The salmon diaries: Life before and after Klamath Dam removal

July 16 2024, by Kat Kerlin

A view of Iron Gate Dam in November 2023, just a few months before becoming one of four hydroelectric dams being removed from the Klamath River. Credit: Alysha Beck/UC Davis

When salmon return from the ocean to the Klamath River after the world's largest dam removal project ends this fall, they will regain access

to 400 miles of historical spawning habitat their species has been cut off from for more than a century.

From the river to the lab, looking at the very ear bones of fish, scientists with the University of California, Davis, are playing a key role helping to answer a big dam question: Will it work? Will a diverse population of salmon thrive again once the dams are removed and the Klamath River restored?

The answers are important not only for the Klamath but also for dams across the world that have outlived their usefulness. Less than 100 miles south of Klamath, for instance, is the Eel River, where a dam is slated to be removed in 2028. In 2023 alone, 80 dams were demolished across the U.S.

"It will work," said Robert Lusardi, a freshwater ecologist and assistant professor in the UC Davis Department of Wildlife, Fish and Conservation Biology. "There's nothing better we could do for fish and for people in Northern California and throughout the world than to remove these dams. But if we don't track and try to better understand how things are changing, we're not going to understand their importance for future efforts."

The Yurok Tribe and the fight for the Klamath River

The mouth of the Klamath River empties into the Pacific Ocean along California's northernmost coastline in the town of Klamath, on the ancestral lands of the Yurok Tribe. Here, cold surf crashes against sea stacks amid piles of driftwood. The sun is shining on this often foggy beach, warming a wintry November day at the end of the 2023 fall-run salmon season.

Barry McCovey, director of the Yurok Tribal Fisheries Department,

points to a flicker of silver wriggling in a cove. "Pacific lamprey," he said.

The eel-like fish inches itself back to the safety of the estuary. Like salmon, steelhead and sturgeon, the native species is anadromous, spending part of its life in the river and part in the ocean. The mouth of the Klamath is a critical gateway for these species. Yet it's one that—for a century up until 2024 —could take them only so far, to Iron Gate Dam, beyond which await hundreds of miles of unreachable spawning habitat.

The four hydroelectric dams being removed—J.C. Boyle, Copco No. 1, Copco No. 2 and Iron Gate—were built between 1908 and 1962 to produce energy upstream of the Yurok, Hoopa and Karuk tribes and downstream of the Klamath Tribes of Oregon. Reduced water quality and drastic salmon declines followed. The once abundant spring-run Chinook are down to less than 2% of pre-dam populations.

"When the dams went in, the tribal people in the Klamath Basin weren't consulted," McCovey said. "That was offensive, and people were uncomfortable with that and have been for over 100 years. We knew we needed to get the dams out. We knew that you can't just go and break an ecosystem in half."

Beth Rose Middleton Manning, a professor of Native American studies at UC Davis, said tribes were rarely consulted throughout the history of U.S. dam construction.

"In almost every location where there's a dam, there's a history of displacement, disruption and putting in that infrastructure without the consent of the communities and nations whose homeland that is," she said.

"The river is who we are," said Hoopa Valley Tribe member Brittani

Orona, a Hupa scholar and postdoctoral fellow at UC Santa Cruz. "Without fisheries, without this river, we cease to be Hupa, Yurok and Karuk peoples."

The mouth of the Klamath River empties into the Pacific Ocean along California's northernmost coast, marking a gateway for salmon and other anadromous species. Credit: Alysha Beck/UC Davis

McCovey remembers when dam removal seemed an impossible dream. Tribal members were laughed out of the room when they proposed it. Then, in 2002, the deaths of at least 30,000 salmon marked a turning point, and a rallying cry to "undam the Klamath" rose from Native and non-Native voices, policymakers, lawyers, scientists and the public.

In 2022, the Federal Energy Regulatory Commission surrendered the four dams' license and approved the decommissioning project. Demolition began in 2023 and is expected to conclude this fall—in time for Chinook salmon returns.

FERC's announcement was momentous. But for McCovey and many others who had waited their entire lives to hear it, dam removal had to be seen to truly be believed.

"Seeing Copco come down and actually holding a piece of that dam in my hand kind of solidified that, OK, this is really happening," McCovey said.

Now he's working with partners to ensure the river is safe and hospitable for returning salmon.

"The juvenile fish that left a couple of years ago are going to be coming back to a completely different river," he said. "It's an exciting time to be a salmon in the Klamath River."

Below Iron Gate Dam: Chinook salmon

Inland and upriver, the landscape changes from green, foggy redwood forests to cream-colored meadows tipped with frost. Nearby Mount Shasta cuts stark angles across the horizon. Below the highway, anglers in drift boats fish for steelhead, which are also expected to benefit from an undammed river. We travel as far as the salmon can, to Iron Gate Dam.

On this late November morning, just two months before Iron Gate is breached, the construction site beeps and grumbles as trucks dig and scrape alongside the dam. Below, on the riverbank, crews from the U.S. Fish and Wildlife Service and the Yurok Tribe prepare pontoon boats

for the last weekend of this fall's fish carcass surveys.

"This is the coldest put-in I've ever felt," Lusardi said, pushing our raft into the river. It's about 32 degrees. Froth along the riverbeds has crystallized, and circles of ice form in the flotsam. Icicles hang from branches dangling in the water. Steam rises off the river as three deer swim across, their heads bobbing before reaching the bank.

With temperatures like this to return to, fall-run Chinook still come back each year below Iron Gate. Spring-run Chinook, however, are a different story. Once the largest run in the basin, spring-run Chinook are now a rarity. They move into the river during spring, and used to spend their summers in the cool, clean waters of the upper Klamath. But dams cut off access to those habitats, and what is left is too warm in the summer to support them.

"They're looking for cold water refugia, and that's what doesn't exist," Lusardi said.

"It's no surprise we lose spring-run Chinook when we cut off every habitat that helped them evolve," said Damon Goodman, California Trout's Mount Shasta-Klamath regional director, who accompanies us down the river.

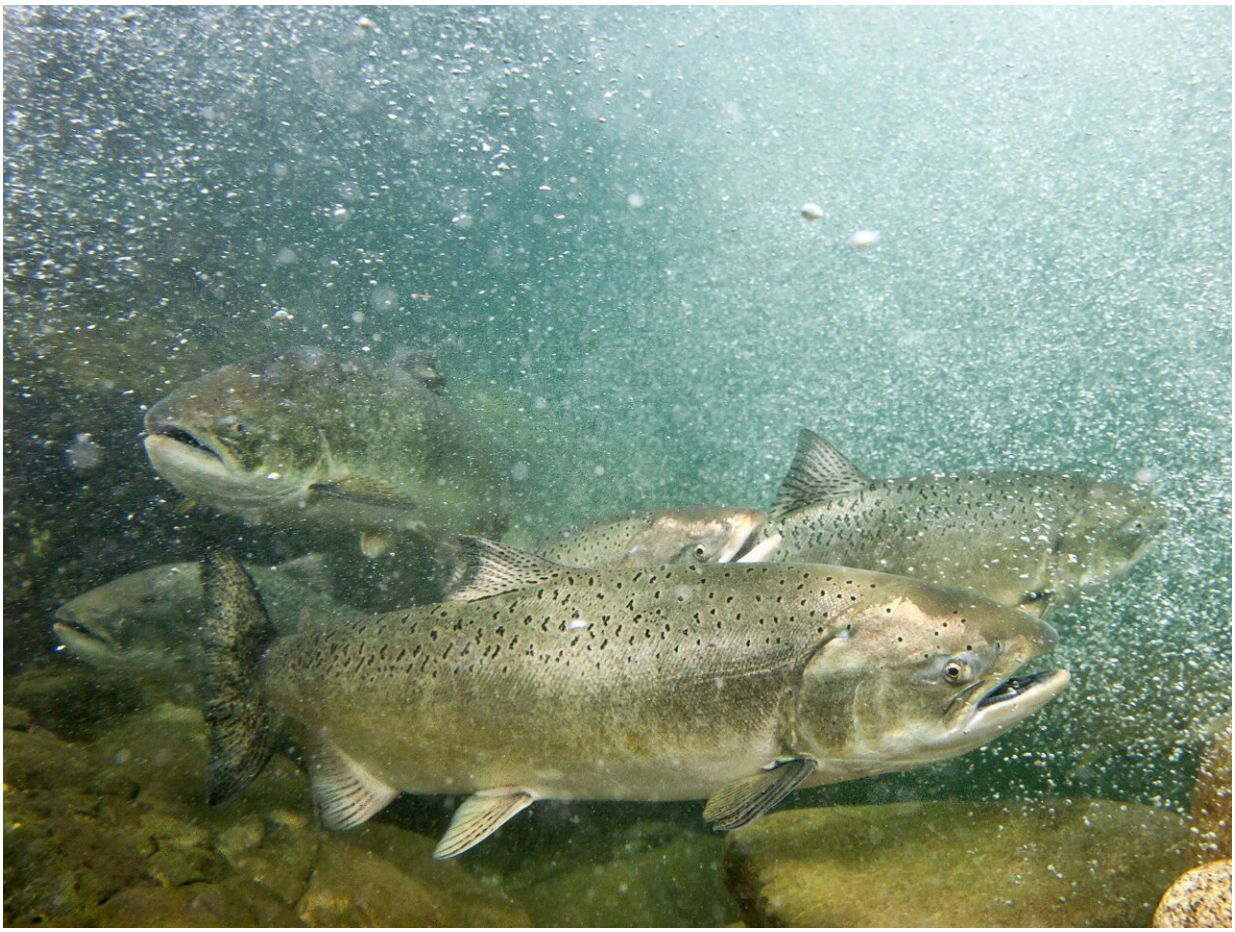
Importance of habitat diversity for wild salmon

In 2017's State of the Salmonids report, UC Davis fish biologist Peter Moyle and Lusardi warned that nearly half of California's native salmon populations were expected to go extinct in the state within 50 years, including spring-run Chinook. More recently, California canceled its salmon fishery for 2023 and 2024 due to low returns. The Yurok didn't even serve salmon at their annual salmon festival last summer over conservation concerns.

To understand how to possibly turn around this trajectory, it helps to go back at least 50 million years. As salmon evolved on the landscape, they developed a diversity of life experiences, what biologists call "life histories," that kept them resilient. Diverse habitats were incubators of life history diversity. Historically, habitats in the Klamath watershed produced salmon of different sizes, with different periods of migration and different behaviors. If a disturbance reduced some populations, others survived, ensuring their long-term persistence.

Levees and dams changed all that, cutting off access to diverse habitats. At the same time, hatcheries reduced genetic diversity. Climate change and warming waters exacerbate existing problems. These issues facing salmon in the Klamath are shared by rivers and native fish across the state and globe.

"When you homogenize the landscape, you homogenize the fish," said Lusardi. "Temperatures are changing; flows are changing. To deal with that, you need genetic and behavioral diversity. Removing a dam and providing access to these historical habitats allows these animals to recreate some of that diversity that is so important for their future persistence."



Spring-run Chinook are struggling amid habitat loss, climate change and other threats. Credit: Peter Bohler

Tell-tale traces of strontium in otoliths

On this day, the Yurok and USFWS crews glide along the edge of the river looking for dead salmon. Leanne Knutson of the Yurok Tribe stands up in the boat holding a long pole with a hook at the end. When she sees—or smells—a dead fish, she scoops it with the hook, lifting it from the water. Sometimes it's a keeper. Usually it disintegrates, this late in the season.

Salmon deemed fresh "enough" for science are collected and measured. Their otoliths—tiny ear bones—are removed and given to Lusardi for lab analysis at UC Davis. These otoliths, and the strontium signals they carry within them, are key to understanding where and how salmon use the river.

Jamie Holt, a fish technician with the Yurok Tribe for about 25 years, records each fish from the back of the boat.

"I never thought I'd have a life's work that amounted to something, but here we are," Holt said.

Before we leave, Holt hands Lusardi an open box full of plastic bags sloshing with aquatic insects. He'll take these back to his lab for more analysis, more clues to understand this changing river.

"There are a lot of us with high hopes," Goodman said. "Others think it's a boondoggle. We need to be able to tell the story accurately so we can learn from it and refine what we do in the future. Science and data are a huge part of that."

Tracking a salmon's life with strontium signals

Back at UC Davis in the spring, junior specialist and lab manager Sarah Howe sits at a lab table at the Center for Watershed Sciences. She holds a tiny white fragment in her hand. It's an otolith, pulled from the brain cavity of a salmon collected the previous fall on the Klamath River.

Howe places the otolith on a slide, then grinds it in concentric circles over black sandpaper, using a device a jeweler might use to polish a gem. She checks her progress under the microscope beside her, then flips the otolith over. The susurrous grinding continues until she reaches the otolith's core.

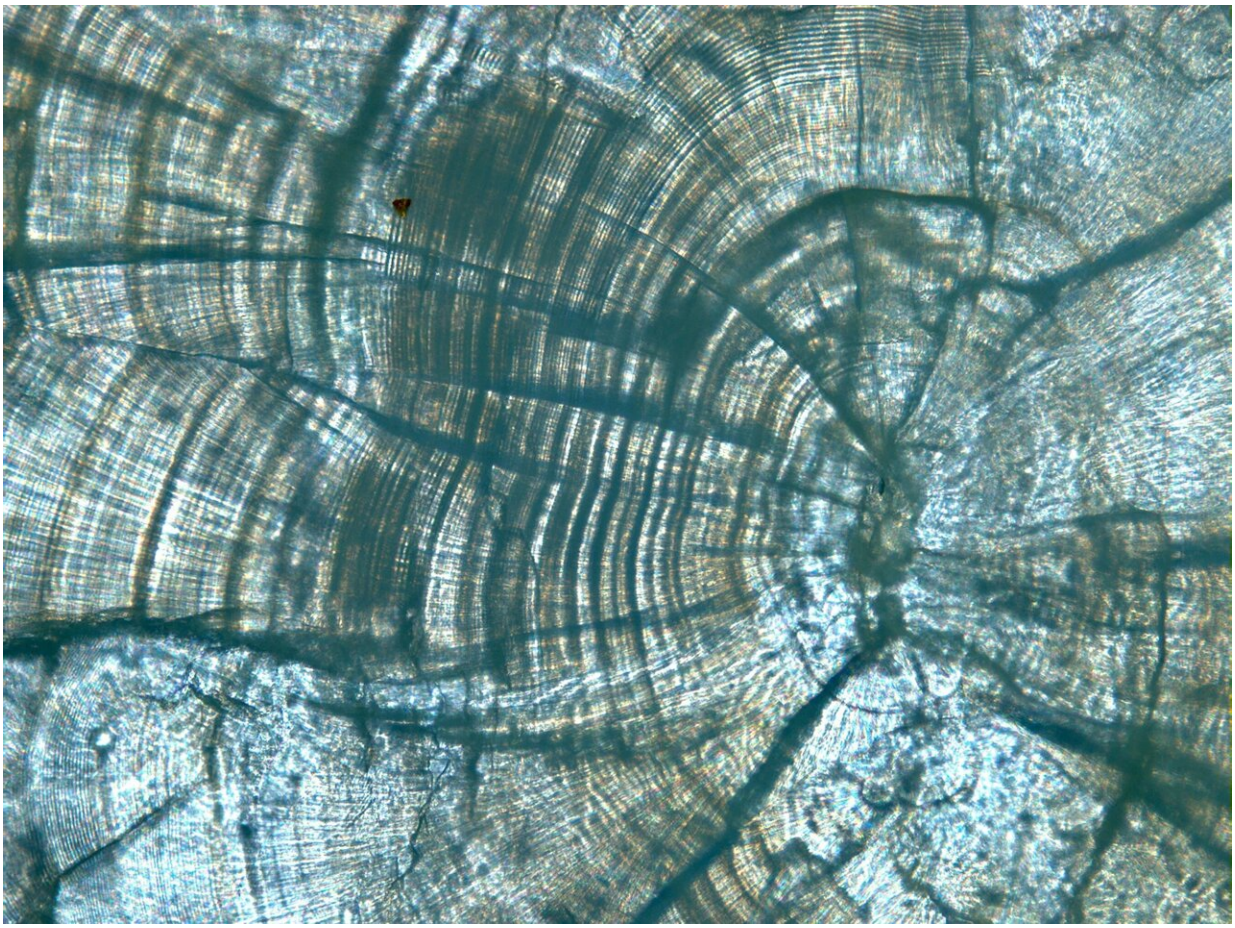
"It's a mundane process," she acknowledged. But it's helping to answer huge questions of ecological, economic, cultural and spiritual significance. "This will give us a view of the fish's entire life history."

That's because of strontium, a naturally occurring element reflective of a watershed's changing geology. As a salmon swims over the rocks and streams of its life, it picks up traces of strontium and stores them in its otoliths until it dies.

Using a technique pioneered by project collaborator Rachel Johnson of National Oceanic and Atmospheric Administration Fisheries, Lusardi's lab has spent the past four years sampling strontium in the water of different streams throughout the Klamath Basin to create an "isoscape"—a map of strontium signals throughout the watershed they can match to the otolith of an individual fish.

"No one has done the strontium otolith work with any dam removal project anywhere," Lusardi said. "We're chasing diversity. This project is the first to look at this question of life history diversity related to dam removal. It will tell us where the fish go, the habitats that they use, and when they leave."

Once Howe's polishing concludes, the shiny white otolith core gets packaged and sent next door, to the UC Davis Department of Earth and Planetary Sciences, where it will be laser blasted to reveal its strontium content in fine detail.



An otolith, like this one from a Klamath River salmon, reads like a fish's diary, with each ring representing a day of the fish's life. Credit: George Whitman and Claire Inouye/UC Davis

Reading a fish's diary: Insights from salmon otoliths

At the other end of the lab, Center for Watershed Sciences staff researcher George Whitman looks at what appears to be a large, white tree ring on his computer screen. The image is of an otolith, and each ring represents a day of the fish's life. Whenever the fish undergoes stress, it lays down a darker line.

"Being born is stressful, apparently," he said, pointing to a deep line along the image's first layer.

Another line indicates when the fish lived in gravel as a small fry, when it left the river where it was born, and when it entered the ocean.

"I like to think of it as the fish's diary," Whitman said.

Reading many diaries like this one will tell the story of salmon before and after Klamath dam removal. Lusardi's lab collected four years of otolith samples before the dams were removed and has since processed about 200 otoliths. They'll compare their strontium signals to those collected after the dams come down as surveys continue along the river.

Combined with the lab's work investigating the implications of dam removal on water quality, the food web and the reintroduction of spring-run Chinook to the upper basin, this research will unlock how the life history of salmon can be improved and which new habitats they're using.

"Imagine you've spent millions of dollars restoring a creek," Lusardi said. "You might want to know if fish are actually using it, and if not, why not. Right? We can get at some of those answers."

Future environmental impact of Klamath dam removal

The world will be looking to the Klamath River as other dam removals occur. Those involved in this historic effort are looking forward to documenting and passing on the lessons learned here about community, policy, science, persistence and the patience needed to help mend a broken system.

"Dam removal is not just a drop in the bucket," Lusardi said. "We need more projects like this to recover salmon and fish. This is the best possible thing for the Klamath River, but the response won't be immediate."

The Klamath is undergoing major surgery after a century of pain. Healing will take time.

This spring, Klamath Basin residents have watched the reservoirs drain, billions of seeds the Yurok planted along the basin bloom, and a river begin to find itself again.

"I think the biggest takeaway is that it's possible," said McCovey. "What we've been through here on the Klamath can provide hope to people. There are diametrically opposed viewpoints throughout the basin, but we somehow managed to pull everyone together and make this happen. It wasn't always pretty, and the strategies didn't always work, but somehow, at the end of the day, we're here."

Provided by UC Davis

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