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Chinook salmon. Photograph courtesy of Michael Humling, U.S. Fish and Wildlife Service

Protecting California's Bay-Delta with Innovative Science

By Donyelle Davis and Paul Work

California's Bay-Delta is facing ongoing drought and declining fish populations. The water in the Delta arrives primarily from the Sacramento and San Joaquin Rivers, supplying water for more than 22 million people. This water source supports California's trillion-dollar economy—the sixth largest in the world—and its $27 billion agricultural industry.

The Bay-Delta: A Critical Ecosystem

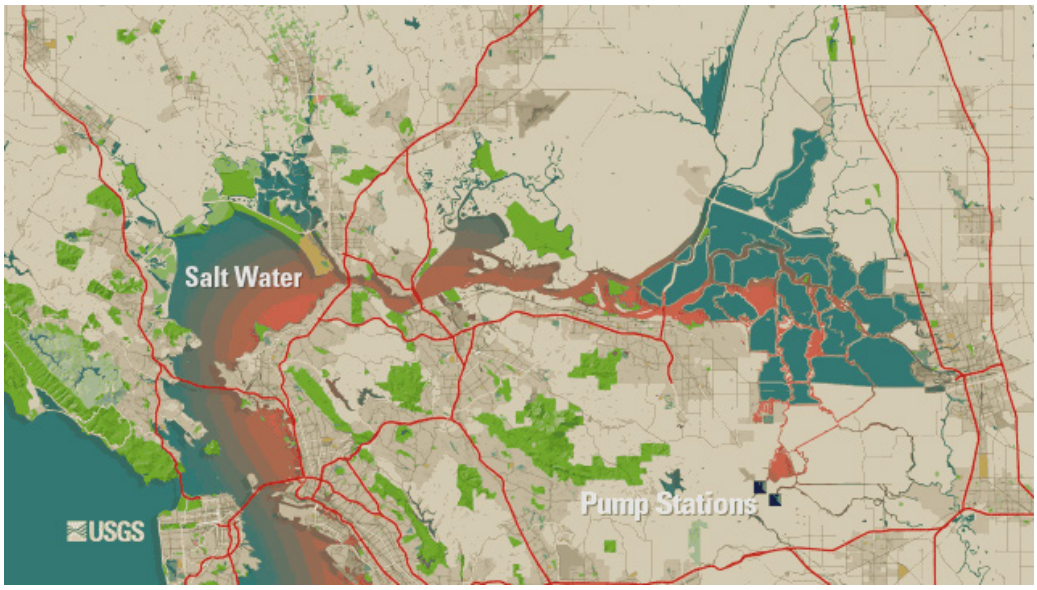
The San Francisco Bay and Sacramento-San Joaquin River Delta—known in California as the Bay-Delta—is a 1,600-square-mile estuary and habitat for more than 500 species of wildlife.

The Delta has been heavily modified by humans and the water that flows into, through, and out of the Delta is carefully controlled. The Delta is the central hub of California's water system.

The natural outflow of the Delta is to the San Francisco Bay and the Pacific Ocean, but water is also pumped into small diversion canals for local uses and into two large water systems: the Central Valley Project and the State Water Project. Both systems deliver water to cities and farms south of the Delta.

Despite efforts by local, State, and Federal agencies to balance water deliveries and the Delta's ecological health, the Delta is failing to support sustainable populations of key species like the Chinook salmon and the Delta Smelt. In the face of ongoing drought and declining fish populations, regulators restricted pumping from the Delta.

"Salmonids in the San Joaquin River Basin were once abundant and widely distributed, but currently face numerous limiting factors." explains Jacob McQuirk, supervising engineer at the California Department of Water Resources (DWR), the agency that maintains the State Water Project. Agencies like DWR are exploring new strategies to restore fish populations and improve the reliability of water deliveries south of the Delta.



In addition to the Delta's natural outflow, water is also pumped into small diversion canals for local uses and into large water systems.

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Tracking Fish Movement and Survival

Scientists are using an advanced technology called acoustic telemetry to help water managers assess the effectiveness of strategies designed to protect fish. Acoustic telemetry uses transmitters and receivers to track fish movements. Transmitters are electronic tags implanted in fish that emit sonic pulses. Underwater receivers called hydrophones then "listen" for these pulses, which are emitted when a tagged fish swims near a hydrophone. These data allow scientists to track fish movement, better understand where fish are migrating, and identify how factors such as water temperature, clarity, salinity, flow, and availability of food are affecting their survival.

To implement effective strategies that protect fish populations, water managers need detailed information on the stressors that affect their survival in the Delta. In 2011 and 2012, U.S. Geological Survey (USGS) scientists applied acoustic telemetry to evaluate a project that steered fish toward a preferred migration path and could increase their chance of survival.

The project used a nonphysical barrier called a "Bio-Acoustic Fish Fence," or BAFF, that uses light and sound to deter fish from moving from the Sacramento River into smaller sloughs and waterways, where they are less likely to survive. The study used thousands of acoustically tagged juvenile Chinook salmon to see if the fish in the Sacramento River could be deterred when they reached a diversion known as the Georgiana Slough.

USGS crews during Bio-Acoustic Fish Fence experiments in 2011 and 2012. Photograph credit: California Department of Water Resources

An Effective Fish Protection Strategy

The results of the acoustic telemetry study showed that fewer tagged salmon migrated into the Georgiana Slough when the BAFF was on, which led to significant increases in deterrence, protection, and overall survival rates for juvenile salmon.

"We've used the USGS's expertise in our efforts to improve migrating juvenile salmonid survival and comply with National Marine Fisheries Service required actions to evaluate engineering solutions to keep out-migrants from taking paths of lower survival into the interior Delta," says McQuirk.

This nonphysical-barrier study was an interdisciplinary, interagency effort involving the U.S. Bureau of Reclamation, DWR, and the USGS. The USGS led the design and deployment of the acoustic telemetry network, fish tagging, characterization of water flows, data processing, and evaluation of the effectiveness of the BAFF compared with other types of barriers.

"The USGS leveraged the massive amounts of acoustic telemetry and flow data to determine the optimal barrier alignment to maximize salmon protection," McQuirk says. "Although we are still awaiting the necessary funding to complete the design, construction, and operation of the new BAFF, plans are being made to build the new barrier with the optimized alignment as soon as funding is available."

The USGS is uniquely positioned to provide the multidisciplinary science necessary to address the critical needs of the Delta ecosystem. When combined with the data from 42 USGS real-time water flow and water quality monitoring stations network in the Delta, tools like acoustic telemetry offer insight into the complex and fragile Bay-Delta system. This science is essential for water managers like McQuirk and other agencies that depend on timely, accurate data to make informed decisions about the future of the Delta and the State of California.

A USGS scientist surgically implants an electronic transmission tag. Photograph credit: USGS