# Sacramento River Steelhead: Hatchery vs. Natural Smolt Outmigration

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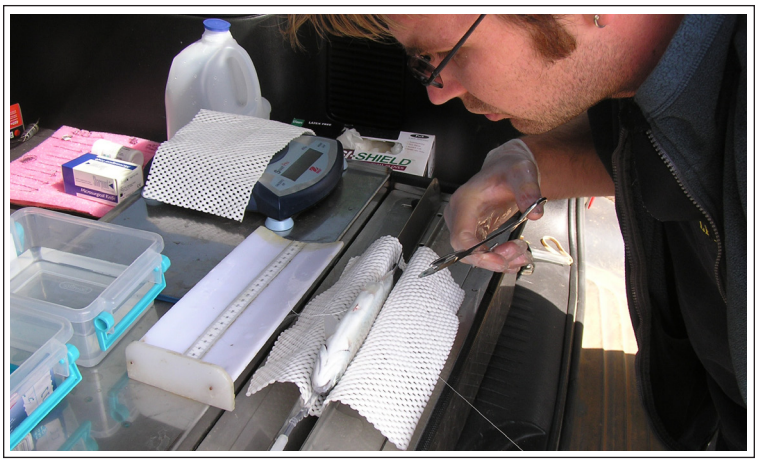
## BACKGROUND

The Sacramento River steelhead trout (*Oncorhynchus mykiss*) is a threatened species whose numbers are supplemented by the release of captive-bred juveniles. Each year, the Coleman National Fish Hatchery alone produces 600,000 yearling steelhead smolts and releases them into Battle Creek, a tributary of the upper Sacramento River. Smolts are young, silver trout (or salmon) that are ready to migrate to sea for the first time. The hatchery operations are mitigation for loss of natural steelhead in their historic spawning grounds. Coleman is one of several hatcheries in the Sacramento River basin that cultures steelhead for mitigation purposes.

An adult steelhead with a "geolocation" tag that detects Earth's magnetic field and daylight, allowing researchers to estimate the fish's position at sea to within a 60-kilometer radius. Photo: UC Davis

## PROJECT

This research explored the survivorship of outmigrating natural and hatchery smolts along various routes that they can take to reach the sea, in an effort to better identify bottlenecks in wild steelhead recovery, among other things. This was done by surgically implanting smolts with tiny pinging acoustic tags. The fish were then released into Battle Creek and two other locations on the upper Sacramento River and tracked via the California Fish Consortium's array of acoustic receivers, positioned along all major transit ways to sea. Over the course of a two-year period, more than 625 smolts were tagged, released and tracked. From the data, the Delta Science Fellow has been able to characterize and compare movement patterns and behaviors of wild and hatchery smolts at kilometer length scales and daylong time scales. Some of the major findings are presented here.



Delta Science Fellow Phil Sandstrom sutures an incision on a steelhead smolt. The smolt has had a tiny acoustic tag surgically implanted inside it. Photo: UC Davis

## FINDINGS

**Wild smolts are faster swimmers**. No matter what route they take to get to sea, natural smolts go the distance in less time. They also typically begin migrating immediately upon release. Hatchery smolts, in contrast, often stay near their release point for several days before moving downstream. This behavioral difference – the hatchery fish may be waiting for a different environmental cue, for example – tends to greatly increase the number of days a typical hatchery fish spends in the river system, irrespective of its slower transit times.

**Wild smolts exit the San Francisco Bay in a temporal cluster**. There is less variation in their transit times and greater coherency in when fish enter the ocean. For example, in 2008-09, all of the wild smolts that made it to the Golden Gate Bridge listening station did so within a five-day period (May 8-13), with an average transit time of 12 days and a range of 10 to 15 days. In contrast, the hatchery fish departed the bay over a seven-week period from Jan. 1 to Feb. 19, with an average transit time of 21 days and a range of 10 to 57 days.

**Outmigrating wild smolts enter the ocean later in the year, on average, than hatchery fish.** Besides the example given above, in 2009-10, hatchery-born migrants were detected passing the Golden Gate Bridge over a more than three-month period from Jan. 17 to April 24, compared with an April 15 to June 23 time frame for natural smolts.

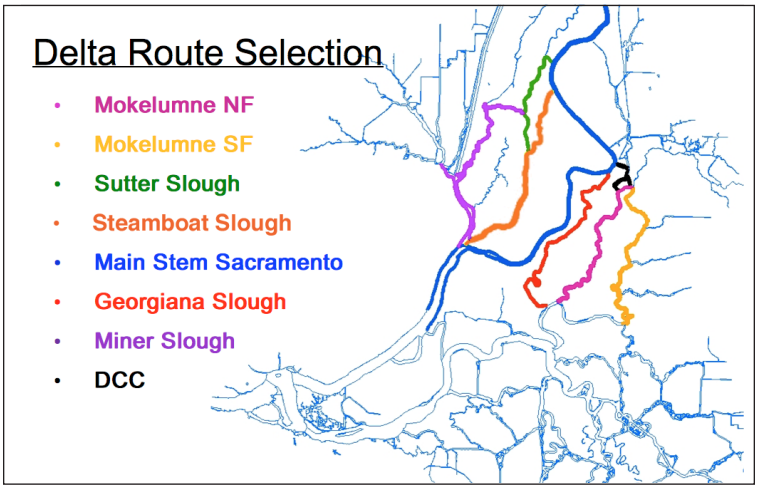
**Wild fish are less likely to die in transit.** Hatchery smolts had higher rates of mortality during their outmigration. Interestingly, the "death zone" for these young fish was not the delta's interior, but the upper Sacramento River itself. Depending on the year, between 30 percent and 60 percent of hatchery smolts perished within 50 kilometers of

where they were released. Once beyond that 50-kilometer mark, a fish's chances of survival rose markedly.

**Flow rates are sometimes predictive of hatchery smolt survivorship.** In 2008-09, scientists documented a strong relationship between the migratory success of hatchery steelhead smolts and peak flow rates. That year about 93 percent of the fish detected at the Golden Gate Bridge were from two groups of fish that had started their migrations during short surges in flows, from rains or snowmelt. A similar pattern was observed with fish that successfully navigated past the Red Bluff Diversion Dam.

**Hatchery juvenile steelhead are not attempting to outmigrate through the interior of the delta**. During the course of the study, only one tagged smolt was detected navigating through the Delta Cross Channel, a massive set of radial gates that can be opened and closed to control fresh water flows into the delta's interior. The majority of young steelhead navigate through the delta along the main stem of the Sacramento River, with roughly 25 percent of smolts following Georgiana Slough and the remainder split about evenly among routes through Sutter, Miner, and Steamboat sloughs, all of which feed into the main stem of the Sacramento River further downstream. Fish had high survival rates (greater than 80 percent) along all routes, except for Sutter Slough, through which survivorship fell to below 45 percent. Fish attempting to transit through Georgiana Slough in 2010-11 also had lower rates of survival (about 70 percent survived).

**There are not striking differences in outmigration routes selected by hatchery and wild smolts**. Hatchery and natural smolts were about equally likely to migrate down the main stem of the Sacramento River, though there was a slightly higher fraction of wild fish detected in the Georgiana Slough and lower fractions in Sutter and Steamboat sloughs. In addition, no wild steelheads were detected in Minor Slough. All wild smolts had high rates of survival through all these routes, except for in 2008-09 when mortalities were high on the main stem of the Sacramento River.




A schematic of the Sacramento-San Joaquin Delta with major outmigration routes for Sacramento River steelhead color-coded by transit way. DCC stands for Delta Cross Channel, a set of gates that opens and closes to control freshwater diversions into the interior of the delta, where water pumping occurs. Credit: P. Sandstrom

## OUTREACH

The Delta Science Fellow presented results from this project to NOAA Fisheries biologists who are drafting a biological opinion on the Long-Term Operational Criteria and Plan (OCAP), which coordinates the Central Valley and state water projects. He has also been invited to share his findings with U.S. Fish and Wildlife biologists, developing a monitoring program for steelhead.

## RESEARCH MENTOR

Peter Klimley, Wildlife, Fish and Conservation Biology at UC Davis

## COMMUNITY MENTOR

Joseph Merz, Cramer Fish Sciences, Gresham, Ore.

## RELEVANT LINKS

Biotelemetry Laboratory *http://wfcb.ucdavis.edu/www/faculty/Pete/pages/bio_sandstrom.htm*

California Fish Tracking Consortium *http://californiafishtracking.ucdavis.edu/org_davis_phil.shtml*

Delta Solutions Program *http://deltasolutions.ucdavis.edu/people/#panes:p-5*

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