

Survivor salmon that withstand drought and ocean warming provide a lifeline for California Chinook

November 1 2021, by Michael Milstein



The Central Valley spring-run Chinook salmon is a threatened species. Credit: Carson Jeffres UCD

In drought years and when marine heat waves warm the Pacific Ocean, late-migrating juvenile spring-run Chinook salmon of California's Central Valley are the ultimate survivors. They are among the few salmon that survive in those difficult years and return to spawning rivers to keep their populations alive, according to a study published October

28 in *Nature Climate Change*.

The trouble is that this late-migrating behavior hangs on only in a few rivers where [water temperatures](#) remain cool enough for the fish to survive the summer. Today, this habitat is primarily found above barrier dams. Those fish that spend a year in their home streams as juveniles leave in the fall. They arrive in the [ocean](#) larger and more likely to survive their one to three years at sea.

Researchers led by first author Flora Cordoleani, associate project scientist with the Institute of Marine Sciences at UC Santa Cruz and NOAA Fisheries, based their findings on an analysis of the ear bones of [salmon](#), called otoliths. These bones incorporate the distinctive isotope ratios of different Central Valley Rivers and the ocean as they grow sequential layers.

The team used otolith data from returning (that is, successful) adult spring-run Chinook salmon to reconstruct their juvenile outgoing migration patterns and growth rates, focusing on two tributaries of the Sacramento River without dams that begin beneath Lassen Peak, north of Sacramento. Late-migrating juveniles from Mill Creek and Deer Creek returned from the ocean at much higher rates than more abundant juveniles that leave for the ocean earlier in the spring.

The different timing characteristics of the fish are referred to as "life-history strategies." Those with a late-migrating life history strategy represented only about 10 percent of outgoing juveniles sampled in fish monitoring traps. However, they were about 60 percent of the returning adult fish across all years, and more than 96 percent of adults from two of the driest years.

"Some years the late migrants were the only life-history strategy that was successful," Cordoleani said. "Those fish can make it through the

difficult drought conditions on the landscape because they come from the few remaining rivers with accessible high-elevation habitats where water is cool enough through the summer."



The late-migrating juvenile spring-run Chinook salmon are crucial to the survival of the population in drought years. Credit: Jeremy Notch, UCSC

Recovery strategies

The finding underscores the importance of providing secure cool-water habitat for fish so they can survive difficult conditions during drought and ocean warming, said senior author Rachel Johnson, a research scientist with NOAA Fisheries and UC Davis. "Most salmon blocked from their historical habitats appear to migrate just too early and perish once they encounter the warmer water temperatures during droughts," she said.

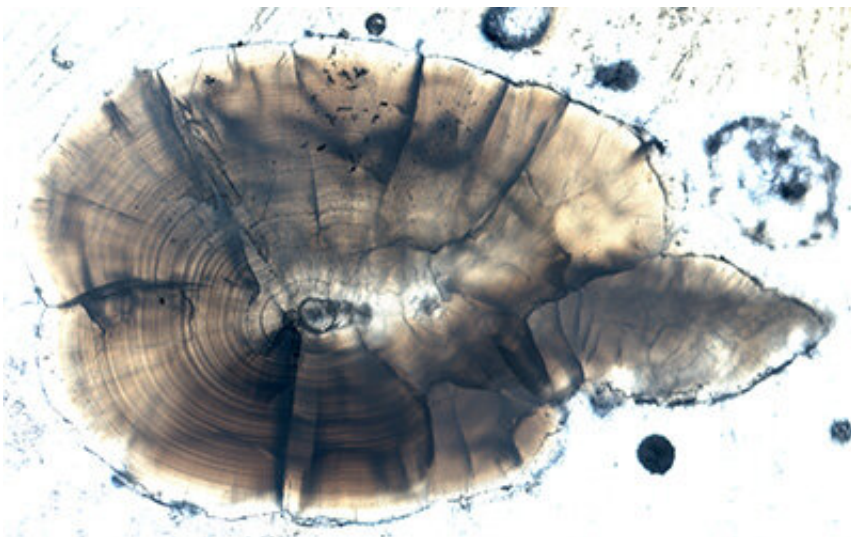
Coauthor Corey Phillis at the Metropolitan Water District of Southern

California said, "It appears the late-migrating life history has evolved as an insurance policy against the unfavorable spring river conditions that occur during droughts."

The study also projected how Central Valley river temperatures would rise with climate change, leaving only a few higher-elevation rivers cool enough to still sustain salmon. Many of those areas are above existing dams without fish passage.

NOAA Fisheries has outlined reintroduction of salmon to cold-water rivers above dams as a critical recovery strategy for endangered Sacramento River winter-run Chinook. The reintroduction of threatened spring-run Chinook salmon to the San Joaquin River watershed has taken hold. Offspring of reintroduced spring-run Chinook salmon are now returning from the ocean. NOAA Fisheries is also advancing the reintroduction of spring-run Chinook to the upper Yuba River upstream of Englebright Dam.

The study found that temperatures would remain cool enough for salmon to survive in the north Yuba River as the climate changes.



This photo of an otolith (salmon ear bone) shows the visible growth rings. Researchers analyzed isotope ratios in the growth rings to reconstruct migration patterns and growth rates. Credit: George Whitman UCD

"We need to reconnect salmon to their historical habitats so they can draw from their own climate-adapted bag of tricks to persist in a warming world," Johnson said.

By growing for a year in their home river, the later-migrating fish head for the ocean bigger than the others and in cooler temperatures. That way, more survive and return to rivers to spawn when marine heatwaves warm the ocean and depress salmon survival. A Marine Heatwave Tracker developed by the Southwest Fisheries Science Center shows that heatwaves have become an increasing presence in the Pacific Ocean in the last decade.

Heatwaves reduce survival

A large heatwave currently stretching across the Pacific off Northern California and Oregon, as shown by the tracker, may affect salmon survival. Warmer ocean waters are generally less productive, reducing salmon survival and depressing returns to rivers.

The researchers highlighted the importance of protecting varied life histories that may help a species survive climate change. This is particularly true in California, which is at the southern end of the range of many salmon and at the edge of conditions where they can survive.

"The rarest behaviors observed today may be the most important in our future climate," said coauthor Anna Sturrock of the University of Essex.

In conclusion, the authors wrote, "We show for the first time that the late-migrating strategy is the life-support for these populations during the current period of extreme warming. As environmental conditions continue to shift rapidly with [climate change](#), maximizing habitat options across the landscape to enhance adaptive capacity and support climate-resilient behaviors may be crucial to prevent extinction."

More information: F. Cordoleani et al, Threatened salmon rely on a rare life history strategy in a warming landscape, *Nature Climate Change* (2021). [DOI: 10.1038/s41558-021-01186-4](https://doi.org/10.1038/s41558-021-01186-4)

Provided by University of California - Santa Cruz

Citation: Survivor salmon that withstand drought and ocean warming provide a lifeline for California Chinook (2021, November 1) retrieved 2 May 2024 from <https://phys.org/news/2021-11-survivor-salmon-drought-ocean-lifeline.html>

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