# Aquatic Insects, Algae and Habitat Diversity for the Elwha River:

## Analyzing the nutrients and organisms above, between and below the dams


## Abstract

The Elwha River in Washington State has two dams that, since the early 1900's, have been blocking the return of salmon to its upper **watershed**. Both of these dams are scheduled to be removed, in the hopes that the salmon will return. Juvenile salmon rely on benthic invertebrates — insects that live in the river — as a main food source. Scientists from the United States Geologic Survey (USGS) and the National Oceanic and Atmospheric Administration (NOAA) decided to explore the ways that the dams have affected the **benthic invertebrates**, the **periphyton —** or algae — that they eat, and the **habitats** that these organisms live in. They gathered three years' worth of data, collecting samples of invertebrates and periphyton, and measuring the size of sediment that makes up their habitats both above and below the dams. They discovered that the dams affected the amount and type of both invertebrates and periphyton, as well as the kind of places these organisms live.


## Introduction

Have you ever reached into a river and picked up a rock? You may have felt a green slimy coating covering the rock, or watched a tiny critter scurrying across the rock when you turned it over. Both of these things — the "slime" and the "bugs" — are actually essential foundations of a river **ecosystem**, and they are important clues that scientists use to learn about the health of rivers.

**A view of diverse habitat with logs, sediment and mix of pools and fast flowing water.**
**Image by Olympic National Park**

A river is much more than just water. Rivers are constantly moving sediment through the process of erosion, transporting fallen trees and wood, and being reshaped by changing flows of water. Fallen trees and wood play an important role in shaping habitats in rivers, because they slow down the water. These areas of slower water allow finer sediments to settle out of the water and create protected areas out of the main flow of the river where organisms can live. Living trees and other organisms around rivers also contribute to these habitats, by adding 'food' to the water. Leaves, insects, and other organic matter from along the shore fall into rivers and settle into these slow areas of water. All of these processes mix nutrients— food for more living things — into the water. In fact, rivers are home to complete **ecosystems** living in and around their watery habitats.

As in all ecosystems, the foundation of an aquatic ecosystem is the green plants that capture sunlight and nutrients in the process of **photosynthesis**. Other organisms, such as benthic invertebrates who cannot capture energy in this way, feed upon those plants as well as the nutrients that fell into the river along the shore. In large rivers, the main green plant that serves this role is periphyton—which makes up a large part of that green slime you felt on the rocks (Thorp and Delong 1994, 2002). **Periphyton** is a combination of algae, diatoms, fungi, and bacteria that feeds the invertebrates that live in rivers. It grows on the surfaces of rocks and wood in slower moving parts of rivers.

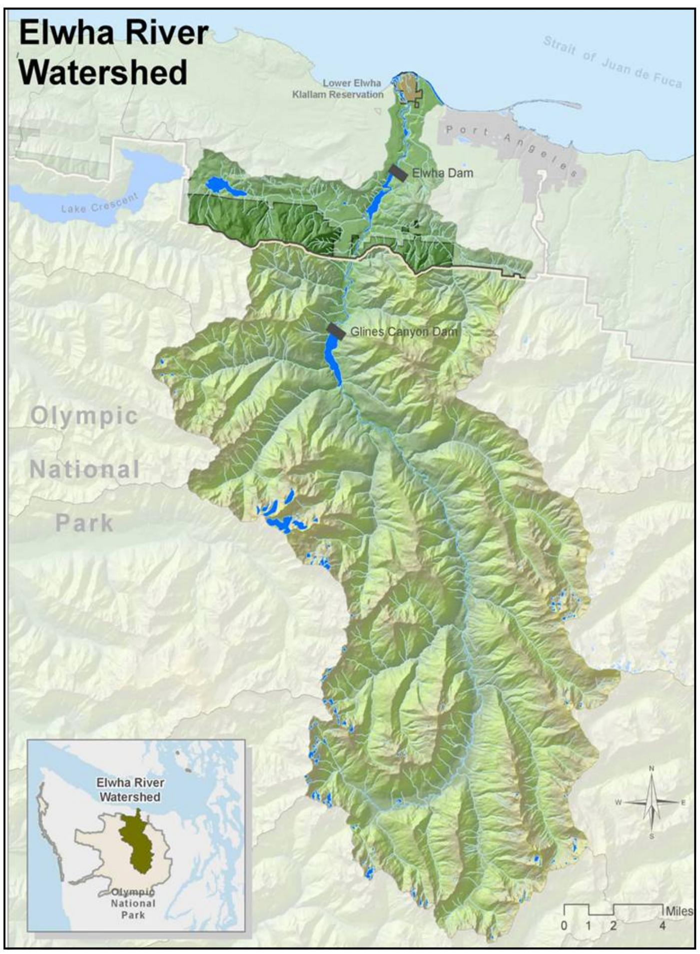
Also living in these slower parts of the rivers are those tiny critters you might have seen scurrying on the underside of your river rock. These are known as **benthic invertebrates**. *Benthic* is a term that refers to the bottom of a body of water, including the sand, gravel and mud that we often see and feel. Most benthic invertebrates are juvenile forms of insects that you might recognize flying around a body of water — mayflies, caddisflies, dragonflies — in the adult phase of their life cycle. They have special adaptations that help them to cling to the rocks, breathe oxygen, and filter food out of the water. Salmon and other fish love to eat these, and people concerned with the condition of rivers love to count and identify them! What do you think they could teach us?

## *Indicator Species: clues about the water*

Benthic invertebrates and periphyton are both used as *indicators.* Indicator species are organisms that are sensitive to changes in their environment. If water gets polluted, some indicator species die off, while others thrive. If big changes happen in the temperature of the water, some species can tolerate the change and others cannot. In order test how healthy a river is, scientists often determine what kinds and how many benthic invertebrate species live there. Certain types of invertebrates, like mayflies and caddisflies, do not tolerate disturbance like other species, such as midges. If a river is undisturbed, you might find more caddisflies and less midges.

**This Stonefly in a great example of an indicator species, as its fragile body and gills need a high level of oxygen and safe spaces for clinging to rocks.**

You may wonder why scientists don't just test for pollution or measure the temperature, rather than going to all the trouble of gathering and identifying these plants and insects. It's because these populations of organisms record, in their bodies and the numbers in their populations, the cumulative effects of impacts on the rivers that they live in. Most of the Elwha River is protected inside of Olympic National Park, so it doesn't have roads, paper mills, or sewage treatment plants impacting the water in its upper watershed. The main human impact on the river is the two dams. So how do you think the dams might affect the invertebrates and periphyton in the river?




**Map of Watershed Courtesy of NOAA Fisheries**

Remember how the trees, fallen wood and sediment created those slower pools for periphyton and invertebrates to live in? Well, dams trap wood and sediment, but still let water flow. During some times of the year, the water that flows between and below the dams picks up sand, small rocks, and wood and moves them towards the ocean. Because of the dams, though, there is much less fine sediment or wood carried in the water to replenish these areas.

Scientists knew that these things shape the habitats where periphyton grew and invertebrates lived. They observed that on the Elwha River, below the dams, there were not as many fine sediments or pools for these organisms to live in, and thought this might be affecting what invertebrates could live there. They had a hypothesis that the dams have altered habitat and diversity of periphyton and invertebrates in the ecosystem.

To test this hypothesis, Jeff Duda, Holly Coe and Sarah Morley developed three research questions to investigate.

### Questions:

The scientists' main goal was to gather as much data as they could about the invertebrates and periphyton in the Elwha River in order to understand how removing the dams will affect these important living things. There are three questions the scientists wanted to answer:

**Questions Studied:**

1. Do different kinds of invertebrates and periphyton live in different kinds of riverine habitats?
2. How are the invertebrates and periphyton communities above the dams different from the ones between and below the dams?
3. How will removing the dams on the Elwha change the periphyton and invertebrate communities?

## Methods

In order to answer their questions, the scientists had to gather enormous amounts of data.

First, they ***chose their study sites***, picking different kinds of river habitats, so they could answer their first question. At these sites, they collected water samples to ***measure water chemistry***. They also ***sampled the invertebrates and periphyton*** . To do this, they used specially constructed nets that allowed water to flow through, but captured the bugs that were dislodged from the rocks. To sample the periphyton, they used a tooth brush to scrape away the slime that grew on the rocks.


**Researchers using a Slack sampler, which standardizes the area of sediment and water where insects are found**

This data collection may sound simple enough, but it's important to remember that the Elwha River is 72 kilometers long, and you can only get 22 kilometers up the river with a car! The rest of the river is in Olympic National Park, and the only access is by trail. This means that to gather most of their data, the scientists had to lace up their boots and hike between 18 and 40 km into the backcountry, carrying their belongings in backpacks, and camping for a week at a time while they gathered their data. They didn't just spend one summer doing this; in order to make sure they had enough information, they collected their data over three different summers, from 2004 to 2006.

### *So, how did they gather their data?*

**1.** ***Choosing the Sites***
First the scientists chose their collection sites. They spread the sites throughout the watershed and looked for an area where they could sample from a **tributary**, a **side channel**, and the **main channel** of the river. Most of their sites were above both of the dams, because this is the longest part of the river. In total, the scientists sampled 52 different sites (see map of some of the sites selected).

***2. Sampling the Invertebrates***
Once they had chosen the sites, the scientists used a **Slack sampler** to collect invertebrates. A slack sampler is basically just a mesh net with a jar on the end. The scientists place the net upright in the water and agitate (like a washing machine) the rocks and sand just upstream of the net, which washes any bugs living there into the net. To make sure the amount of space sampled was the same way everywhere, they placed a plastic frame on the river bottom. Once all the invertebrates were removed from the nets, they put them in a jar containing alcohol, which acts as a preservative. It was important that the bugs did not decay, so that the different kinds of species could be identified by taxonomists in a laboratory. A taxonomist is a specialist who has to use a microscope to identify all of the different kinds of bugs in the sample.

**3.** ***Sampling the Periphyton***
When periphyton grows, it loosely glues itself on the surfaces of rocks. The scientists used a tooth brush to remove the periphyton from the rock, scrubbing and rinsing with filtered water and gathering the green sludge into a container. Back in the laboratory, they filtered the sludge onto filter paper and weighted the paper to

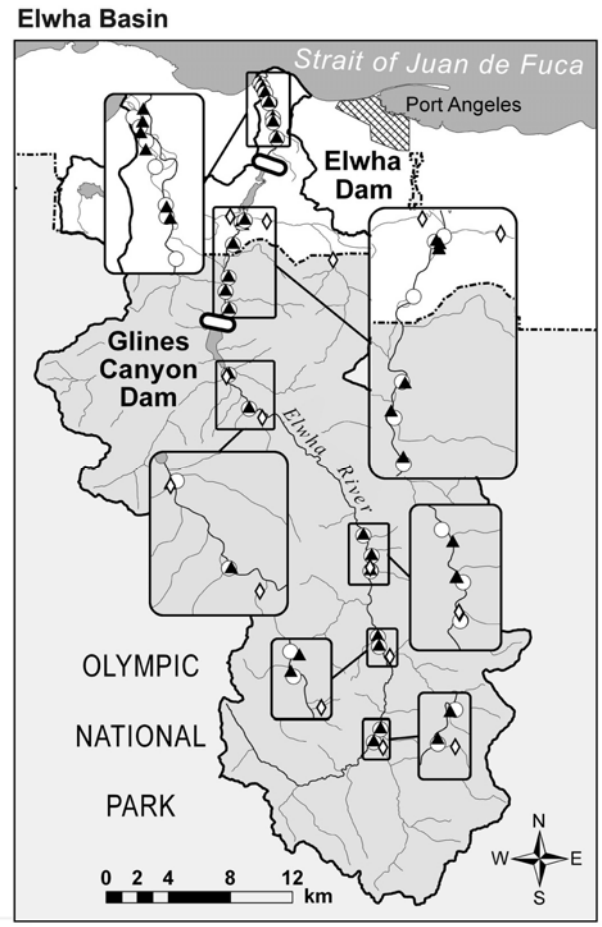
determine the amount of periphyton present. They also tested their samples for amounts of chlorophyll, which told them how much algae and diatoms were present in the periphyton. In this way they figured out how much periphyton was growing in each study site at the time they sampled the bugs.

**4. *Water Chemistry***

The scientists took water samples at each site and tested them for levels of nutrients such as phosphorous and nitrogen. Because these samples had to be tested quickly, they kept the water on ice over night and had them packed out of the backcountry on horseback to get to the labs on time!

**5. *Gathering Habitat Data***

The scientists measured features of each site that would help them to explain what was driving any differences in the bugs and periphyton collected at each site. After all, in every river there are natural changes in the bugs living on the bottom as you move from the **headwaters** near the mountains to the sea. They were most interested in the size of the sediment (rocks, gravel, and sand) from where they took their bug samples. They measured the size of the river channel and the overall size of the river bottom rocks by randomly measuring the size of 100 rocks. They also measured temperature, percentage of canopy cover (or tree cover) directly above the site, and other chemistry variables in the water. All of this data helped them create a full picture of each sample site.




**Map which shows sampling site locations in the upper, middle and lower river sections.**
**Graphic courtesy of NOAA Fisheries**

## Discussion

The researchers found that different kinds of habitats along the river did not affect the makeup of the periphyton and invertebrates too much. However, they did find these habitats and organisms differed greatly among areas above, between, and below the dams. Below each dam, the sediment was larger, the rocks were less covered and stuck in sand and silt, and the sediment overall was made up of very similar sized rocks. Above the dams, the substrate was made up of much more different sized rocks, and had more sand and silt. This supported their hypothesis that the reservoirs behind the dams were capturing silt and sand, changing river species below each dam. The temperature of the water below the dams was also higher than above them, likely due to the large reservoirs (lakes created by dams) being warmed up by the sun before flowing down stream. They found that there was much more periphyton below the dams than above them, and they were able to tie these findings to different levels of nutrients they found in the water through their water chemistry testing.

The researchers found 244 different species of benthic invertebrates in their study! They found that above the dams, there was a higher concentration of mayfly larva, where below the dams there were higher concentrations of other more disturbance tolerant species. They also found something surprising—there was a higher diversity of invertebrates below the dams than above them. Because they had also measured the amounts of periphyton and the temperatures of the water, they discovered that there were warmer temperatures and more of one certain type of algae that provided a large amount of food for these invertebrates. Above the dams, the temperatures were cooler and the type of algae growing in the periphyton was a type that mayflies prefer.

This initial data collection is the beginning of a study that will take years to complete. The researchers are using these data to try to predict what might happen after the dams are removed from the Elwha River. The researchers predict that when the dams are taken down, the movement of the small sediment in the water will increase and temporarily decrease the populations of invertebrates and periphyton. However, they expect that as sediment and wood get washed down the river, the areas below the dams will once again increase in complexity—with side channels and pools— and thus create more diverse habitat for a large percentage of the invertebrates.

All of this work is done in order to understand the effects of dams and dam removals on the ecosystems of rivers. No one knows exactly how taking the dams down will affect each element of the river ecosystem, but everyone is hoping the salmon will be able to return. Understanding the invertebrates, periphyton, and their habitats will bring us one step closer to learning how and why rivers change, and how they can be habitats for all the creatures that depend on them.

## Glossary

**Benthic:** The **benthic zone** refers to the deepest area in freshwater and marine ecosystems. Benthos refers to the organisms attached to, resting on, or burrowing into the bottom sediments in freshwater or marine ecosystems.

**Ecosystem:** The interacting group of organisms and their natural habitat in a particular area.

**Headwaters:** A stream of a river that is close to the source of the river. The headwaters of the Elwha River are high in the Olympic mountains.

**Invertebrate:** Any animal without a backbone. *Benthic invertebrates* are invertebrates that live specifically in the bottom sediments of rivers and lakes.

**Periphyton:** The combination of algae, diatoms, bacteria and fungus that grow attached to rocks, stems, twigs and bottom sediments in a freshwater lake or river.

**Photosynthesis:** The process by which green plants use sunlight, water, and carbon dioxide to create sugars.

**Watershed:** All of the land and water that drains into a particular river. A watershed includes tributaries (small feeder streams), the side channels and the main channel of the river, as well as lakes or reservoirs which may have developed in the land or river.

## Researcher Biographies

**Jeff Duda, Research Ecologist, USGS**

Ever since his grandfather took him on long fishing trips in the Canadian wilderness, Jeff Duda has had a love of rivers and the many different kinds of organisms that can be found under water. He began seriously studying the biology of rivers and lakes in college at the Fish Lake biological station in Lapeer, Michigan. Here he learned that people could make a living by studying nature and spending a lot of time outdoors. He took a detour from studying wet things, when he went to work in the Mojave Desert to study the desert tortoise. Since his MS thesis in 1998, he has returned to studying rivers and streams in Wyoming, California, Georgia, and Washington. He has studied fish, salamanders, and invertebrates, focusing effort on trying to figure out what things make populations of these organisms tick.

**Holly Coe, Freshwater Ecologist, NOAA Fisheries**

As a child growing up in California and England, Holly dreamed of becoming a marine biologist. But after spending time as an undergraduate studying freshwater invertebrates in the Sierra Nevadas, California, she decided that freshwater ecology was her calling. Even a stint in Antarctica studying krill wasn't enough to pull her away from the excitement of research in streams and rivers. She decided to further her education at the University of Washington by studying invertebrates living beneath rivers. She now works at NOAA's Northwest Fisheries Science looking at the importance of restoration actions on algae, invertebrates and salmon living in rivers.

**Sarah Morley, Freshwater Ecologist, NOAA Fisheries**

Sarah grew up in Seattle and never saw salmon spawning in the wild until she was an adult. She got hooked on studying streams when she went to college and got to do a research project on benthic invertebrates in a small agricultural stream in Costa Rica. After coming back to the Northwest, she decided she wanted to spend as much time as possible being near streams and rivers and learning how to help keep them healthy. In graduate school at the University of Washington she studied how urbanization affects the creatures living in streams. As a member of the Restoration Team at NOAA's Northwest Fisheries Science Center, Sarah gets to spend a lot of her time wading around in rivers and helping to figure out what types of restoration are working.

## 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.

PENINSULA COLLEGE

NATIONAL PARK SERVICE

OLYMPIC PARK INSTITUTE