



Evolutionary Basis of Pre-mature Migration in Salmonids

New Information Leads to Petition to List Upper Klamath-Trinity spring Chinook as Endangered

Introduction

Chinook, or King, salmon is a staple for Native People throughout the Pacific Northwest and supports California's commercial salmon industry. Chinook salmon are present throughout the Pacific Rim from Japan and Russia to Alaska and down the Canadian and American west coast to San Francisco Bay. Chinook spend most of their lives, 3-5 years, in the ocean but return as adults to the freshwater stream they were born in to spawn and die. After hatching, juvenile salmon spend up to a year rearing in freshwater before migrating to sea.

Steelhead trout, also a salmonid, has a similar life cycle, spending the majority of its life in the ocean but spawning and rearing in fresh water. Steelhead are highly prized by fishermen for the challenge of hooking one and the often greater challenge of landing one of these tenacious fish.

Both Chinook salmon and steelhead trout are irreplaceable cultural resources for the native peoples of the Pacific Rim and the Karuk in particular. Annual runs of these fish signal the start of religious ceremonies, are harvested traditionally, and still serve as an important subsistence food source for rural tribal communities.

Steelhead and Chinook are unique among salmonids in that they exhibit two strikingly distinct life history types within their species when it comes to when they migrate and spawn, referred to as run timing. Most rivers in the Pacific Rim, including the Klamath, host seasonal runs of Chinook, with distinct migrations of adults from ocean to river in the spring and again in the fall. Similarly, steelhead migrations occur in summer and winter. However, state and federal fisheries managers generally lump spring and fall run populations into the same management unit and focus management activities on the more abundant fall runs. Historically, spring run Chinook were the more abundant run in many watersheds such as the Klamath. The same is generally true for summer and winter steelhead.

Pre-mature vs Mature Migrators

Fall Chinook and winter steelhead, called mature migrators, return to freshwater from the ocean in a sexually mature state. These fish migrate directly to their spawning grounds and spawn immediately. Conversely,

Karuk is the second largest federally recognized Tribe in California with over 8,000 enrolled members and descendants.

The mission of the Karuk Tribal Council is to promote the general welfare of all Karuk people, to establish equality and justice for our tribe, to restore and preserve Tribal traditions, customs, language and ancestral rights, and to secure to ourselves and our descendants the power to exercise the inherent rights of self-governance.

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spring Chinook and summer steelhead, called premature migrators, return to freshwater before they've sexually matured. These fish migrate high into the watershed and hold in cold, deep pools over the summer while their gonads develop, then spawn in the fall or winter near the same time as mature migrators.

Premature migrators are special for a number of reasons: they have much higher fat content than mature migrators (so they taste much better), they play an important ecological role by carrying marine nutrients higher into watersheds than mature migrators, they play very significant roles in the cultures and traditions of the Karuk and many other indigenous peoples of the Pacific Rim, and they provide a larger number of harvest opportunities for fishermen for a greater portion of the year than mature migrators alone.

However, spring Chinook and summer steelhead (premature migrators) have been extirpated or are in decline across most of their historic range while fall Chinook and winter steelhead (mature migrators) remain relatively more abundant. This decline in premature migrators is due largely to the construction of dams which deny access to high-elevation cold water habitats as well as other anthropogenic activities such as logging and mining.

Declines in Spring Chinook and Summer Steelhead Have not Led to Regulatory Protections

Despite sharp declines, spring Chinook and summer steelhead, in most situations, don't receive special regulatory protections. That's because most previous studies have failed to identify the genetic difference between seasonal runs within the same watershed. Thus, regulatory agencies typically lump premature and mature migrators into the same conservation unit. Thus, if the number of mature migrators within a population is relatively healthy, the premature migrators receive no special protections even if they are on the brink of extinction. This lumping-together of premature and mature migrators was justified by the previously held assertion that the premature migration phenotype could easily re-evolve from mature migrating populations if current premature migrators were lost and their habitats later restored. This assertion stems from the prevailing theory explaining the evolutionary basis of premature migration (and other natural phenotypic variation) – that is, that most phenotypic variation in natural populations is under the control of many genes, each of which has only a small effect on phenotype. If this were the case for premature migration, one would expect this trait to be evolutionarily plastic and therefore able to rapidly re-evolve if habitat conditions changed.

The research just published by Prince et al. challenges this prevailing dogma. The research shows that pre-mature migration in Chinook and steelhead is not controlled by many genes working in combination but instead is the result of a single evolutionary event in each species at a single genetic locus. The researchers went on to find evidence of only two such evolutionary events since the two species diverged approximately 15 million years ago. These data reveal the fact that the premature migration behavior is unlikely to re-evolve for a very long time (perhaps millions of years) if these fish are forced into extinction. From a fisheries management and policy perspective, the data suggests that additional protections and management plans are needed and may be legally required.

The Big Picture

Prince et al. demonstrate that incredibly important genetic adaptations can rely on a single or small number of genes, and that current conservation policies can fail to protect this type of adaptive variation. Current policies protect genetic adaptations between distantly related population units, but they don't necessarily protect adaptations within closely related population units (premature and mature migrating populations within a watershed stay relatively closely related through interbreeding at a low frequency), and the consequences of that can be substantial: in the case of Chinook and steelhead, the consequences could be the permanent loss of an economically, culturally, and ecologically important life history. In order to account for this type of adaptive variation, current conservation policies will likely need to be improved.

Identifying the premature migration gene has also enabled the development of genetic markers to easily test the run timing of ambiguous samples such as juveniles or carcasses and characterize the frequency of the premature migration genetic variants across space and time. This will allow for a better local scale understanding of the ecology of premature migrators vs. mature migrators, additional factors behind the decline of premature migrators, and steps that can be taken to bolster premature populations.

Petition to List

Spring Chinook are a fundamental part of Karuk culture and tradition. The return of spring Chinook, or *ishyaât*, initiated the beginning of the first salmon ceremony followed by a new season of harvest and processing of salmon. Since the construction of the last of the Klamath dams, Iron Gate in 1962, spring Chinook populations have plummeted. This year, surveys of the last population of wild spawning spring Chinook in Karuk territory tallied 110 fish. Historically, hundreds of thousands of spring Chinook traveled through Karuk territory along the middle Klamath.

The Karuk Tribe views ESA listing as a last resort. Although the Karuk Tribe is optimistic that Klamath dam removal (scheduled to occur in 2020) will provide opportunities for spring Chinook recovery, additional protections and a recovery plan as required by the Endangered Species Act is necessary to ensure that future generations will be able to harvest and eat spring Chinook as their ancestors did for countless generations.

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