

The demolition of the Glines Canyon Dam, seen here in May 2011 (left) and November 2012 (right), allowed Washington state's Elwha river to run free for the first time in nearly a century.

# LET THE RIVER RUN

Removing two dams from the Elwha is a can't-miss restoration experiment **By Alexandra Witze**

**O**n a sun-dappled autumn day in the Pacific Northwest, Jeff Duda stands on the banks of a thundering river. He could not have picked a more glorious time to show off the Elwha River of Washington state. Its waters rush from the forested peaks of Olympic National Park, down through broad sweeping river bends, and out to meet the otters and salmon of the Strait of Juan de Fuca.

In the same spot just a few years earlier, Duda, an ecologist at the U.S. Geological Survey in Seattle, would have been submerged at the bottom of an unnaturally placid reservoir, ponded up behind a towering concrete dam.

Engineers built a pair of dams along the Elwha about a century ago to capture its waters and provide hydropower to a nearby timber and paper mill operation. Both dams were recently dismantled as part of a broader push, across the United States and elsewhere, to remove aging dams.

And science is benefiting, getting a front-row seat to ecosystem restoration on a mammoth scale. When the dams came tumbling down, they released a torrent of mud and silt. The sediment rushed downriver, reshaping the Elwha's banks and forming fresh sandbars where new grasses and shrubs are beginning to grow. Meanwhile, the spectacular native salmon are once again making their way upstream to spawn, pushing past the crumbled remnants of the dams that once blocked their way.

Think of it as the Elwha Experiment — a rare chance to watch a mighty river unleashed. “This is a once-in-a-lifetime opportunity,” Duda says.

## How the dams came down

In the last few decades, more than 1,100 dams have been removed in the United States, according to the conservancy





group American Rivers. (Another 75,000-plus remain.) Most of the demolished dams were modest structures, just a few meters high at most. But several dams taller than 15 meters have been torn down, including the two Elwha structures: Elwha Dam and Glines Canyon Dam.

The 33-meter-high Elwha Dam was finished in 1913, eight kilometers upriver from the ocean. The 64-meter-high Glines Canyon Dam was erected in 1927, another 14 kilometers upstream. Both were built over the objections of the Lower Elwha Klallam Tribe, whose nation sits at the mouth of the Elwha and once relied on the river's teeming salmon runs. Neither dam offered any way for fish to circumvent them, such as the fish ladders that are common in modern hydropower projects.

To the paper mill and power company employees, the dams worked great, providing a steady stream of electricity for local businesses. The tribal experience was very different, however. Once the dams went up, 90 percent of salmon habitat was cut off, and the fish populations plummeted. Where hundreds of thousands of salmon had once returned to spawn in the Elwha's waters, only a small fraction of that made their way up the truncated riverway.

For decades, the tribe fought to have the dams removed. The first real opening came in the late 1960s and early 1970s, when the dam operator applied for federal licenses to keep the structures running. Environmentalists joined the battle. After

several roadblocks and paperwork delays, Congress passed a landmark act in 1992 allowing the federal government to acquire and demolish the dams and restore the Elwha's landscape and fisheries.

How a dam comes down can affect the final shape of the



Before the Elwha Dam, five species of native salmon raced up the river's waters to spawn each year. The dam blocked their path, as seen in this September 2010 image, and dramatically cut back their native habitat.



restored river. In one approach, popularly known as “blow-and-go,” engineers dynamite all the concrete at once and let the sediment and water pour out together. A second option is to take a dam out in stages, gradually lowering it from the top and letting water stream out in a more controlled fashion.

“Whether you instantaneously remove a structure or you take it down in stages turns out to be a huge determinant about the nature and mechanism of the downstream erosion,” says Gordon Grant, a geomorphologist at the U.S. Forest Service’s Pacific Northwest Research Station in Corvallis, Ore. “We sort of knew this, but we hadn’t really explored and understood it. How does a river get its teeth back into all this stored sediment?”

Previous blow-and-go removals of dams provided some early clues to help guide the Elwha work. In 2007, when engineers took down the 15-meter-high Marmot Dam in Oregon, one-fifth of the sand and gravel that had been stored behind it washed away in the first 48 hours. In 2011, things moved even faster at the 38-meter-high Condit Dam in Washington, where the fine-grained sediment formed a slurry and squirted out as a high-speed debris flow, startling observers with its speed and force.

To avoid sediment overload, engineers opted for a combination of techniques for the Elwha dams. The lower dam, the Elwha Dam, was mostly taken out over a matter of months beginning in 2011. Engineers routed the water flow first to one side of the dam during demolition, then to the other side. The upriver Glines Canyon Dam came down in much more gradual stages over several years, as earth-moving equipment cut notches in the top of the concrete to allow the water to drain. The final blast came last August. Together, the two Elwha dams had trapped about 21 million cubic meters of sediment, or about 5 Wembley stadiums’ worth.

After the first dam came down, the river began picking up that stored sediment and moving it downstream, particularly during winter storms. “The river basically took decades’ worth of its own sediment supply and shoved 90 percent of it out to the river mouth,” says Amy East, a USGS geomorphologist in Santa Cruz, Calif. People hadn’t anticipated how efficient the river would be at moving its sediment downstream, she says.

The fine-grained silt that had been trapped behind the dams finally had a chance to spread out downriver. It formed large sandbars and caused the river to spread out in a complex system of braided channels, East and her colleagues reported in a paper that appeared in *Geomorphology* on January 1. The silt also filled in a riverbed that had been stripped down to large cobbles and little else. With fine-grained material now blanketing the river bottom as well, algae and other aquatic plants could begin to move in.

All that silt came with a price, however. So much rushed downstream that it temporarily clogged the intake filters at a water treatment plant that serves the nearby city of Port Angeles. The city had to rely for a short time on a limited supply of well water. In response, managers slowed the demolition of Glines Canyon Dam to reduce sediment flow.

### The muddy plume

Today, just upstream from the treatment plant, USGS scientists are trying to make sure that sediment doesn’t overtake the treatment plant again. At the “diversion” in the river where some of the Elwha’s water is shunted to the treatment plant, researchers regularly take water samples to figure out how much sediment is muddying the flow.

In a cold October downpour, USGS technician James Starr visits every 24 hours to remove samples. On the banks of the raging river, atop a barren concrete platform, Starr unhooks a water pump festooned with tubes. Every hour on the hour for the past day, the pump has switched itself on and sucked up river water to fill a narrow vertical flask. Starr’s job is to take these 24 flasks — each a different shade of muddy — and determine how much sediment they contain.

It’s been raining for a couple of days, and several of the flasks are full of chocolate-brown fluid. “I captured the spike in turbidity yesterday, and it’s still really high now,” says Starr, wiping his hands clean. Knowing

**Power versus habitats** The Elwha River (shown in 2012, before the dams came down) runs to the Pacific Ocean past the Lower Elwha Klallam tribal lands. The dams formed reservoirs and provided electricity but salmon populations plummeted.



how much silt is flowing through here, and how it changes over time, is helpful to scientists trying to protect the local water supply.

Eventually, most of the sediment flowing through this diversion will make it all the way to the ocean. As the dams started to come down, pilots flying over the coast photographed the huge muddy plume that poured out. The high levels of sediment began to affect the marine ecosystems just offshore from the river's mouth. The lush kelp forests that once covered the seabed began to die.

"You could see it right away," says Steve Rubin, a USGS biologist in Seattle who leads annual dive surveys to see how the dam removal is affecting marine life. "It was pretty dramatic."

Kelp need sunlight to photosynthesize, and the sheer amount of sediment in the water may have made it too dark for them to survive, Rubin says. In an early underwater trip just months after the first dam came down, Rubin and his dive team found themselves in water so pitch-black that they had to grab one another to communicate.

With time, the sediment is clearing, but the experience offers clues to what happens when rivers unleash sediment that's been pent up for decades behind dams.

### For the salmon

The main argument for taking out the Elwha dams has always been the salmon. The river is one of the few that is home to all five native species of Pacific salmon that live part of their lives in freshwater and part in the ocean. They are born in rivers and lakes, then swim down to the sea and venture into the deep ocean. They eat rich marine food and grow much larger before they feel the call to return to their native streams to spawn. These big salmon then make their way upriver to mate near their birthplace.

Unless a dam blocks their way. Then they travel as far as they can, turn around and search for an alternate place to spawn. During the 2011 ceremony to mark the beginning of the dam removals, Duda and others standing atop Elwha Dam looked down at the river below and saw fish circling on the downstream side of the dam, as if awaiting the chance to finally break through and swim upriver.

When the dams came down, many fish began traveling upstream naturally from the ocean. Other salmon are raised in one of two local fish hatcheries and then physically transported up the Elwha. Conservationists have sued to stop this practice, saying that stocking the river with hatchery fish makes it harder for wild fish to survive. Legal battles continue.

The fish seem to be doing fine. As first the Elwha and then the Glines Canyon dams came down, the salmon surged past the old barrier and colonized the river above.

Pink salmon (below), steelhead trout (right) and other native fish are making a strong return to the Elwha now that they have access to the full run of the river.



And they are reproducing there. Fresh sediment released from behind the dams fills in and enriches areas on the riverbed that had once been bare stones, turning them into a richer, more diverse environment where salmon can lay their eggs. In September, as Amy East was doing topographic surveys of the riverbed, she came across spawning nests, known as redds. "I had to be careful where I walked because I didn't want to disturb the redds they just created," she says. "We had never seen this before — it was so cool to see that it actually worked."

Tribal, state and federal experts now conduct snorkel surveys, along with sonar and radio tagging studies, to count the numbers and species of fish as they return. Full results are not yet out, but the populations are beginning to soar, says George Pess, a fisheries biologist at the National Oceanic and Atmospheric Administration in Seattle.

One measure of ecological success is the number of redds in the river, and surveys in certain river stretches found about 400 redds after the first dam came down. That number leaped to 800 in 2013 and nearly 1,100 in 2014. Biologists are also seeing successful matings between fish that have returned from the sea and fish that have not made it out of the Elwha watershed. "The cool thing is, we've seen these fish interacting with each other in a positive fashion," Pess says. "You can have a 15-pound female mate with a 12-inch male."

Researchers have seen different salmon species starting to colonize the areas with which they were historically associated before the dams were built. Sockeye salmon, for instance, typically like to live in lakes, and they are appearing in a tributary of the Elwha that leads to a mountain lake. The eel-like fish known as lamprey have moved into the middle section of the Elwha, between the two former dam locations, where they were once as populous as salmon.

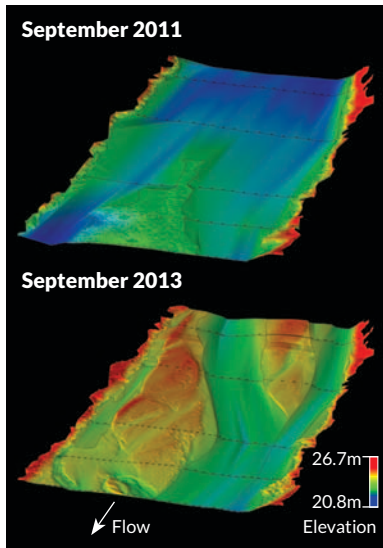
Scientists plan to use what they learn from the Elwha to help those dealing with other dams. East has been working on a dam removal project on the Carmel River in California, where engineers want to drain the reservoir without flushing the sediment downstream. Data from the Elwha could help



those engineers figure out how much water they can safely release without carrying too much sediment, says East.

The work could even help engineers who are still building dams. Many places in East Asia are going through a massive dam-building phase. Duda recently took a group of Mongolian environmentalists around the Elwha, showing them the trees that drowned and the fish that were cut off when the dams went in. Understanding the changes that are likely to happen could help them better prepare, he says, to focus conservation efforts on species likely to suffer the most.

On the Elwha, the story will develop for decades to come. Geomorphologists will continue to survey the landscape, watching as new channels and sandbars form in a river still in flux. Biologists will count



As the two dams came down, flowing sediment resculpted the Elwha's riverbed, forming new sandbars (lower river seen above).

returning fish, along with the birds and other wildlife that will come to feast on the newfound salmon.

Back on the riverbanks, the concrete remains of the former Glines Canyon Dam tower overhead like something out of a lost civilization in a Tolkien novel. All around Duda, tiny seedlings spread outward on the riverbanks. They have been planted in this former reservoir to encourage native trees to take hold and grow a fresh forest for the Elwha.

"We've got a lot of work to do here still," says Duda. "We're not nearly done yet." ■

### Explore more

- J. Gussman and J. Plumb. *Return of the River*. [www.elwhafilm.com](http://www.elwhafilm.com).
- L.V. Mapes. *Elwha: A River Reborn*. Mountaineers Books, 2013.

## 'Locally extinct' fish discovered spawning in the Grand Canyon

The decline of a species whose habitat has been drastically altered by a dam can sometimes be reversed — even when the dam remains in place, according to recent findings in Grand Canyon National Park. After an extensive ecosystem restoration effort, biologists working in the park in April discovered newly hatched razorback suckers (*Xyrauchen texanus*). The endangered fish are endemic to the Colorado River and its tributaries but they were thought to be locally extinct in the Grand Canyon for the last two decades.

Distinguished by the narrow, bony keels on their glossy gray backs, razorback suckers "are spectacular fish," says biologist Mark McKinstry, of the U.S. Bureau of Reclamation in Salt Lake City. "They can live for 40 years and travel up to 1,000 kilometers upstream."

Once found throughout the Colorado River basin, razorbacks now exist in just a few isolated spots, including Lake Mohave in Arizona and Lake Mead, the reservoir downstream of the Grand Canyon. Glen Canyon Dam, completed just 24 kilometers upstream of the national park in the 1960s, has fundamentally changed the river's chemical, physical and biological environment in the Grand Canyon, boosting the number of nonnative predatory fish and sending the native fish populations into a tailspin. By 1991, the razorback sucker was listed as endangered.

When razorbacks manage to spawn, other fish eat the eggs and prey on surviving juveniles, so few offspring make it to adulthood. Following unsuccessful attempts to establish populations in other southwestern rivers, biologists were convinced the species' survival required "an extensive restocking effort," McKinstry says.

To assist with native fish recovery, the National Park

Service removed predatory fish and the Bureau of Reclamation changed dam operations (designed to minimize "river tides," restrict minimum flows and mobilize sediment to rebuild crucial habitat). Yet despite these efforts, not a single razorback had been sighted in the Grand Canyon since 1995. That is, until 2012, when biologists captured an adult razorback sucker in the park.

Anticipating that the lower Grand Canyon might now host a population of these fish, researchers released nine razorbacks there in March. They hoped the fish, each carrying a sonic tag, would lead them to wild razorbacks and potential spawning grounds.

A month later, monitors detected several of the tagged "scouts" — plus the completely unexpected larval razorbacks.

"The findings of larvae this year, and a lot of them, suggest that more fish are using the river than originally thought," says McKinstry. — Terri Cook



Razorback suckers, listed as endangered in 1991, are finding their way back to the Grand Canyon.