How young salmon navigate a gauntlet of danger en route to the sea

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Mike Gil tracking fish movement in the Gulf of Thailand. Credit: Heather Hillard

For young salmon, the journey along the San Joaquin River in Central California is no small feat. Every spring and fall, thousands of these

fish—each as long as a pinky finger—embark on a 350-mile race, swimming day and night and dodging predators along the way to reach the Pacific Ocean.

But less than 5% survive the journey, and in some years, hardly any make it. Elevated water temperatures, dams and poor water quality all endanger the animal, but human-introduced predators, including striped and largemouth bass, kill most of them.

In a new CU Boulder-led study, researchers reveal how these salmon learn to swim in different parts of the river at different times of day to avoid predators and conserve energy. The study was published in the journal *Ecology Letters*.

"The salmon fishery in the San Joaquin River delta area is on the verge of collapsing," said Mike Gil, the paper's first author and assistant professor in the Department of Ecology and Evolutionary Biology. "We know these juvenile salmon are getting wiped out on their migration to sea. We need to know why and how this is happening, and if there are opportunities to leverage conservation practices."

After spending their first year in the river where they hatched, juvenile salmon migrate to the ocean to access the nutrients they need to mature. Once they reach reproductive age, adult salmon return upstream to spawn.

According to the California Department of Fish and Wildlife, the population of Chinook salmon migrating in the fall in the Sacramento and San Joaquin river systems has dropped from 872,669 in 2002 to 79,985 in 2022—a 90% decline in just two decades.

Gil and his team placed trackers in 424 juvenile Chinook salmon, as well as 23 striped bass and 17 largemouth bass. Using detectors placed along

the riverbanks, the team monitored the activities of salmon and their predators, including when and where predators attack the most, for two months as they traveled through the San Joaquin River.

They found that salmon migrate over a much longer distance at night, a behavior that scientists had previously observed without fully understanding why.

The team's data showed that during the day, predatory bass tend to concentrate and attack more frequently mid-river, where salmon prefer to swim. There, the currents flowing toward the sea are stronger, so salmon can ride the water downstream, saving energy.

To avoid those bass, young salmon have adapted to migrate mid-river at night. Meanwhile, by day, they seek refuge near the riverbanks—even though that means expending more than double the energy to swim the same distance.

"Intuitively, one would think these fish should just be taxiing right down the middle of the river all the time, so they can get out to the ocean and get away from all these terrifying predators as fast as possible. But that's not what we saw," Gil said. "Our study suggests that bass activities are forcing these fish to adopt a different strategy."

The researchers also found that during dawn and dusk, predator attacks spiked. Gil said this is likely because striped bass, with their bigger eyes, can see better in low-light conditions than juvenile salmon, which have smaller eyes.

"These fish seem to really pick up on changes in ambient lighting," Gil said.

He hopes that the findings could help direct efforts to save local salmon

populations.

For example, limiting light pollution at night in towns near the river and its estuaries could help these fish survive.

"We as humans are quite limited in our understanding of how animals in the wild behave. By better understanding this, we can make the most informed decisions about how to keep these species around," Gil said.

More information: Michael A. Gil et al, Integrating Landscapes of Fear and Energy Reveals the Behavioural Strategies That Shape Predator–Prey Interactions, *Ecology Letters* (2025). DOI: 10.1111/ele.70068. onlinelibrary.wiley.com/doi/10.1111/ele.70068

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