and how they affect their water quality results and the ecosystem as a whole. -In the concluding discussion, students will connect their findings to current environmental issues and explore ways in which people might be able to address the issues.

species through disease, *predation, habitat* destruction and overuse of resources or the introduction of new *species*. **E.** *Investigations* of *environmental* issues should uncover *factors* causing the problem and relevant scientific *concepts* and findings that may inform an *analysis* of different ways to address the issue.	different solutions to problems.	

Macroinvertebrates: Messengers of the Waterways (Grades 6-8)

Lesson adapted by Kirsten Moore

Subject

Science

Objectives

1. Students will observe the stream system's macroinvertebrate subsystem and learn how different macroinvertebrates have different roles within the larger stream system.
2. Students will learn how to use macroinvertebrate ratings to determine the health of their stream.
3. Students will discuss how certain macroinvertebrates have adapted to more polluted conditions than others, and why this difference in tolerances is important for scientists to use as a "tool" to study stream health.
4. Students will interpret how the biotic and abiotic components affect diversity and water quality.

Materials

1. Student field journal
2. Student writing utensil
3. White trays
4. Hand lenses, magnifying classes
5. Thermometer in a jar of freshly collected stream water
6. Catchment nets
7. Macroinvertebrate dichotomous key (laminated)
8. Additional bug/insect/macroinvertebrate identification books

Size/Setting/Duration

12-15 students/Marietta Slough/~50 minutes

Background

Macroinvertebrates are animals that are large enough to see with the unaided eye and have no backbone. These animals include: insects, worms, snails, crayfish, leeches, clams, mussels, etc. These aquatic insects live in the stream at different stages of their lives (larvae or nymph and adult). Macroinvertebrates can tell us a lot about the stream's water quality without ever having to do pH, DO, or water temperature tests. The species of macroinvertebrates present in a stream can also be used to indicate the quality of the water.

Some macroinvertebrates cannot survive in polluted water while others can survive or even thrive in polluted water. In other words, macroinvertebrates vary in their tolerance for pollutants, nutrient conditions, and range of temperature and dissolved oxygen. Macroinvertebrates are good indicators because: they are sensitive to physical changes in their habitat, they do not travel long distances in their lifetime like some fish can, they cannot easily escape changes in the water quality, and they are easy to collect in the stream.

Most aquatic macroinvertebrates make their home in rocks, leaves and the sediment of streambeds. These organisms have many special adaptations, allowing them to live in demanding environments. Macroinvertebrates that live in riffles and fast-moving water may have features that help them hold on to rocky or hard substrates, such as hooked feet, suction cups, and flat bodies. Macroinvertebrates that live in muddy substrates may have adaptations for a low oxygen environment.

While it is best to allow students to use their own knowledge and observations to draw their own conclusions as to where macroinvertebrates might be found, some background information can be shared to point students in the right direction. Students may then go out in the creek to test their hypotheses based on this background knowledge. Shave the following points with the students. (1) The area of the stream from which you are collecting should have at least a moderate rate of flow; if it is stagnant, limited oxygen may reduce macroinvertebrates' chances for survival. (2) Since macroinvertebrates need oxygen, look for them in places in the stream where oxygen is most likely present (i.e. riffles). (3) Vegetated banks and rocks provide safe shelter. (4) Rocky stream bottoms allow for air pockets and safe places for macroinvertebrates to live. (5) Look where there is food! MAcroinvertebrates can be found in areas that have vegetation along stream banks, because leaves drop in the water providing food when they decompose. Also look in quiet eddy waters where detritus and other organic material accumulate.

The presence of macroinvertebrates in the stream is not only important as an indicator of the stream's health, but is necessary for salmon to be able to thrive. These tiny insects are a prime food choice for fry (baby salmon that have just hatched) and provide the salmon with a source of nutrition and energy for their trip back out to the ocean.

Activity

1. (00:00-00:04) After the students have gathered around the macroinvertebrate collection station, transition from water quality testing (previous station) to macroinvertebrates. Explain that there are multiple ways to determine a stream's health: we can measure physical and chemical components of the water (as we did in water quality testing) or we can observe what kind of life exists in the stream system.

2. (00:004-00:10) Have the students complete the stream observation questions in their field journals. Questions are as follows:
   - Look at the stream banks. Do you observe lots of plant life or little plant life?
   - How many different plants can you count around the stream?
   - Look up. Is there canopy cover from trees?
   - Is the water clear, brown, or green?
   - Collect water in a clear jar. Are there free flowing sediments (dirt and plant matter) in the water?
   - Are there logs, branches or boulders in the stream? How many?
   - Feel the temperature of the water. Is it warm or cold?
   - Check the temperature of the water with a thermometer and record it.
   - Do believe this stream is healthy? Explain your reason for this answer.

3. (00:10-00:15) Gather the students' attention, by asking whether the stream is healthy or not. Students should reference prior activity in measuring water quality. After taking a poll, tell the students they will have the chance to confirm their answer by see what some bugs have to show us. Explain that one way to observe the health of a stream is to actually look at what, or *'who'* is living in the stream. Whether you like bugs or not, the more kinds of insects we find living in a stream, the healthier it is!

4. (00:15-00:20) These insects are called, "Macroinvertebrates!" Pass the dichotomous keys around to the students, explaining how to use them. *Macro-Dance:* To introduce the different types of macroinvertebrates, teach students the macro-dance. Explain the different macro dance moves. Macroinvertebrates have no backbones, so dance as if you didn't have a spine! The next four dance moves are the types of macroinvertebrates. Macroinvertebrates obtain their energy by eating, just like we do. Macroinvertebrates are divided into categories, based on *how* they eat: the shredder shreds its food, so to represent the shredder, move like a robot with karate chopping arms; the strainer strains its food out of the water, so to dance like a strainer, make disco eye movements, but over the mouth; the scraper scrapes its food off of rocks and vegetation, to represent this, claw the air in front of you; and the predator stalks and hunts its prey, to be like a predator, make a big clap like clapping jaws! Have students practice their favorite dance moves, saying the type they are mimicking.

5. (00:20-00:40) *Looking at Macro-invertebrates! White trays, nets, hand lenses/magnifying glasses, and the dichotomous keys will be used in this portion of the lesson.* Before handing out the equipment, remind the

students that we want to respect the environment and the insects we are temporarily removing from their homes. Proceed by demonstrating how to take a macroinvertebrate collection. This introduction to sampling is vital and will help reinforce the proper procedures for performing these tasks in their groups. Lower the net into the water, and carefully clean the rocks in front of the net so the macroinvertebrates flow with the stream into the net. Tell the students to pick a 2 foot area to sample from to prevent disturbing the entire stream. Once the samples have been collected in the net, fill the white tray with a layer of water, and empty collected debris and macroinvertebrates in the tray. Stress that the insects need water to live. Move trays to a flat spot so debris can settle.

Before releasing the students to their own work, identify hazards around the creek (steep embankments, slippery rocks, fast moving cold water), and remind students they must stay in control while working (refrain from throwing rocks/debris in the creek, walk carefully around the stream and the other groups, and stay within pre-determined boundaries).

Divide the students into 4 groups and distribute a net, a white tray, magnifying glasses and a key to each group; supervise student groups in sampling practices.

When a group finds a macroinvertebrate have them do their best to identify it. Remind students of the characteristics to look for while identifying macroinvertebrates (referencing the Stream Macroinvertebrate Identification Charts). Have students circle the insects they found in the journals.

Instructors can facilitate inquiry-based learning while the students are collecting, analyzing and recording their findings in their field journals. Through questioning and instruction, help students correct any misconceptions.

6. (00:40-00:45) Brief Assessment: ask one member of each group to give the identifying characteristics of the macroinvertebrates they found.

Conclusion: summarize the group findings, main understandings, and designate the remaining time to stewardship orientated questions that will encourage students to think broadly about what they learned and to apply locally in their community. Especially emphasize how activities upstream might affect the downstream system the students have been observing. Have the students plot their location on a map of the watershed to provide a visual and generate discussion on land use within the watershed. Spend some amount of time discussing how science and our growing knowledge of water quality and stream health have helped to develop conversation between those whose activities impact the system upstream and those who live and use the stream. *See EALRS listed below for key points to emphasize.*

7. (0:45-0:50) Carefully release macroinvertebrates ~10 feet upstream from the sample site. Lower the tray into the flow of water before emptying. All materials should be clean of organic matter and water. If students are releasing the, ensure they respect the organisms.

EALR Information 6-8 Macroinvertebrates: Messengers of our Waterways

Component	Grade Level Expectation	Evidence of Learning
EALR 1: Systems (SYS) ***Inputs, Outputs, Boundaries, and Flows*** **A.** Any system may be thought of as containing subsystems and as being a *subsystem* of a larger *system*. **D.** In an open system, matter flows into and out of the *system*. In a closed system, energy may flow into or out of the *system*, but *matter* stays within the *system*. **F.** The *natural* and designed world is complex; it is too large and complicated to *investigate* and comprehend all at once. Scientists and students learn to define small portions for the convenience of *investigation*. The units of *investigation* can be referred to as *"systems."*	Learn how to use systems thinking to simplify and analyze complex situations. Systems concepts that students learn to apply at this level include choosing system boundaries, determining if a system is open or closed, measuring the flow of matter and energy through a system, and applying systems thinking to a complex societal issue that involves science and technology.	-Students will observe the stream system's macroinvertebrate subsystem and learn how different macroinvertebrates have different roles within the larger stream system. -Students will be able to classify the collection site as an open system. -Students will recognize that their macroinvertebrate investigation only tells part of the stream system's story.
EALR 2: Inquiry (INQ) ***Questioning and Investigating*** **A. Question—** Scientific inquiry involves asking and answering *questions* and comparing the answer with what scientists already know about the world. **C. Investigate—** Collecting, analyzing, and displaying data are essential aspects of all *investigations*. **F. Explain—** It is important to distinguish between the results of a particular *investigation* and general conclusions drawn from these results. **H. Intellectual Honesty—** Science advances through openness to new *ideas*, honesty, and legitimate skepticism. Asking thoughtful *questions*, querying other scientists' explanations, and evaluating one's own thinking in response to the *ideas* of others are abilities of scientific *inquiry*. **I. *Consider* Ethics—** Scientists and engineers have ethical codes governing animal *experiments*, research in natural ecosystems, and studies that involve human subjects.	Learn to revise questions so they can be answered scientifically and then to design an appropriate investigation to answer the question and carry out the study. Students learn to think critically and logically to make connections between prior science knowledge and evidence produced from their investigations. Students can work well in collaborative teams and communicate the procedures and results of their investigations, and are expected to critique their own findings as well as the findings of others.	-Students will question whether or not the stream is a healthy habitat for salmon. After investigating macroinvertebrate populations they will answer their question based on what scientists already know about tolerances of specific macroinvertebrate species. -Students will collect data and analyze and display their findings in their field journals. -Students will recognize that their findings are but one investigation and that the conclusions they draw from these results are general. -Students will discuss their results and be encouraged to question their findings and consider what variables might have played a part in determining their findings. -Students will consider ethics involved in removing organisms from their natural systems.
EALR 4: Ecosystems (LS2) ***Flow of Energy through Ecosystems*** **A.** An *ecosystem* consists of all the populations living within a specific area and the nonliving factors they interact with. One geographical area may contain many ecosystems.	Learn to apply key concepts about ecosystems to understand the interactions among organisms and the nonliving environment. Essential concepts include the process of photosynthesis used by plants to transform the energy of sunlight into food energy, which is used by other organisms, and possible causes of environmental	-Students will understand that the presence of macroinvertebrates depends on other living organisms and the nonliving physical environment. -Students will discuss different changes (positive, negative, natural, and anthropogenic) to the riparian system and how they affect the ecosystem as a whole. -In the concluding discussion, students

D. *Ecosystems* are continuously changing. Causes of these changes include nonliving *factors* such as the amount of light, range of temperatures, and availability of water, as well as living *factors* such as the disappearance of different *species* through disease, *predation*, *habitat* destruction and overuse of resources or the introduction of new *species*. **E.** *Investigations* of *environmental* issues should uncover *factors* causing the problem and relevant scientific *concepts* and findings that may inform an *analysis* of different ways to address the issue.	change. Students also learn to investigate environmental issues and to use science to evaluate different solutions to problems.	will connect their findings to current environmental issues and explore ways in which people might be able to address the issues.
EALR 4: Biological Evolution (LS3) ***Inheritance Variation and Adaptation*** **E.** *Adaptations* are physical or behavioral changes that are inherited and enhance the ability of an *organism* to survive and reproduce in a particular *environment*.	Learn how the traits of organisms are passed on through the transfer of genetic information during reproduction and how inherited variations can become adaptations to a changing environment. Sexual reproduction produces variations because genes are inherited from two parents. Variations can be either physical or behavioral, and some have adaptive value in a changing environment.	-Students will be introduced to the idea of macroinvertebrates as an indicator species. Indicator species have special characteristics that either allow them to thrive or die in given environmental conditions. These characteristics are inherited. -Students will be able to relate stream health to the macroinvertebrate populations they find thriving in the stream environment.

Native Plants: Each One Teach One (Grades 6-8)

Lesson adapted by Kirsten Moore

Subject

Science

Objectives

1. Students will identify plants and be able to recognize which species have adaptations that allow them to thrive in the riparian environment.
2. Students will recognize the plants and terrestrial system of a riparian area as a subsystem of the entire riparian system.
3. Students will teach their peers about one native plant or element of the riparian zone, reinforcing what they have learned.
4. Students will differentiate between positive, negative, and neutral effects and how we might be able to address environmental issues that affect the riparian area vegetation and habitat.

Materials

1. Student Field Journal
2. Student writing utensil (Colored pencils are fun!)
3. *Riparian Zone Cards* (provided by NSEA)

Size/Setting/Duration

12-15 students/Marietta Slough/~45 minutes

Background

This activity is based on the philosophy that people learn and remember something the best when they teach it. At this station, students will participate in an activity where they will become the teachers, teaching their classmates about one specific native plant or an aspect of the iparian zone (for example, large woody debris).

Scout out the area before you do the lesson and identify your teaching stops. Place *Riparian Zone Cards* on the appropriate plants or near corresponding concepts (large woody debris). Each station should be fairly close to the others so that all students are within sight during the activity.

Activity

1. (0:00-0:05) Tell students that they will be studying native plants and teaching each other about their importance to the riparian zone. Instead of you doing all the teaching, they get to help out by becoming teachers for their classmates. They'll each study one native plant, becoming "experts" on its cultural and environmental significance. Start by refreshing the concept of a riparian zone for the students, asking them what makes a healthy one. Clarify the concept that even though we've been focusing on the stream with the water quality testing and macroinvertebrate collection, the riparian zone includes the surrounding terrestrial environment as well. Pose the question: "How do trees help keep the stream's water clean, cold, and clear?" They should come up with: roots stabilize the banks; leaves feed bugs, bugs feed fish; large woody debris provides places for fish to hide; and shade.
2. (0:05-0:10) Set boundaries for the students and tell them they will be searching for bright orange and green cards. There should be one card per student. Instruct the students to stay by their card once they find one, study the information listed on the card, and to fill out their *Each One Teach One* worksheets in the Student Journal. Before releasing students to find the cards, provide an example of a mini lesson that each student should prepare for his or her plant.
3. (0:10-0:15) Once the students have found a card allow five minutes to fill out their *Each One Teach One* worksheets in the Student Journal. Make

sure they understand that they'll be teaching what they learn, so they should put answers into their own words and be ready to share by showing and telling! As the students study their plant/element and fill out their journal, go around and offer your excitement and knowledge about each one.

4. (0:15-0:45) Gather students together once they've completed their worksheets. Begin walking the trail, pausing at each plant with a card to have the corresponding student teach about it. Students should share 2-3 interesting facts about that plant or element in their lesson. Encourage student teachers to show the plant while they share (if they are talking about how soft the leaves are - invite the other students to feel the leaves). Students learning should take notes on and sketch each plant as the go (space provided on back of worksheet).

Component	Grade Level Expectation	Evidence of Learning
EALR 1: Systems (SYS) ***Inputs, Outputs, Boundaries, and Flows*** **A.** Any system may be thought of as containing *subsystems* and as being a *subsystem* of a larger *system*. **D.** In an open system, matter flows into and out of the *system*. In a closed system, energy may flow into or out of the *system*, but *matter* stays within the *system*. **F.** The *natural* and designed world is complex; it is too large and complicated to *investigate* and comprehend all at once. Scientists and students learn to define small portions for the convenience of *investigation*. The units of *investigation* can be referred to as *"systems."*	Learn how to use systems thinking to simplify and analyze complex situations. Systems concepts that students learn to apply at this level include choosing system boundaries, determining if a system is open or closed, measuring the flow of matter and energy through a system, and applying systems thinking to a complex societal issue that involves science and technology.	-Students will recognize the plants and terrestrial system of a riparian area as a subsystem of the entire riparian system. -Students will be able to classify the activity site as an open system. -Students will recognize that their investigation of riparian vegetation only tells part of the riparian system's story.
EALR 2: Inquiry (INQ) ***Questioning and Investigating*** **C. Investigate—** Collecting, analyzing, and displaying data are essential aspects of all *investigations*. **I. *Consider* Ethics—** Scientists and engineers have ethical codes governing animal *experiments*, research in natural ecosystems, and studies that involve human subjects.	Learn to revise questions so they can be answered scientifically and then to design an appropriate investigation to answer the question and carry out the study. Students learn to think critically and logically to make connections between prior science knowledge and evidence produced from their investigations. Students can work well in collaborative teams and communicate the procedures and results of their investigations, and are expected to critique their own findings as well as the findings of others.	-Students will collect data and analyze and display their findings in their field journals and then present their findings to their classmates. -Students will consider ethics involved harvesting certain native plants.
EALR 4: Ecosystems (LS2) ***Flow of Energy through Ecosystems*** **D.** *Ecosystems* are continuously changing. Causes of these changes include nonliving *factors* such as the amount of light, range of temperatures, and availability of water, as well as living *factors* such as the disappearance of different species through disease, *predation*, habitat destruction and overuse of resources or the introduction of new *species*. **E.** Investigations of *environmental* issues should uncover *factors* causing the problem and relevant scientific concepts and findings that may inform an *analysis* of different	Learn to apply key concepts about ecosystems to understand the interactions among organisms and the nonliving environment. Essential concepts include the process of photosynthesis used by plants to transform the energy of sunlight into food energy, which is used by other organisms, and possible causes of environmental change. Students also learn to investigate environmental issues and to use science to evaluate different solutions to problems.	-Students will note and discuss possible environmental changes that impact riparian areas and what effects these changes might hold on the system. -Students will note and discuss human impacts on the riparian area and what effects these impacts might hold on the system. -Students will differentiate between positive, negative, and neutral effects and how we might be able to address environmental issues that affect the riparian area vegetation and habitat.

ways to address the issue.		
EALR 4: Biological Evolution (LS3) ***Inheritance Variation and Adaptation*** **E.** *Adaptations* are physical or behavioral changes that are inherited and enhance the ability of an *organism* to survive and reproduce in a particular *environment*.	Learn how the traits of organisms are passed on through the transfer of genetic information during reproduction and how inherited variations can become adaptations to a changing environment. Sexual reproduction produces variations because genes are inherited from two parents. Variations can be either physical or behavioral, and some have adaptive value in a changing environment.	-Students will identify plants and be able to recognize which species have adaptations that allow them to thrive in the riparian environment. -Students will learn and then teach their peers about characteristics that allow the plants to survive and reproduce. -In their field journals, students will record characteristics of both invasive and native species that give them survival advantages.

Student Field Journal

Sample Pages

The ABC's of THE RIPARIAN ECOSYSTEM

Look around you. You are in a riparian zone! The riparian zone is the area that surrounds a stream. It is made up of various living (biotic) and nonliving (abiotic) components that come together to form important habitat for salmon and other species. A riparian zone is a sensitive area and can easily be impacted by human activity. Look around you and study the map of the watershed. Using the columns below, list what you observe under the appropriate category.

A = ABIOTIC

* This means the nonliving parts of the ecosystem, including:

____
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B = BIOTIC

* This means the living parts of the ecosystem, including:

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C = CULTURAL

* This means ways humans use the stream and the land surrounding the stream, including:

____
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____
____
____

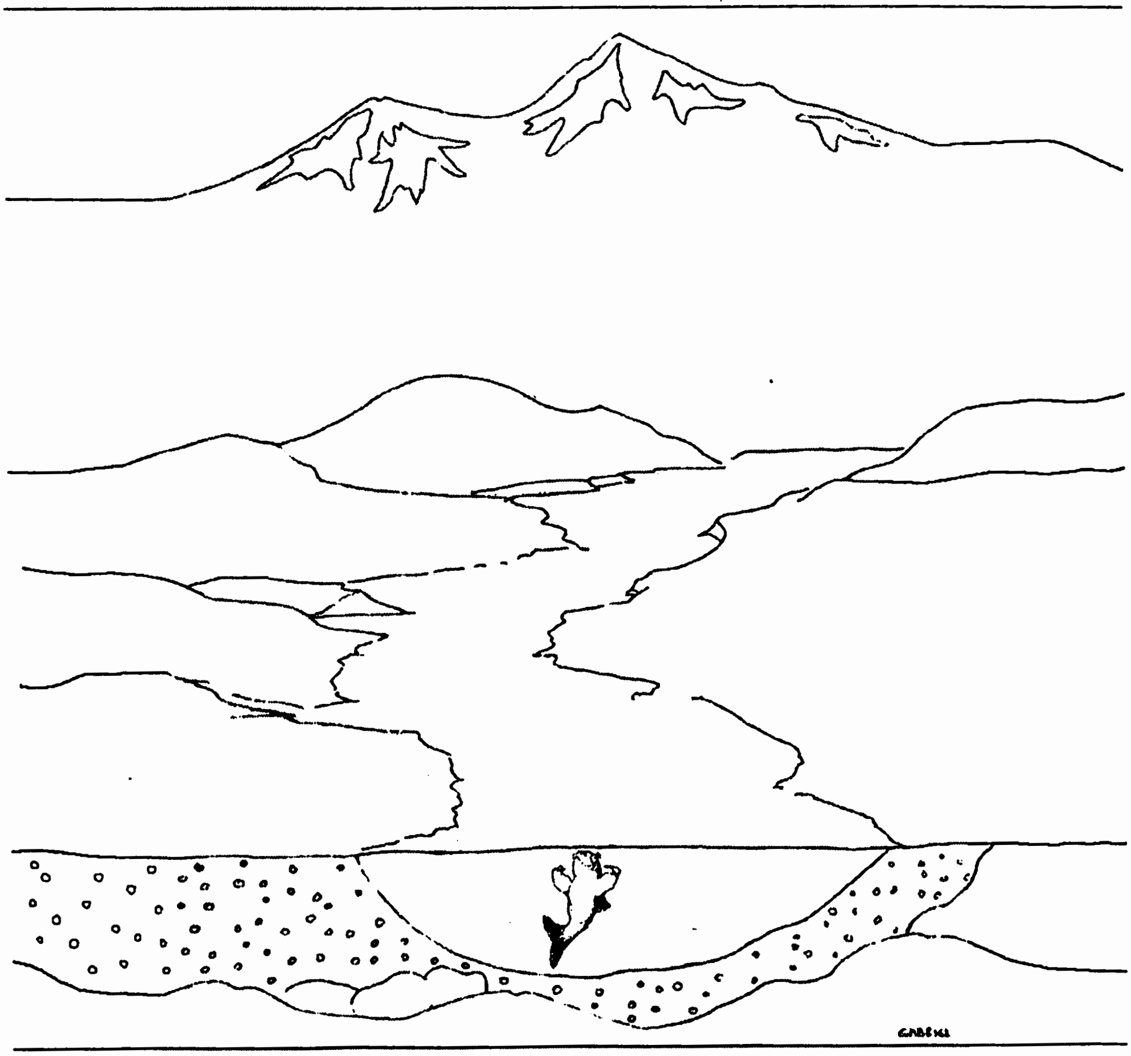
___+___+___ = The Riparian Ecosystem

Stream Habitat Sketch

Name of Scientist:	Name of Location:	Date:	Time:

WHAT DO YOU SEE....	
• Large woody debris? • Gravel, silt or sand on the bottom of the stream? • Garbage? • Plants? • Signs of humans?	• Signs of Animals? • Roads? • Buildings? • Animals? • Cars? • Anything else?

The stream below represents your stream – use your OBSERVATION skills to take draw what you see in and around your stream.



What a Map Tells Us

Watersheds of Whatcom County.

1 First, find and color in the watershed that your school is in.

2 What is the biggest lake on the map? ______________________

3 What are two glaciers in the Nooksack River Watershed? __________

____

4 Name three large towns that are on the watershed map. __________

____

5 What are the two major highways that run through our watersheds?

____

6 Name three streams that flow into Bellingham Bay. ______________

____

7 Which stream flows into Canada from Washington? ______________

8 Which streams flow into Washington from Canada? ______________

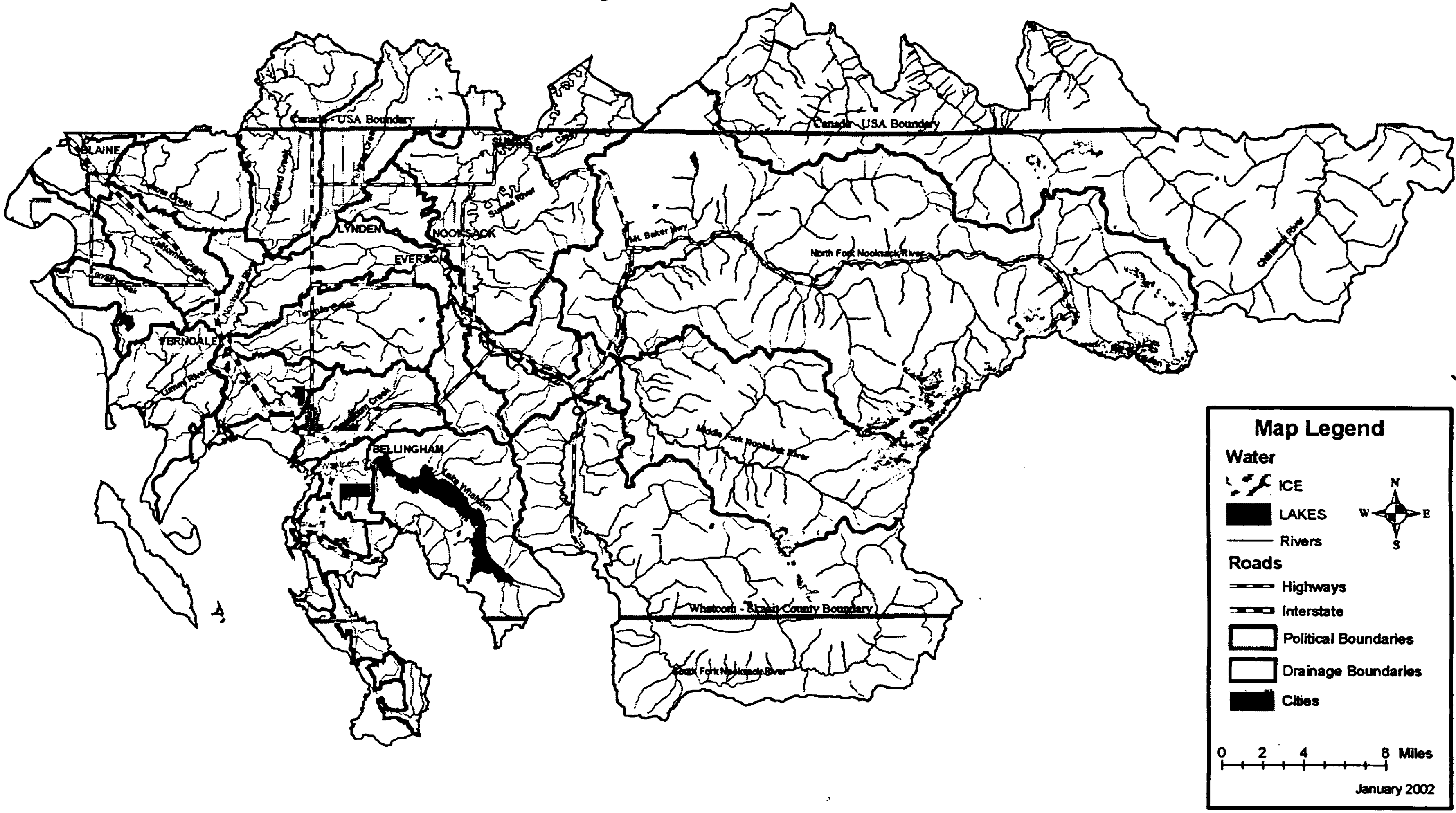
____

9 How many forks does the Nooksack River have? ________________

10 Name the body of water into which the Nooksack River flows.

____

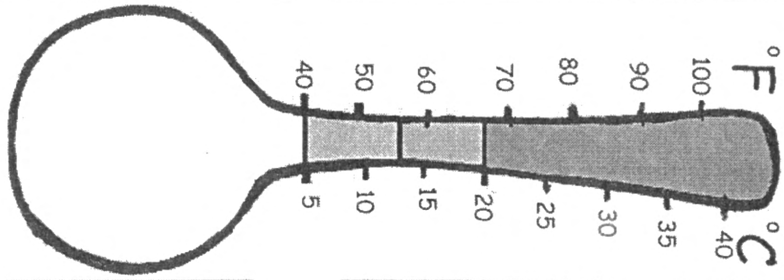
Watersheds of Whatcom County



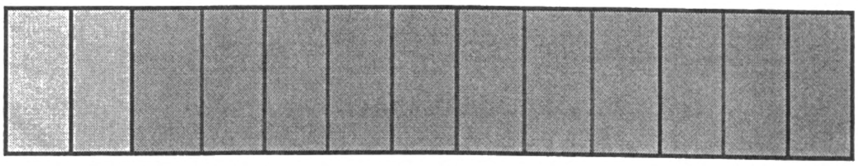
Water Quality Assessment

Weather, Land Use, and Stream Observations:
Hypothesis: (Based on your observations do you think the stream's water quality will be excellent, medium, or poor?)

	EXCELLENT	MEDIUM	POOR



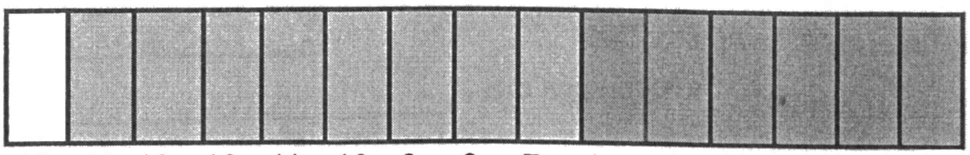
Temperature — Between 5-13° | Between 14-20° | Above 20°



Turbidity

<10 <15 <20 <30 <40 <50 <60 <80 <100 <150 <200 <300 <400

Low to None (<10) | Medium (~15) | High (>25)



Dissolved Oxygen

15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0

Above 9ppm | 7-9 ppm | 6 ppm or Less

Based on your data, do you think the water quality of the stream is...
HINT: Which colors did your results fall under? Each color must be accounted for in your decision.

EXCELLENT or MEDIUM or POOR

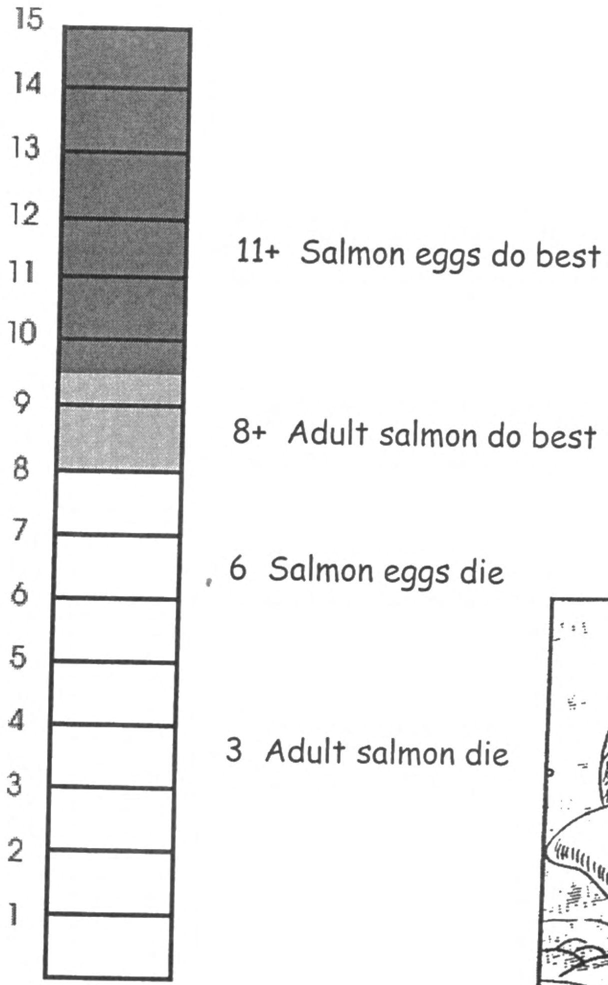
List one thing YOU and your family can do to help improve your watershed's health!

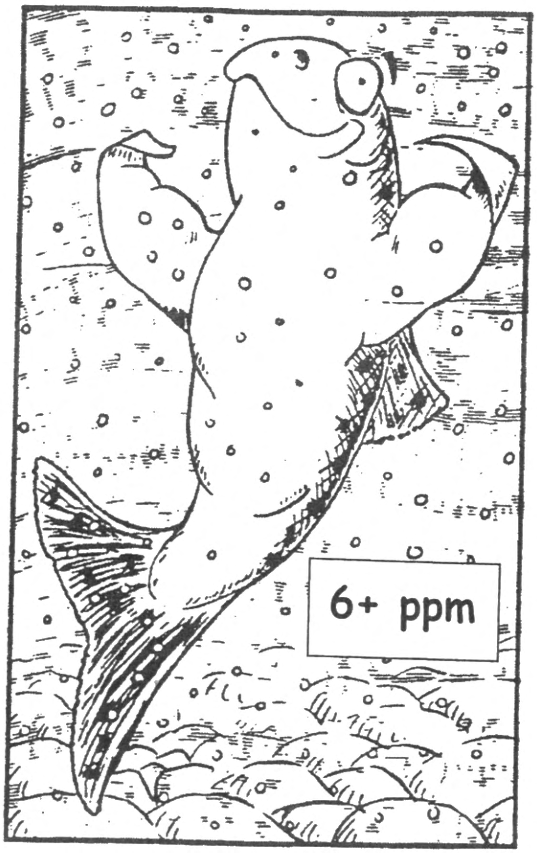
Oxygen Facts

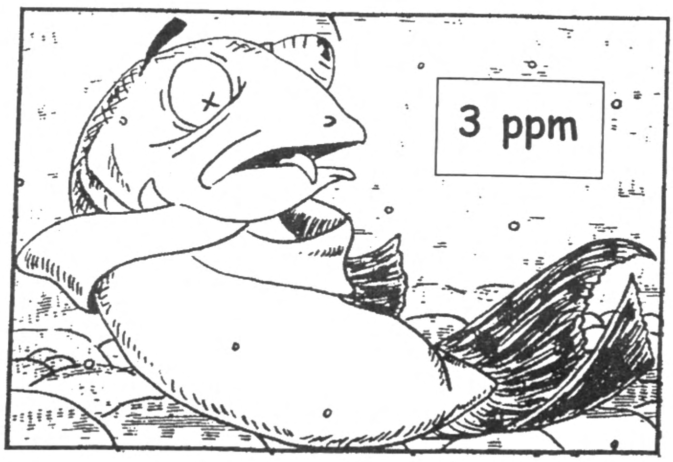
Salmon breath oxygen from the water just like humans breath oxygen from the air. Dissolved oxygen is measured in parts per million (ppm). Salmon need a dissolved oxygen concentration of at least 6 ppm. Salmon can tolerate a concentration as low as 4 ppm, but this is not ideal for survival.

Dissolved Oxygen Scale

Parts per million (ppm) or mg/l

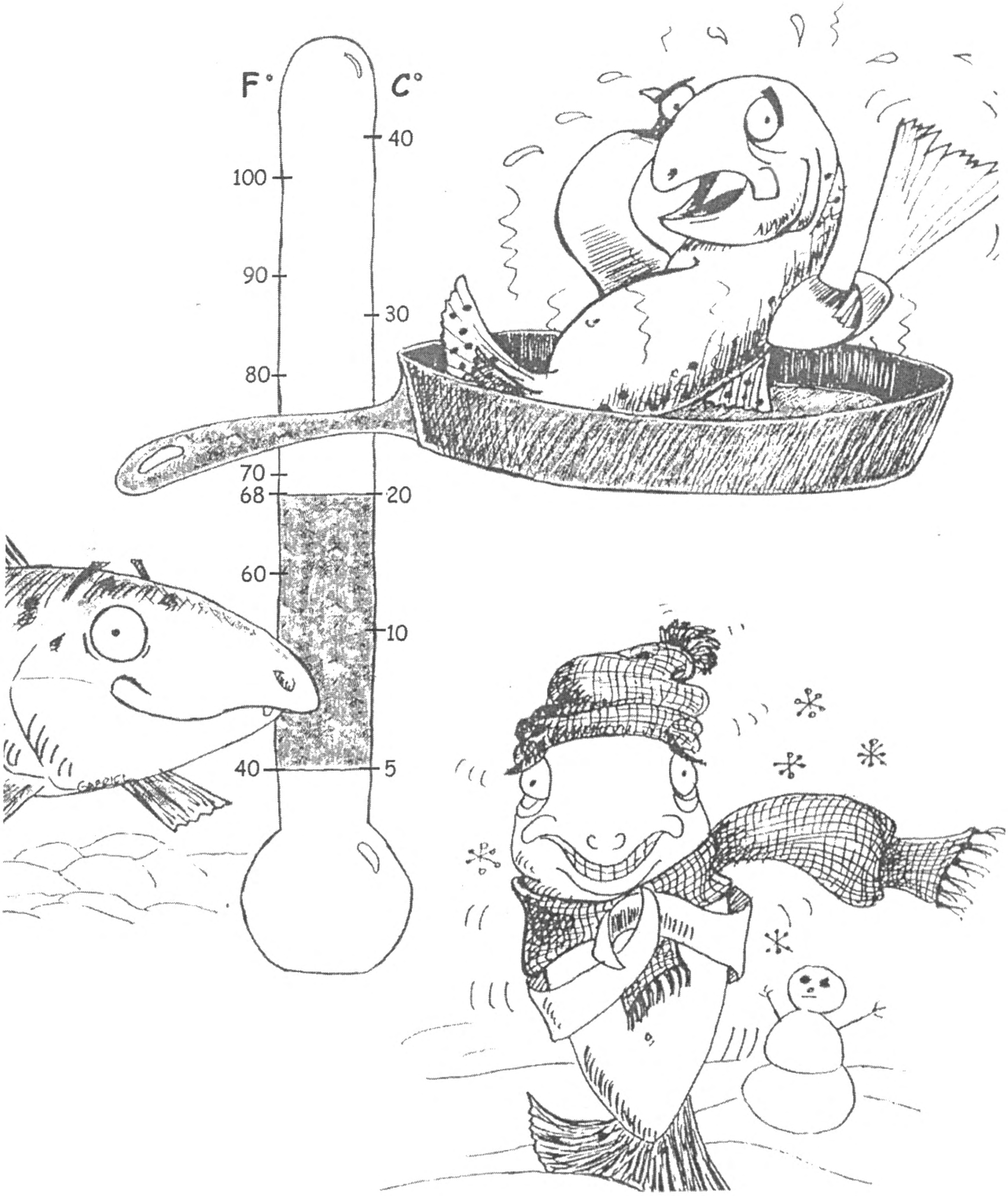






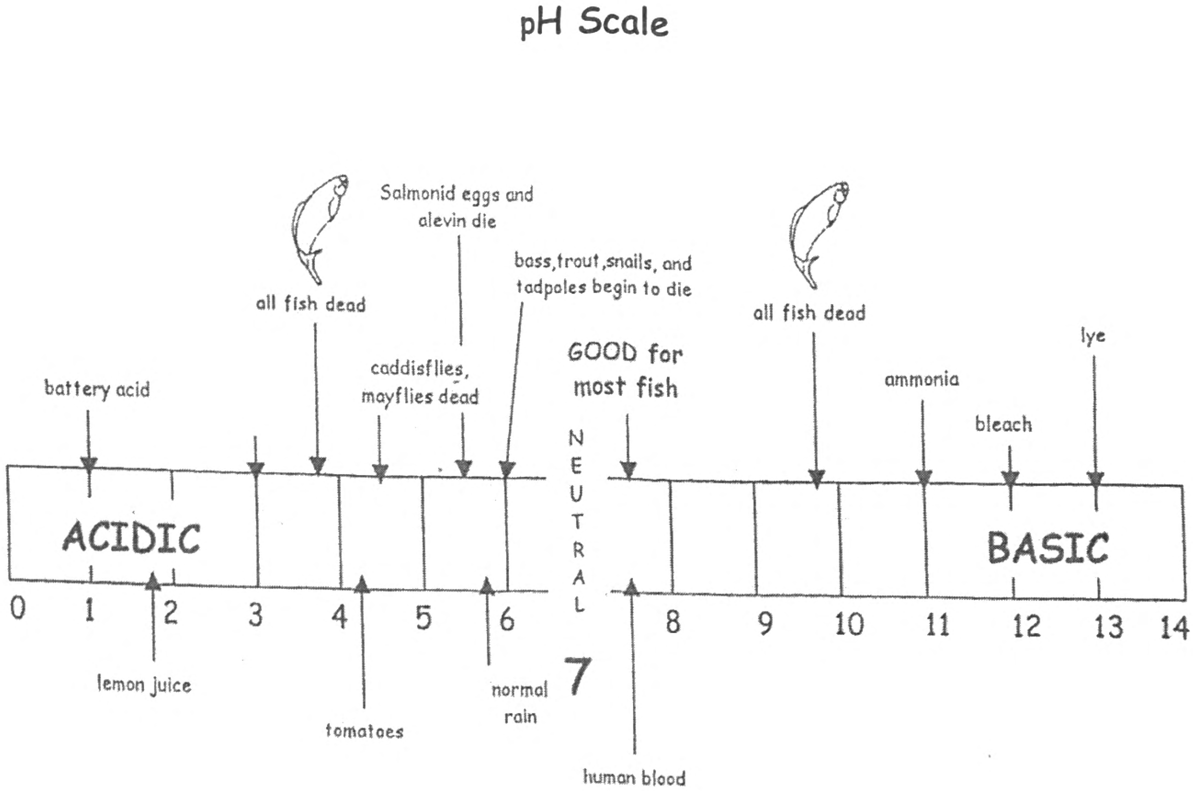
Temperature Facts

Salmon need COLD water because: cold water can hold more oxygen than warm water and salmon bodies are adapted to a range between 5-20°C.



pH Facts

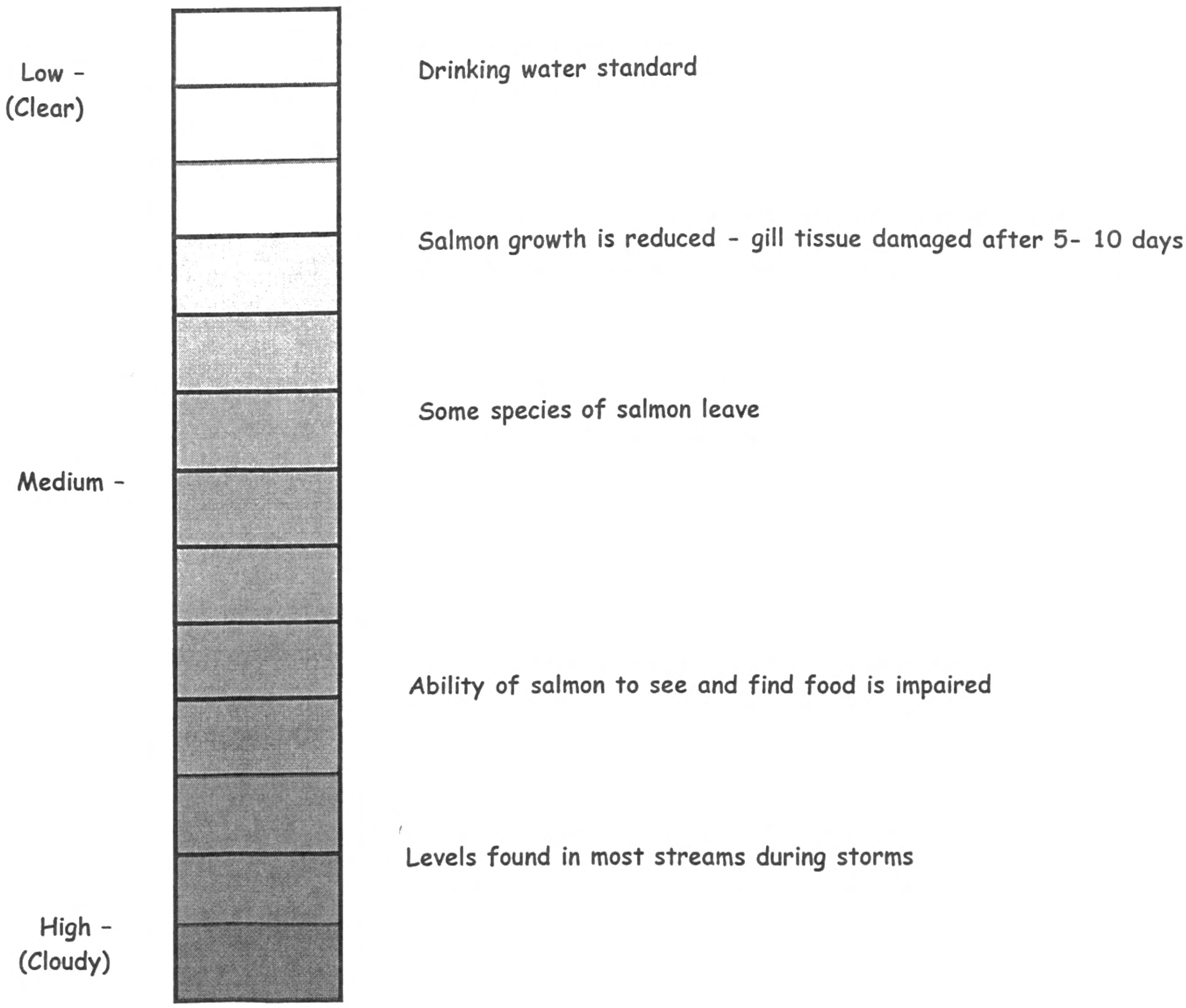
pH is a measure of the chemical makeup of a solution. The pH level tells whether a solution is basic, neutral or acidic. Fish need water to be a neutral pH.



Turbidity Facts

Turbidity is a measure of the amount of sediment suspended in water. Sediment can limit salmon survival during all stages of life.

Turbidity Scale



MACROINVERTEBRATE Mission!

Scientist's Name:______________________________

1) Make a scientific drawing of your macroinvertebrate in the box below, clearly labeling the following characteristics of your bug:

- Legs? Tails? How many?
- What does it look like?
- How does it move?
- Antennae? Gills?

2) Figure out the scientific name of the bug you've drawn using the dichotomous key and label your drawing with the corresponding name.

3) Use the pollution tolerance index chart to determine your insect's level of tolerance to pollution then label your bug with the pollution tolerance group number.

4) The insects that we found indicate that the stream's health is:

POOR	FAIR	GOOD
Found bugs mostly from group 3 or only one group	Found bugs mostly from groups 2 and 3	Found a good diversity of bugs from groups 1, 2, and 3

Mission ACCOMPLISHED!

So what does this mean?

1. How have macroinvertebrates adapted to the stream environment?

2. Why are macroinvertebrates signals of stream health?

3. When is it good to have bugs in your drinking water?

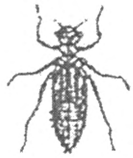
4. Why are there certain types of macroinvertebrates found in a stream?

5. How can humans change what type of macroinvertebrates live in a stream?

6. How come macroinvertebrates all look different?

7. Why are there differences in the way they look? Particularly their body structure?

MACROINVERTEBRATE Mission!



Take a look around you...

1. Look at the stream banks. How much plant life do you see?

2. How many different plants can you count around the stream?

3. Look up. Is there canopy cover from trees?

4. What color is the water?

5. Look at the water in the jar. Are there free flowing sediments (dirt and plant matter) in the water?

6. Are there logs, branches or boulders in the stream? How many?

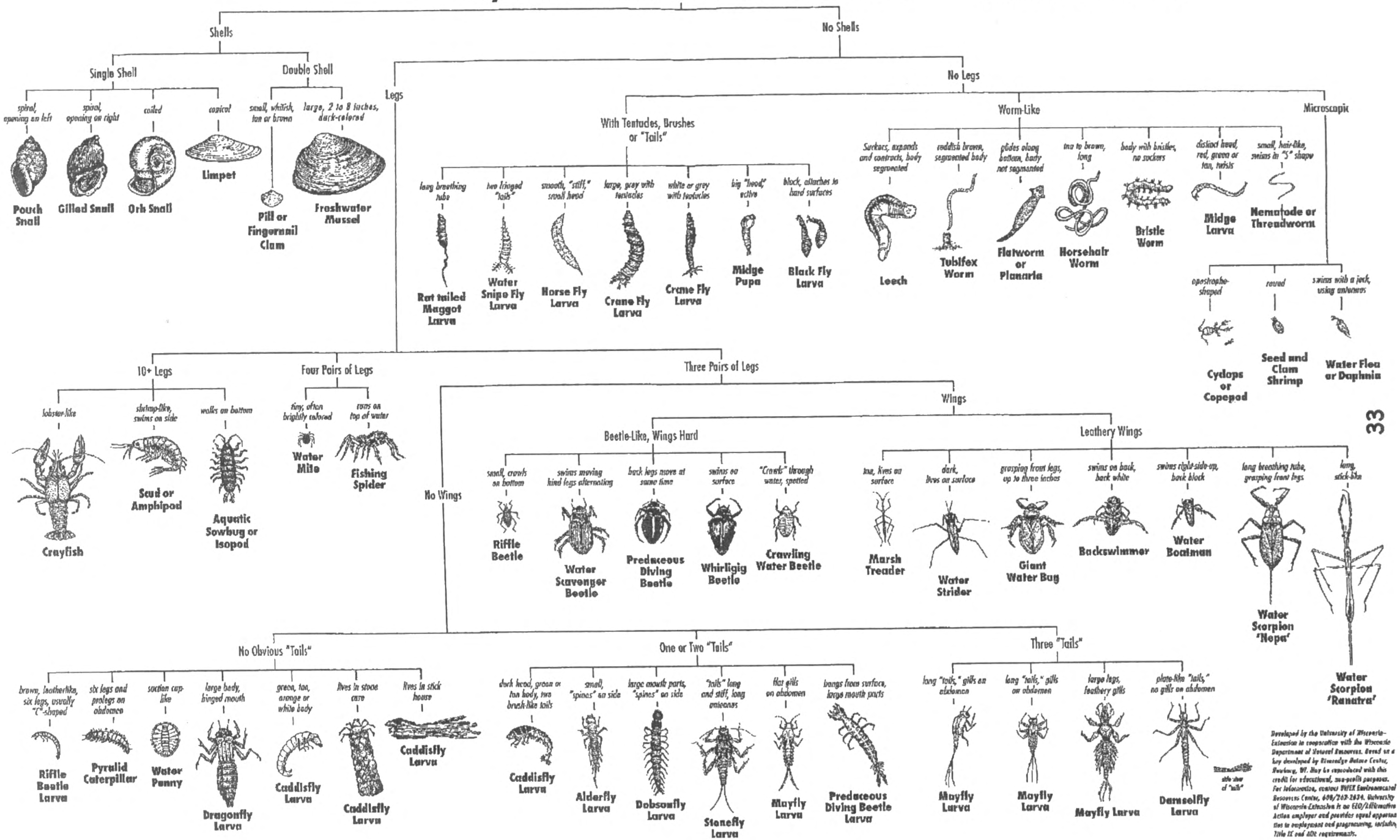
7. Feel the temperature of the water, is it warm or cold?

8. Check the temperature of the water with a thermometer and record it.

9. Do you think this stream is healthy? Why?

Key to Macroinvertebrate Life in the River

(Sizes of illustrations are not proportional.)



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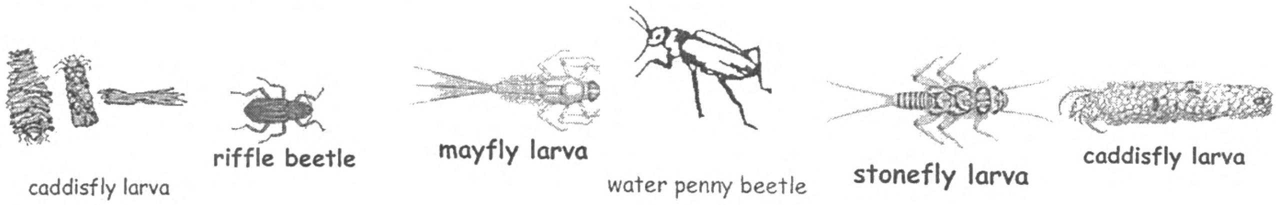
Macroinvertebrate Pollution Tolerance Index

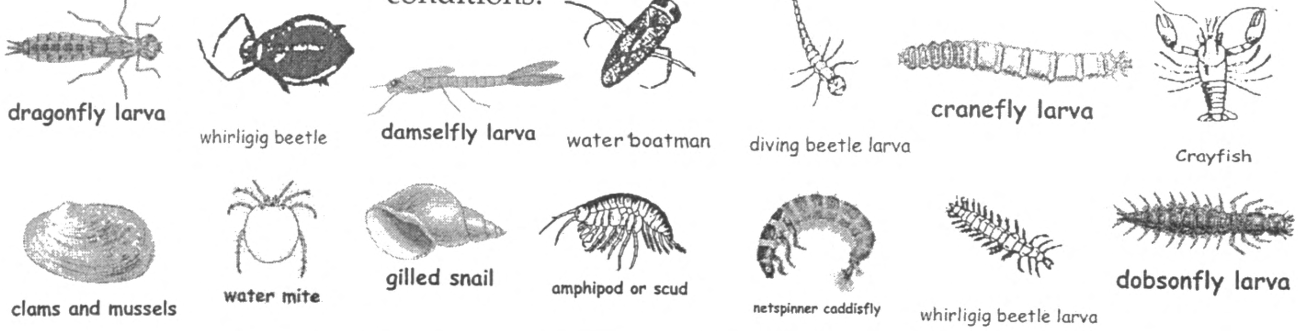
Group 1

These macroinvertebrates cannot live in polluted water! They need clean, clear, cold, oxygenated water to survive.



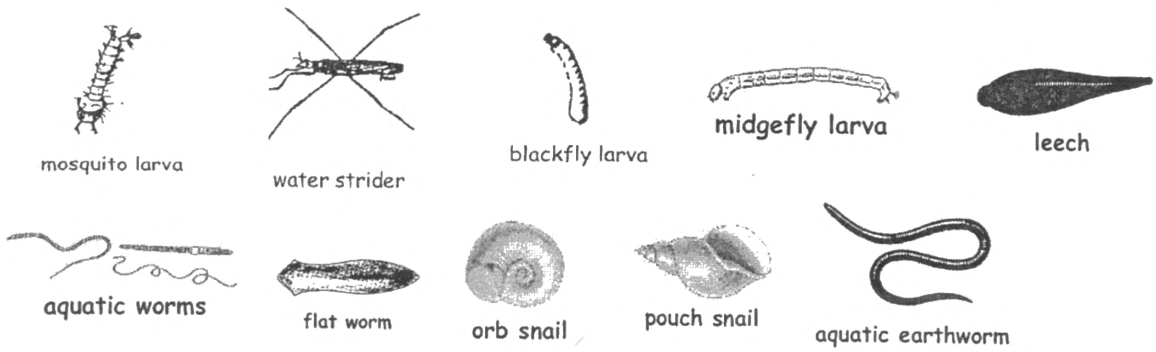
Group 2

These macroinvertebrates can tolerate some pollutants and medium water quality conditions.



Group 3

These macroinvertebrates can tolerate pollutants and low water quality conditions. They like to live in clean water too, but can handle it when the stream's water quality is poor.



Native Plant Each One Teach One

Fill out the boxes, recording your answers in **your own words** and get ready to share!

YOUR NAME: ____________________ PLANT NAME: __________________________

ZOOM in on your plant... make a detailed scientific sketch*: *To make a scientific sketch, label the vegetation (leaves/needles), stem, and any flowers, cones, or berries on your plant.	**SENSE your plant...** List one interesting characteristic you observe*: *Smell, touch, and feel and study your plant.
TELL us about your plant... Choose the fun fact from the orange *Native Plant Fact Card** that benefits salmon in their freshwater habitat and explain how! * Do any of the interesting facts relate to your SENSE observations? If so, show and share...	**DISCOVER the Native American history and uses behind your plant...** located on the orange *Native Plant Fact Card** * Do any of the Native American historical facts relate to your SENSE observations? If so, show and share...

Take notes on the plants you learn about from your classmates in the boxes below. Sketch their plant and/or write two interesting facts about it!

PLANT NAME:	PLANT NAME:	PLANT NAME:
PLANT NAME:	PLANT NAME:	PLANT NAME:
PLANT NAME:	PLANT NAME:	PLANT NAME:

Glossary

To be included in Student Field Journals

Students for Salmon

Glossary

Acid	substance with a pH value less than 7.0; acidic substances have high concentrations of hydrogen ions (H+)
Adaptation	an evolutionary process where a species becomes better suited for its habitat
Alevin	newly hatched fish with yolk sac attached; also called a sac-fry
Anadromous	fish that migrate from saltwater to freshwater for spawning
Base (Alkaline)	substance with a pH value greater than 7.0; basic substances have high concentrations of hydroxyl ions (OH+)
Biological integrity	what the stream should look like if it was in if it was not disturbed by humans
Condensation	conversion of water from gas form to liquid form
Crustacean	small animals such as shrimp, crabs, and barnacles which usually live in the water and breathe through gills. They have a hard outer shell and legs with joints
Cycle	a repeated sequence of events
Dam	a barrier constructed to control the flow of water
Dissolved Oxygen	amount of oxygen dissolved in the water
Downstream	in the direction of a stream's current
Ecology	the science of the relationship between organisms and their environment
Ecosystem	a community of organisms in a given area combined with their physical environment and its characteristic climate
Egg	rounded, shelled reproductive body from which young hatch
Erosion	movement of soil by water and wind
Estuary	area where freshwater and saltwater meet
Evaporation	conversion of water from liquid to vapor
Fry	a stage in a young salmon's life after it looses it yolk sac and begins feeding on zooplankton, crustaceans, and insects
Groundwater	water beneath the earth's surface between saturated soil and rock that supplies wells and springs

Field Journal

Habitat	an area that provides for an organism's basic needs, including food, water, and shelter
Hydropower	electricity created by the flow of water
Infiltration	entry of water into soil
Lake	a large, inland body of water
Land Use	the ways in which humans have used and/or changed the natural landscape
Large Woody Debris (LWD)	sizable pieces of trees in a river or stream, providing structure, riffles, and pools
Macroinvertebrate	an organism that is large enough to see with the unaided eye and has no backbone
Migration	to move from one area to another; this movement is often connected with a changing of season and the availability of food
Non-point Source Pollution	pollutants that enter waterways from broad land areas as a result of the way the land is used
Oxygen	a gas essential for life
Point Source Pollution	air or water pollutants entering the environment from a specific point or conveyance
Pool	deeper and slower water in a stream or river; a portion of a stream where the current is slow, often with deeper water than surrounding areas and with smooth surface texture; pools often occur above and below riffles and generally are formed around stream bends or obstructions such as logs, root wads, or boulders; pools provide important feeding and resting areas for fish.
Precipitation	rain, snow, hail, or sleet falling to the ground
Redd	the underwater gravel nest of spawning salmon; the female salmon create this nest by swishing some gravel away and making a depression in the gravel; this is where the female deposits her eggs
Resource	matter and energy available for use by organisms
Restoration	the process of returning an area of land to former conditions after a disturbance such as a flood, fire, or timber harvest
Riffle	fast, shallow water in a stream; a relatively shallow section of a stream or river with rapid current and surface broken by gravel, rubble, or boulders

Riparian Ecosystem — the green ribbon of trees and plants that border either side of a stream, the stream itself, and all the living and non-living things within this area

River — a large, natural stream emptying into an ocean, lake, or other body of water

Runoff — water that drains over the surface of the land

Salmonid — a fish in the salmon or trout family; including pink, chum, coho, sockeye, Chinook, steelhead, and sea-run cutthroat

Scraper — a type of macroinvertebrate that "scrapes" algae off rocks in a stream for food. Scrapers feeds on algae and other plant material living on rocks and on plant surfaces.

Sediment — solid particles carried and deposited by water

Shredder — a type of macroinvertebrate that "shreds" and feeds on coarse organic matter (detritus) in a stream. Shredders feed on plant material and some animal material, which is generally dead, and break it into smaller particles through their feeding and digestive process.

Smolt — a juvenile, anadromous fish that has undergone physical changes to prepare for life in saltwater

Soils — loose upper layers of the earth in which plants grow; made up of inorganic material, organic material, air, and water

Spawn — in terms of fish behavior, the act of laying and fertilizing eggs

Strainer — a type of marcroinvertebrate that "strains" algae in a stream for food. Strainers feed on fine particle material which they filter from the water.

Stream — a body of running water

Topography — the surface features of a region

Toxic — poisonous, harmful to living things

Transpiration — loss of water from plants through evaporation and as a byproduct of photosynthesis

Tree — tall, woody plant with a mainstem or trunk

Tributary — a stream or river flowing into a larger stream or river

Turbidity — measurement of the clarity of a stream or river; the condition of a body of water that contains suspended materials such as clay or silt particles, dead organisms, or small living plants and animals

Vegetation	plant life (trees, ferns, and flowers) that uses energy from the sun and water to grow
Water	a clear, colorless liquid; there are two hydrogen atoms and one oxygen atom in one water molecule
Watershed	a basin that includes all the water and land areas between ridges that drain to an outlet; the outlet could be a river, lake or the ocean
Wetland	a habitat that is characterized by soils that are saturated with water, or has shallow standing water, for part of the growing season
Zooplankton	floating, often microscopic aquatic animals