Bradyn O'Connor

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Managing for Salmon in the Lower Tuolumne River

Salmon populations along the west coast of the American Continent have had important cultural, ecological, and economic roles to the people who inhabit it. Many native groups developed cultural significance for the fish, they relied on the nutrition provided by the fish and developed religious and cultural significance surrounding it. In modern times the fish is widely consumed and continues to be revered for its unique life history. In addition to their cultural and nutritional value salmon also generate significant economic value. In California, salmon generate an estimated two billion in economic activity(Martin, 2016). These fish are important members of the California community. Unfortunately, since the year 2000 salmon on the west coast of the Americas have experienced rapid population decline (Zueg, 2010). The cause of this decline is not clear but there are various factors that could have influenced or cause this decline in salmon populations.

Historically there were two separate runs of Chinook Salmon in the Tuolumne river. Spring-run Chinook Salmon and Fall-run Chinook Salmon. Spring run Chinook Salmon are now locally extirpated from the river entirely (Zueg, 2010). Fall-run Chinook Salmon migrate upstream as adults from July through December and spawn from early October through late December (Gende, 2002). The anadromous life cycle of the Chinook Salmon creates a challenge for managing the fish species effectively since they require multiple different types of habitats throughout their life history (Gende, 2002). Juvenile salmon require healthy stream ecosystems to develop in, the adults require a healthy ocean ecosystem to grow and to be able to return to the river system to spawn. Salmon populations in the Central Valley are declining in large part due to the degradation of these systems (Yoshiyama, 1998). Attempting to rebuild salmon population requires in depth knowledge of their ecology and of the threats they currently face. Factors such as habitat loss, altered hydrology, increased predation, and barriers to migration can severely limit an population's ability to grow (Yoshiyama, 1997)(Williams, 2006).

Salmon populations in the Tuolumne River experience natural fluctuation in population size (Lindley, 2007). Between 1961 and 1962, the estimated abundance in was 45,000 fish returning to spawn followed by an estimated abundance of only 500 in 1962 (Lindley, 2007). This large fluctuation in salmon populations is common and can be attributed to the irregularity of an anadromous life history combined with California's unique climate (Williams, 2006). Higher returns of spawning salmon are commonly seen in years with high flows (Martin, 2016). In drought years the expected number of spawning salmon decreases (Martin, 2016). Yet, as mentioned previously there have been rapid declines in Chinook Salmon populations. This is even including recent years in which there have been extremely high flow years (Lindley, 2007).

There are various reasons that can be attributed to the decline in the Fall-run Chinook Salmon population in the Tuolumne river. Dams upstream of the spawning grounds entrap sediment, meaning that there is little spawning habitat for adult salmon and limited natural habitat for fledgling juvenile salmon (Brown, 2002). Juvenile salmon face extremely high predation rates largely from invasive non-

native predators (Grossman, 2016). The loss and degradation of suitable habitat in the lower Tuolumne leads to an unavailability of suitable prey species and the juvenile salmon out-migrating to the ocean will be severely disadvantaged due to the lack of nutrients (Lindley, 2007). Regulated flow regimes further amplify these problems, creating suitable habitat for invasive fish and altering the natural ecosystem downstream of the dam that is timing the releases (Jager, 1997).

Habitat Restoration efforts on the Lower Tuolumne are already underway, with the intent of providing as much suitable habitat for juvenile salmon as is economically and ecologically possible (Turlock, 2018). The Turlock Irrigation District has developed and begun the implementation of a restoration plan to meet this goal (Turlock, 2018). This management plan for the sediment transfer proposes to introduce over 75,000 tons of sediment downstream of the La Grange Dam. This would offset much of the sediment loss experienced since the dam was first constructed. Despite this, it would still require constant sediment deposition given that the Lower Tuolumne experienced an estimated loss of 8,000 tons of sediment between 2005 and 2012 (Kondolf, 2014). The TID has already placed 20,000 cubic yards of spawning gravel downstream of the La Grange Dam in order to increase spawning habitat for salmon. This reintroduced sediment is coupled with various restoration projects along the length of the Tuolumne including various gravel bed restoration and bank reshaping projects. These projects have the goal of providing the native fishing with sufficient habitat to spawn and to grow as juvenile salmon. They have restored 487 acres of floodplain habitat to provide rearing habitat for Juveniles (Turlock, 2018). Ten miles of instream habitat have been restored to provide more rearing habitat for juvenile Chinook Salmon (Turlock, 2018). Additionally, 1.2 miles of riparian habitat have been restored to promote better overall ecosystem health. This habitat restoration plan addresses many of the current concerns and threats facing Chinook Salmon in the Tuolumne. The habitat restoration plan implemented by the Turlock Irrigation District is predicted to be successful in assisting the restoration of Chinook Salmon populations to the Tuolumne as it will provide much habitat for rearing juveniles. However, despite the habitat restoration there are other problems facing the fish that are more difficult to address. Juvenile predation and a managed flow regime being chief among them.

There exists a great threat to juvenile salmon in the form of nonnative predation. Juvenile salmon are predated by nonnative predators at extremely high rates. At one juvenile salmon outflow checkpoint on the lower Tuolumne a 96% mortality was recorded due to predatory nonnative species (Grossman, 2016). The predation of juvenile salmon is thought to be the primary cause for the rapid decline in population size in the Tuolumne (Grossman,2016). It is clear that predator removal is a priority for the Chinook Salmon population in the Tuolumne to grow. Predator removal or reduction in conjunction with continuous restoration along the river to a more natural habitat is essential in order to increase the survivorship of Juvenile salmon. Manual removal of these species can be nearly impossible (Grossman, 2016). This is largely due to the logistic and practical difficulties that come with managing fish species. More work and research needs to be conducted on invasive species eradication before this task can be accomplished.

One promising approach for nonnative predator removal in the Tuolumne is returning the system to a natural flow regime. Regulated flow regimes from the dams are one of the biggest contributors to the high proportions of these nonnatives (Brown, 2002). Through altering the flow regime to mimic a natural Californian Mediterranean flow regime there is a chance of reducing the proportion of nonnative fishes (Jager, 2003). However, this is likely impossible. There will always need to be some regulation in the water released from the La Grange Dam, since there is a need for the

drinking water and hydropower provided by the reservoir. However, despite this fact it is still possible to implement a naturalistic flow regime if not a natural one. The timing of water release from the dam can resemble or mimic what the flows would be without any damming. Matching the peak flows and lows could have seriously positive effects for rebuilding salmon populations in the Lower Tuolumne. When the timing of releases from the dams of the Tuolumne follow a natural flow regime it has been shown to increase the survivorship and proportion of native fishes over nonnative fishes (Jager, 2003). Non-native fish are often not accustomed to Californian river flow regimes and will typically not be able to survive the high flows in the Winter and the Drought conditions in the Summer (Jager, 2003). There is much work being conducted to research and understand using the timed release as a management tool for native fish restoration. However, these methods have not been proven to fully restore habitats to their natural states and often conflict with the interests of the dam operators as well as the electricity and water needs supported by the dams.

Ultimately for the salmon population in the Lower Tuolumne to increase it will take a concerted effort combining various management strategies. Habitat restoration, natural flow regimes, and predator removal are all required to restore the salmon population to healthy and economically productive levels. No single factor can be attributed to the decline of the Fall-run Chinook Salmon, so no single solution will suffice. The Turlock Irrigation District realizes this fact and is currently making efforts to address all outstanding threats the salmon currently face. Having already begun restoring habitat in and along the river as well as planned the eventual installment of a hatchery below the La Grange dam there is hope that salmon Populations can rebound.

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