Elwha River Ecosystem Restoration:

Studying the Numbers and Movements of Trout and Salmon Populations Before Dam Removal

Abstract:

The Elwha River once flourished with Pacific salmon and trout. In the early 1900's, two hydroelectric dams were built on the river, which sent fish populations into a drastic decline. The dams eliminated fish access to 70 miles of river, changed river flows, raised water temperatures, and starved sections of river below the dams of important **sediment** and wood sources. Today, salmon born in the river that migrate to the Pacific Ocean and return to the Elwha to spawn can no longer access any of the habitat above the dams that they used to rely upon. In 2012, National Park Service will remove the Elwha and Glines Canyon dams in one of the largest river restoration projects in the United States. The removal of the Elwha dams will allow salmon to once again access their natural habitats in Olympic National Park. Dam removal also will allow populations of rainbow trout trapped above the dams over the last century to explore new habitats below the dams. Scientists are curious how dam removal will affect **resident** and **anadromous** fish populations in the river. To better understand the way fish will respond to dam removal, they first must learn as much as they can about the **populations** of the fish that live there now, and how they move throughout the Elwha River.

Introduction:

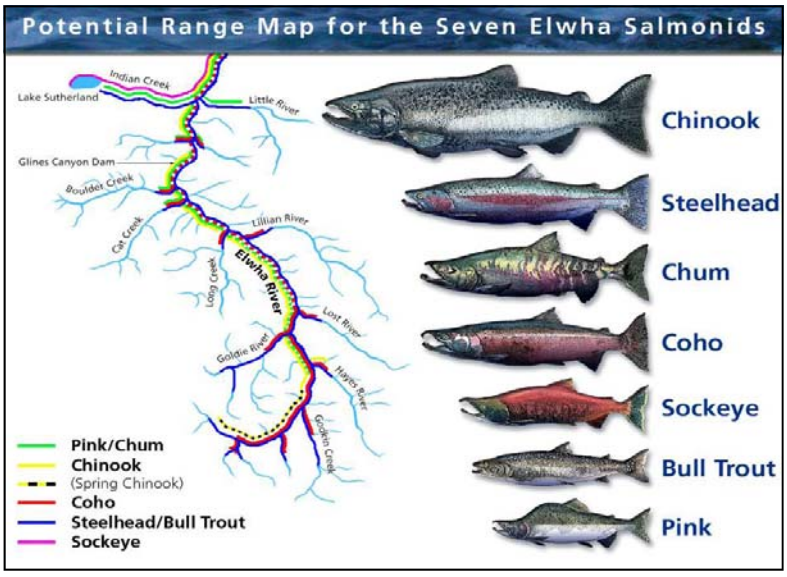
Have you ever floated in a river or a lake and wondered what was beneath you? Have you ever stared into clear water and considered how many fish live in the river? Have you ever had to adjust an antenna on a radio or a television to get better reception? If you have done any of these things, you were using skills that fisheries scientists use to conduct their research. Sam Brenkman— fisheries biologist at Olympic National Park—and several other biologists are conducting a number of research projects on the Elwha River that include: 1. counting and identifying salmon and trout in the Elwha River by floating down the river in snorkel gear, and 2. using high-tech radio transmitters to find out where fish go in the Elwha River. Why are they studying the Elwha River and why do you think the fish are so important?

Historic Range and Image of the Chinook Salmon.
Yellow indicates estimate of the range for Spring Chinook population and the red indicates the range for the Summer Chinook population.
Image courtesy of Olympic National Park

A hundred years ago, the Elwha River was famous for its salmon. The river had healthy populations of 8 different species of Pacific Salmon, trout and char. They entered the river from the ocean in huge numbers and near record-breaking size -- Chinook salmon in the Elwha River were found to be more than 100 pounds. Stories from the past tell of people walking across the river on the backs of the returning Chinook, they were so big and numerous in the river. Salmon are anadromous, which means that although they are born in freshwater rivers and creeks, they actually spend a good portion of their life cycle in the ocean. In the ocean they get big and strong, and then return up the rivers to find a mate and reproduce. These fish have always been popular food for people and for wildlife. When salmon enter the river, insects, birds and mammals look for their nutrient-rich bodies to boost their diet, which helps support the overall Elwha River ecosystem.

It wasn't just salmon that populated the Elwha, though. The river also supported a number of species of resident fish, like rainbow trout. Resident fish can spend their entire lives in one river. The anadromous and resident fish lived and reproduced in a similar place. The Elwha, with its abundance of deep pools, gravelly shallows, cold and clear nutrient-rich water, and woody debris, supported them all. Until the early 1900s, the trout and salmon in the Elwha River competed for habitat and shared important roles in the river ecosystem.

But one hundred years ago entrepreneur Thomas Aldwell saw the Elwha River and its narrow gorges as an economic opportunity. Between 1910 and 1913, Aldwell's Olympic Power and Development Company constructed the Elwha Dam, five miles from the river mouth, in order to generate electricity for the developing region. Many dams have special features called fish ladders built into them to allow fish to swim past them. The Elwha dam, though, was built without fish ladders. This means that the salmon and trout that swam to the ocean could not return to their habitat above the dam, because the new dam stopped their journeys upstream. In the 1920s, another dam, called the Glines Canyon Dam, was built eight miles further up the river. Since the first dam already blocked the salmon from coming up the river, there was no purpose in building a fish ladder on this dam. These dams affected fish on the river in three major ways: they changed their habitat, their populations, and their abilities to move to different parts of the river.



Map showing different areas of the river, including locations of the 2 dams, used by different species and their populations.

Loss of Habitat:

Dams are like gigantic strainers, letting water flow through but catching the bigger materials, like logs and sediment, which are important for creating pools and spawning habitat in the river. The dams block the flowing water and create big lakes above them, called reservoirs. Lake water, because it doesn't move very much, can be heated by the sun and is warmer than river water. Warm water holds less oxygen, and fish need oxygen to survive. The logs and the gravel hit the lake water and gets stuck, instead of flowing down stream where salmon and trout can use them for habitat. Thus, the lower Elwha River has become starved of the small rocks and logs it had before the dams.

Declines in Fish Abundance and Diversity:

Before the dams were built, the fish had access to 70 miles of habitat for spawning. After the dams were built, these fish could only swim 5 miles up the river until they were blocked by the lower dam. Without access to the habitats where they need to spawn, huge numbers of the salmon and trout were unable to reproduce and died below the dams. It is believed that over 400,000 salmon were produced by the rich and diverse habitat in the river before dam construction; today that number has dropped to just a few thousand. Two species of salmon, the sockeye and pink, can now hardly be found. Bears, eagles, and the scores of other animals that depended on salmon must search for other food sources.

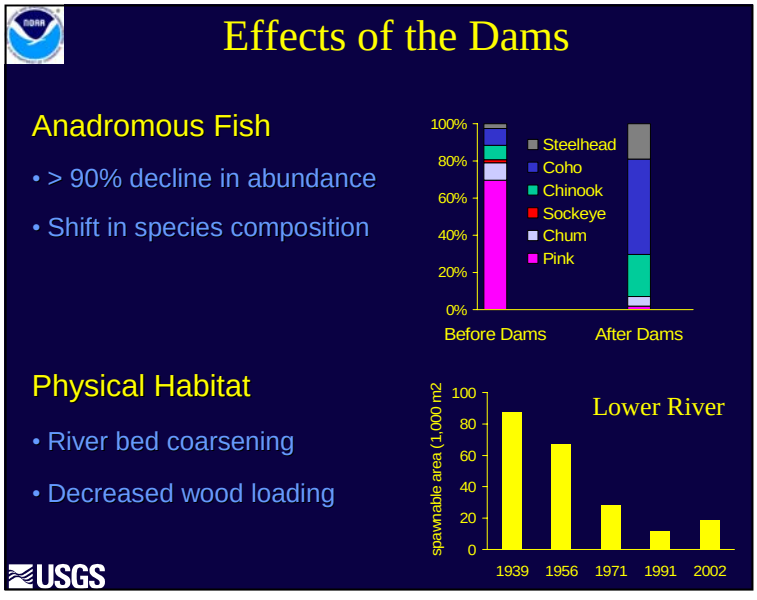


Figure 1: Graphic Courtesy of George Pess, NOAA Fisheries

Disconnected Ecosystem:

Currently, anadromous fish -- like Chinook salmon -- can't make it above the dams. The resident fish – like rainbow trout -- can't make it below the dams to the ocean. Essentially, the dams have separated the two groups of fish that used to share the river. With the salmon no longer returning, the trout above the dams no longer share their habitat with those giant fish. Over the past 100 years, this has significantly changed the populations and movement of all the fish on the river. All of this may change when the dams come out. In the 1990's, it was decided that the best way to restore

the river was to remove the two dams. The removal of the two dams in the Elwha River is the largest dam removal project in the United States. Many scientists are anticipating future changes and curious to observe the conditions before and after the dams are removed. Local citizens and scientists alike hope the salmon will come back up the river and return to the diverse habitat waiting upstream.

Scientists think this return of salmon will have an effect on the resident fish living in between the dams and above the upper dam. They expect that as the anadromous fish come up and resident fish go down the river, competition for food and habitat will change the diversity and numbers of fish. In order to test their predictions, scientists first need to know where the fish actually are and where they move throughout their lives, so they can learn how the dam removals affect the fish. They developed four major questions for their research.

Questions:

1) Where in the river does each population of fish live and how far are they moving – below, between or above the dams?
2) What is the abundance of trout populations in the river from the headwaters to the sea?
3) Do existing fish populations above the dams swim over the dams?
4) How will the trout and salmon habitat change after dam removal?

If you were to answer these questions by counting and *observing* the fish, how would you do it?

Methods:

It's a challenging job to count and follow the movements of fish, especially in the Elwha River. Sampling, or counting, fish on the Elwha River is difficult because of high costs, limited road access, low water visibility, and safety concerns. In fact, portions of the river are inaccessible because of steep slopes, narrow canyons, and periods of high river flows. To focus their efforts, fisheries biologists divided their questions into two categories: ones they could answer by snorkeling as a method and ones they would answer by using a technique called **radio telemetry,** which tracks where the fish are moving.

Snorkellers counting fish in the Elwha River.

Research using Snorkeling:

A great technique for studying fish is an old technique for watching fish – snorkeling. Biologists, who are trained to observe fish, swim along the river with masks and snorkels and count fish by species. But, to snorkel down the river scientifically, they had to be careful with their technique to record where they went and consistently record the numbers of fish they found. By using this method, scientists could see and record all the species of fish there were in the river. Also, by counting the fish in that way, they didn't have to catch or harm the fish they were studying.

Sam Brenkman and the other researchers conducted their snorkel study in August of 2007. It was one of the longest snorkel surveys ever done in a wild river. The divers started at the headwaters of the Elwha River, deep in Olympic National Park, and finished at the Strait of Juan de Fuca, where the river enters the sea. This trip was 42 miles long! It took 21 divers, support from people in airplanes making sure that some of the narrow parts of the river would be safe, and six mules that hauled all of the scientific and camping equipment that the divers needed to gather their data. This was no simple afternoon floating down a river; it took five whole days to complete the study!

Each of the divers wore drysuits—special waterproof suits designed to keep them dry and warm—masks, snorkels and underwater gloves. They took underwater cameras with them and *dive slates* -- special plastic boards that you can write on underwater. Because the divers would be moving at the river's pace, and counting moving things, they had to come up with a specific method to make sure that they counted the fish correctly. Two divers, one on each side of the river, swam downstream and counted each species greater than 15 cm in length (Figure 4). They moved downstream at the speed of the current, and look side to side to the farthest point visible, working together to count their side of the river. The divers really had to know their fish! They had to be able to identify them, estimate their size, count them, and record their

information—all in water around 50 degrees, about as cold as your refrigerator.

Though this study using snorkeling provided some really important results (see figure 2 in the results section), it couldn't answer all the questions. Snorkeling couldn't tell them exactly where the fish were going throughout their lifetimes-- the snorkelers couldn't follow one fish around by swimming along side it all year! So in order to figure out where the fish went, they caught some of them and put a tiny radio transmitter in each one. They then used special equipment to pick up a signal to help track these fish's movements over the year.

Sam Brenkman, Fisheries Biologist at Olympic National Park, uses a receiver and radio antennae to pick up signals from radio tagged bull trout and rainbow trout.
Photo courtesy Olympic National Park

Research Using Radio Telemetry:

To use radio telemetry first requires catching and working with a sample population of fish. Between 2005 to 2007, researchers captured 99 bull trout and 41 rainbow trout and surgically implanted the radio transmitters into their bodies. Each transmitter sends out a signal with a unique code. The scientists recorded this radio code and the type of fish. They were then able to track the movements of these fish using receiver stations that were placed throughout the Elwha watershed. Each station included two antennae, a receiver, and amplifiers that detect upstream or downstream movements (See Picture). Some fish were tracked using receivers and antennas mounted on airplanes and boats, and some others were tracked by scientists walking along the river bank carrying antennae to listen for and hopefully find the signal of one of the fish. This method allows scientists to know how far the fish move and whether they spend time in the reservoirs, slip down stream through the dams, and which sections of the river system they like to use.

Results:

Snorkeling:

By using both of these methods, the scientists learned more about their 4 questions. The snorkeling project provided good information about the diversity, location, and concentrations of the threatened trout and salmon. For the total counts, the research team found 7,300 rainbow trout, 215 bull trout (a species listed as threatened under the Endangered Species Act), 539 adult Chinook salmon (also threatened), and 26 pink salmon. Numbers of bull trout were very low below the Elwha Dam, low to medium in the middle river, high in the Lake Mills area, and low above both of the dams.

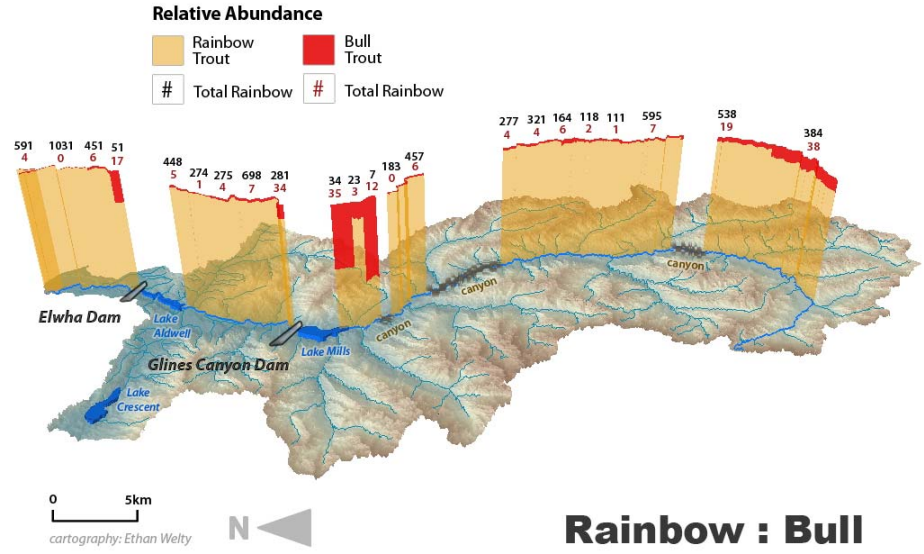
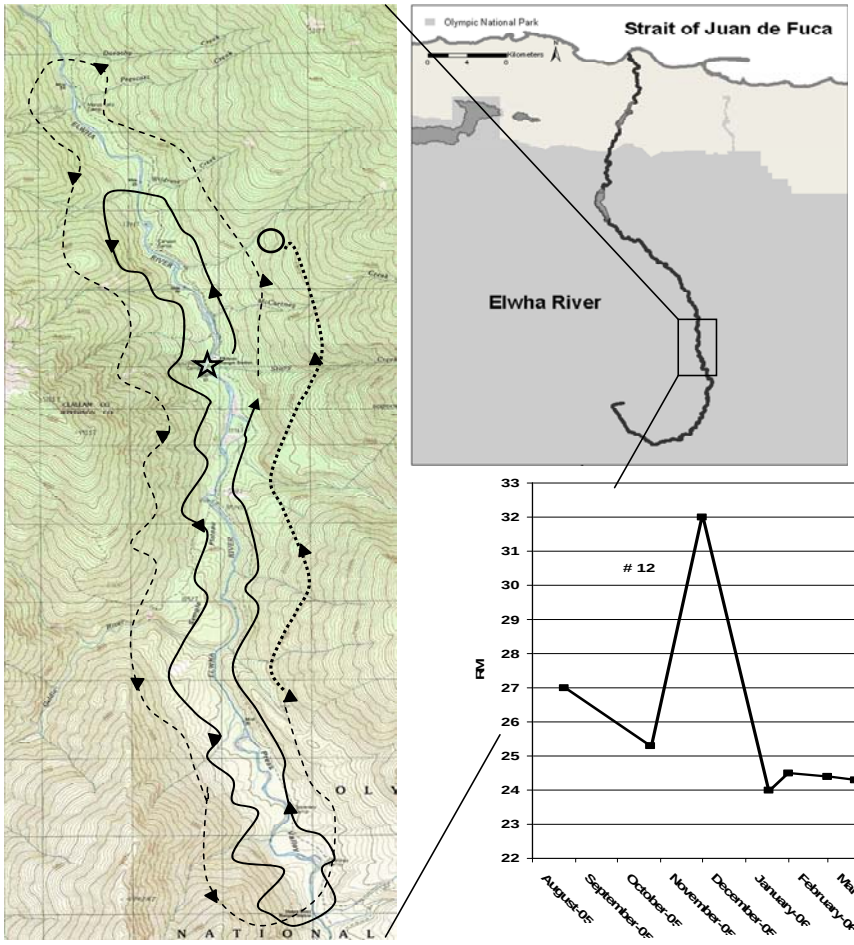


Figure 2: Map that shows the locations and numbers of rainbow trout and bull trout observed during the week long snorkel survey. Map by Sam Brenkman

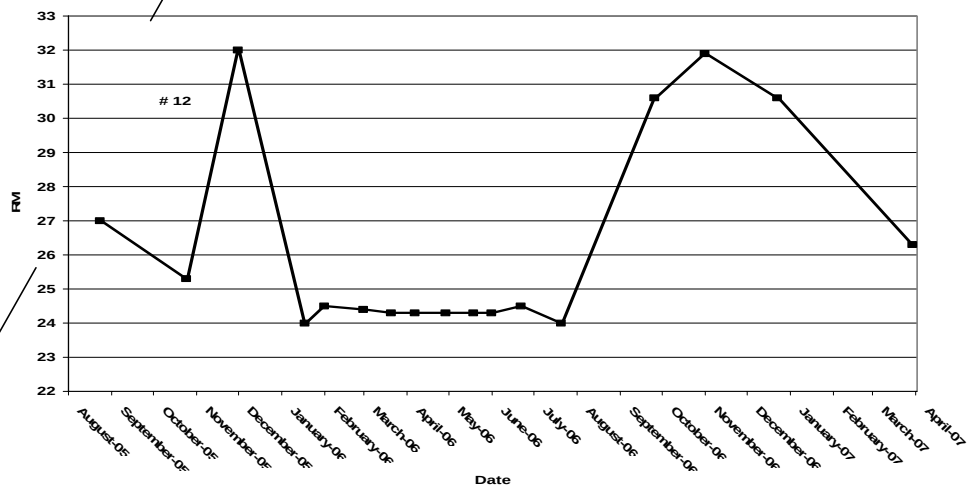
Upstream of Glines Canyon dam, the snorkelers only found rainbow trout and bull trout. There were 23 times as many rainbow trout as bull trout. These populations of fish have been physically disconnected from populations below the dams for more than 90 years. In-between the dams, divers found bull trout, rainbow trout, and non-native brook trout which were planted in the river for anglers to catch. The overall number of fish species increased as the snorkelers went below the dams, since they entered the zone which contains anadromous fish coming from the ocean. Below the dams, divers observed Chinook, pink, and coho salmon and sculpin, bull trout, threespine sticklebacks, starry flounder and freshwater mussels.



Bull Trout #12

526 mm, 1.5 kg

Background: Maps show an example of one trout migrating up and down river, starting from the star and ending at the circle. Graph highlights the distances covered in miles of river during each month.
Maps and Data by Sam Brenkman



Radio Telemetry:

Through their radio telemetry project, researchers gained critical information that could only be discovered using this method. By watching where the rainbow and bull trout moved, they discovered the danger of the dams, and the way that the steep canyons or wider valleys impact the movements and locations of the trout. By using telemetry, they were able to follow the movements of individual fish. In the figure below, you can see the movements of one specific fish over two years. They then compiled all the information to make generalizations about the fish dynamics. Here are some of the highlights discovered:

- Bull trout are in all areas of the river, from its headwaters to the mouth.
- Bull trout that live in Lake Mills spawn in the river in September and October.
- Bull trout were found to be larger in size than rainbow trout.
- Canyons in the river system did appear to impact where fish were found, since some fish were found below but not above a canyon..
- Fish were found to fall downstream below both of the dams, though most didn't survive the fall.

Discussion:

This is among the first studies to gather such extensive information about where salmon and trout live in the Elwha River system within Olympic National Park. The scientists couldn't have discovered such detailed answers to their questions without the cooperation of many people and the use of such unique methods of study. Biologists from the Lower Elwha K'lallam Tribe, University of Washington, the National Park Service, NOAA Fisheries, US Fish and Wildlife Service, US Geological Survey, Washington Department of Fish and Wildlife, and the Wild Salmon Center all contributed time and resources to the project. The data that the scientists gathered will serve as an important baseline for studies when the dams are removed and salmon return to the upper Elwha River for the first time in 100 years.

Though scientists haven't had a chance to collect data after the dam removal yet, they have formed a number of predictions about what might impact the salmon and trout populations. First, with the removal of the dams, the

anadromous fish will be able to access almost 15 times the habitat that they currently can access in the river. Thus, scientists do expect the numbers of fish to increase, the diversity of the fish to increase, and the mixing of the fish to increase. Some populations will benefit and some may decline due to the new competition. The section of river currently between the dams will be especially interesting, as anadromous fish swim up the new section of open river and the resident fish swim down to that section of river. Scientists are very curious to see how they compete for that important space in the middle Elwha River.

Second, scientists expect big changes to occur with the habitats below the Glines Canyon dam, as the reservoirs are drained and the sediment and logs begin to flow again downstream. The middle and lower river sections now starved of gravel and woody debris will be reshaped by the return of these important elements: 1. deep pools may once again form, 2. gravelly shallows which fish need for spawning will be reestablished, and 3. cold, oxygen-rich water will replace warm, still lake water. Many more changes will come as salmon and trout discover these habitats and reconnect parts of the ecosystem disconnected for a century. Where do you think the biggest changes will occur in the river system? Some day, Sam Brenkman and his fellow scientists hope that the salmon will once again be famous, and found in big enough numbers to feed people, eagles and bears. But, only time, and more research, will tell.

Glossary

Abundance: the number of animals.

Anadromous: Migrating from saltwater to freshwater to spawn (or reproduce).

Baseline: A measurement, calculation, or location used as a basis for comparison.

Habitat: The area or natural environment in which an organism or population normally lives.

Nutrients: a substance that provides nourishment, e.g. the minerals that a plant takes from the soil or the constituents in food that keep a human body healthy and help it to grow.

Population: A group of organisms of one species that interbreed and live in the same place at the same time.

Radio transmitter: Individually coded tag that is surgically inserted.

Receiver: A battery operated system that records individual frequencies of radiotagged fish. The receiver can be used during manual and aerial tracking or as a fixed station along the river.

Resident Fish: Population of fish which stays in freshwater throughout its life.

Spawn: the reproductive process of salmon. To spawn, females release eggs while males release milt into a depression on the riverbed called a 'redd.' Fertilization takes place as the eggs drift down into the gravel.

Survey: a scientific count or study of a wildlife population.

Researcher Biography

Sam Brenkman, Fisheries Biologist, Olympic National Park
grew up in Madison, Wisconsin, and was introduced to streams and fishing at an early age by his grandfather. He began studies in biology and natural resource management at the University of Wisconsin, and later completed degrees at Oregon State University. His interest in the management and conservation of native fishes grew after spending years of adventure and work in the Blue Mountains, Klamath Basin, lower Columbia River, and coastal portions of Oregon and Washington. Sam's interests in fisheries conservation peaked after traveling to study fish populations in remote portions of Iceland. Today, Sam and his co-workers at Olympic National Park work to manage 12 major watersheds, 31 freshwater fish species, and over 70 populations of Pacific salmonids throughout 922,000 acres of Olympic National Park.

Sam wishes to acknowledge: Steve Corbett (NOAA Fisheries— far left in photo), Pat Crain (Olympic National Park), Jeff Duda (U.S. Geological Survey), Phil Kennedy (Olympic National Park), Mike McHenry (Lower Elwha Tribe—far right in photo), George Pess (NOAA Fisheries), Roger Peters (U.S. Fish and Wildlife Service), Christian Torgersen (US Geological Survey) and Dick Goin (Go to Volunteer).

Curriculum Writer's Biography

Ryan Hilperts, M.S. Candidate, University of Victoria

Ryan Hilperts loves the Elwha River, and stories. Even though she has traveled far and wide around the world, she always returns home to the Olympic Peninsula to teach and explore the place she calls home. She currently studies at the University of Victoria on Vancouver Island—just across the Strait of Juan de Fuca from the Elwha River--where she is designing a masters project about the community stories of the Elwha River Restoration. On her daily bike ride home from school, she can see the gigantic watershed the Elwha River has carved on its journey through the Olympic Mountains and out to sea.

Elwha Research Learning Unit

This research summary is a piece of a larger Elwha Research Learning Unit which has been funded by the Research Learning Network and coordinated by Olympic Park Institute. This is one of seven research summaries which capture the diverse and exciting science which is being done in preparation for the upcoming Elwha River dam removals. All seven summaries are examples of the important work which fits together to help us better understand the Elwha River Ecosystem and neighboring Strait of Juan de Fuca. Three of these research topics have been turned into activities which have been designed for us to practice the scientific process by using real research from this inspiring dam removal effort. For the complete learning unit, go to OlympicParkInstitute.org or ElwhaScienceEd.org.

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