

Critical Assessment of the Delta Smelt Population in the San Francisco Estuary, California

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ABSTRACT

The delta smelt (*Hypomesus transpacificus*) is a small and relatively obscure fish that has recently risen to become a major focus of environmental concern in California. It was formally abundant in the low-salinity and freshwater habitats of the northeastern San Francisco Estuary, but is now listed as threatened under the Federal and California State Endangered Species Acts. In the decade following the listings scientific understanding has increased substantially, yet several key aspects of its biology and ecological relationships within the highly urbanized estuary remain uncertain. A key area of controversy centers on impacts to delta smelt associated with exporting large volumes of freshwater from the estuary to supply California's significant agricultural and urban water demands. The lack of appropriate data, however, impedes efforts to resolve these issues and develop sound management and restoration alternatives.

Delta smelt has an unusual life history strategy relative to many fishes. Some aspects of its biology are similar to other coastal fishes, particularly salmonids. Smelts in the genus, *Hypomesus*, occur throughout the Pacific Rim, have variable life history strategies, and are able to adapt rapidly to local environments. By comparison, delta smelt has a tiny geographic range being confined to a thin margin of low salinity habitat in the estuary. It primarily lives only a year, has relatively low fecundity, and pelagic larvae; life history attributes that are unusual when compared with many fishes worldwide. A small proportion of delta smelt lives two years. These individuals are relatively highly fecund but are so few in number that their reproductive contribution only may be of benefit to the population after years of extremely poor spawning success and survival. Provisioning of reproductive effort by these older fish may reflect a bet-hedging tactic to insure population persistence.

Overall, the population persists by maximizing growth, survival, and reproductive success on an annual basis despite an array of limiting factors that can occur at specific times and locations. Variability in spawning success and larval survival is induced by climate and other environmental and anthropogenic factors that operate between winter and mid-summer. However, spawning microhabitats with egg deposition have not been discovered. Spawning success appears to be timed to lunar periods within a water temperature range of about 15 to 20°C. Longer spawning seasons in cooler years can produce more cohorts and on average higher numbers of adult delta smelt. Cohorts spaced in time have different probabilities of encountering various sources of mortality, including entrainment in freshwater export operations, pulses of toxic pesticides, food shortages and predation by exotic species. Density dependence may provide an upper limit on the numbers of juvenile delta smelt surviving to the adult stage. This may occur during late summer in years when juvenile abundance is high relative to habitat carrying capacity. Factors defining the carrying capacity for juvenile delta smelt are unknown, but may include a shrinking volume of physically suitable habitat combined with a high density of competing planktivorous fishes during late summer and fall.