Hatchery fish mask the decline of wild salmon populations

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Scientists have found that only about ten percent of the fall-run Chinook salmon spawning in California's Mokelumne River are naturally produced wild salmon. A massive influx of hatchery-raised fish that return to spawn in the wild is masking the fact that too few wild fish are returning to sustain a natural population in the river.

The study, published in the online journal *PLoS ONE*, highlights the danger of relying on census techniques to evaluate the health of wild salmon populations and their habitats. Most hatchery fish in California are unmarked and therefore undetectable in population surveys. For this study, the researchers were able to identify hatchery fish by using a novel technique to detect traces of a hatchery diet preserved in the ear bones of adult fish.

"We expected to find hatchery fish, but the sheer number of hatchery fish returning to spawn in the wild is surprising," said first author Rachel Johnson, a fishery biologist affiliated with the Institute of Marine Sciences at UC Santa Cruz and with the Bay-Delta Office of the U.S. Bureau of Reclamation. "It looked like a healthy population of fish returning to spawn, but the reality is that without the hatchery fish the wild stocks are not sustaining themselves."

The Mokelumne River is one of the major salmon producing rivers for fall-run Chinook salmon in California. Throughout the Central Valley rivers, returning fall-run Chinook salmon numbers have rebounded since a disastrous year in 2007, which led to the unprecedented closure of the

commercial salmon fishing season for consecutive years in 2008 and 2009. In the Mokelumne, the number of returning adult salmon has grown from just 418 in 2008 to more than 18,000 in 2011.

But relying on the census numbers alone provides a false sense of the productivity of the river, Johnson said. The discrepancy between the numbers of fish spawning in the river and the actual survival and productivity of wild fish is a serious issue for conservation efforts aiming to restore the wild populations. "We might not be monitoring the right thing to evaluate the effectiveness of recovery efforts," Johnson said.

The new study reveals just how thoroughly the system is dominated by hatchery fish. The Mokelumne River Fish Hatchery releases several million juvenile Chinook salmon every year. The hatchery fish are protected from many of the hazards that cause mortality among wild fish during the initial freshwater phase of their life cycle. There is growing evidence that the different selective pressures on hatchery fish lead to genetic differences, so that the offspring of hatchery fish may be less fit for life in the wild than naturally produced fish. This is especially worrisome if, as the new study suggests, hatchery fish are gradually replacing the wild population.

"We could be doing more harm than we recognize," Johnson said. "Humans are influencing the wild stocks, but we have not been adequately measuring that in our monitoring of endangered species."

This concern applies globally to several species of salmon and steelhead, from Japan to the U.S. west coast, she said. "We used the Mokelumne River as a case study to highlight the implications of not monitoring hatchery fish in the wild. But the practice of releasing enormous numbers of unmarked hatchery-produced fish to enhance salmon stocks remains the cornerstone of salmon conservation and harvest management

worldwide."

The researchers based their findings on an analysis of ear bones, called otoliths, from fish collected after spawning in fall 2004. Coauthor Peter Weber of Lawrence Livermore National Laboratory led the development of the technique for analyzing chemical signatures in the otoliths. These bones grow in increments over the life of the fish and incorporate elements from the fish's diet. Hatchery feed is largely derived from marine fish meal, which leaves a chemical signature distinctly different from that found in wild fish. This signature from a fish's early diet can be detected even several years after it has left the hatchery.

Nearly 12,000 fish returned and spawned in the Mokelumne watershed in 2004. Most were hatchery fish that returned to the hatchery, but about 1,500 fish spawned in the river. The otolith analysis showed that only ten percent of those spawning in the river were produced there, and only 4 percent of the total spawning population were of natural origin.

"When you use the raw fish counts, it looks like the population is doing well. But if you look at the number of fish that are produced in the wild and return to spawn in the wild, and you follow them through the cycle, you see that the wild fish don't survive at a high enough rate to replace their parents. So the habitat is not supporting a sustainable wild population," Johnson said.

Mass marking of all hatchery fish would make it easier to distinguish between hatchery and natural-origin fish in population surveys and to actively manage for the recovery of wild populations, she said. Currently, most California hatcheries mark a fixed proportion of the salmon they produce, which helps researchers track them.

"In the Pacific Northwest, many hatcheries mark all of their fish by clipping off the adipose fin. They operate segregation weirs to create

'salmon sanctuaries,' so that hatchery fish can be managed separately to reduce the risk of them spawning with wild fish, competing for habitat, or potentially reducing the fitness of wild populations," Johnson said.

More information: Johnson RC, Weber PK, Wikert JD, Workman ML, MacFarlane RB, et al. (2012) Managed Metapopulations: Do Salmon Hatchery 'Sources' Lead to In-River 'Sinks' in Conservation? PLoS ONE 7(2): e28880. doi:10.1371/journal.pone.0028880

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