Science Foundation Chapter 3
Appendix 3.1 – Case Study
Delta Smelt (*Hypomesus transpacificus*)

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DESCRIPTION OF THE SPECIES

The delta smelt, *Hypomesus transpacificus*, is a small, endemic, pelagic fish that lives in the Delta during spawning and early life, and in brackish waters in the Delta and Suisun Bay during its juvenile to early adult stages. Delta smelt is listed as an endangered species by the state and a threatened species by the federal government. Most of the population indices of this fish show strong declines over the last few decades.

CRITERIA FOR SELECTION OF THE SPECIES

Delta smelt is the most important species in the debate about the environmental effects of water diversions and outflow requirements in the Delta. High catches of this species in the fish salvage facilities associated with the export pumps have led to reductions in pumping and consequently to water shortages. Concern over potential effects of persistently low outflow in late summer-fall has led to efforts to understand these effects and at least potentially to manage them. The Bay-Delta Conservation Plan (BDCP) is developing detailed plans for restoration of marshes in the Delta and Suisun Bay with the intent of improving conditions for delta smelt and other estuarine fishes. The likely success of these plans hinges on whether restoring marshes will help to support delta smelt.

OTHER INFORMATION ABOUT THE SPECIES

The ecology of delta smelt is discussed in numerous papers, notably Bennett (2005). Delta smelt have a 1-2 year life cycle, with most fish spawning at 1 year and relatively few surviving to 2 years. The 2-year-old spawners may provide a hedge for the population against recruitment failure in a single year. Most spawning occurs in the freshwater Delta, although during wet years delta smelt may spawn in the Napa and Petaluma Rivers.

Spawning occurs in a narrow window of temperature in spring. Adhesive eggs are attached to substrate, and larvae hatch at about 4-5 mm length. Larvae begin to feed on small zooplankton such as copepod nauplius larvae, transitioning to adult copepods and later to cladocerans, mysids, and amphipods as they grow. Larvae and early juveniles move from freshwater into brackish water in June-July, and adults begin to move back to freshwater around the end of December.

Delta smelt are pelagic. They are more abundant in shallower regions than deeper channels (Aasen 1999, Bennett et al. 2002), and appear to be mainly surface-oriented. Delta smelt appear to be chronically food limited, as suggested by statistical and simulation modeling and the low abundance of zooplankton in the upper estuary (Kimmerer 2008, Maunder and Deriso 2011, Rose et al. 2013).

The summer-fall habitat of delta smelt historically has been the low-salinity zone (LSZ, a salinity range of approximately 0.5 to 5). This region is typically found in Suisun Bay to the western Delta, more landward during dry years and later in summer. The US Fish and Wildlife Service's 2008 Biological Opinion for delta smelt showed that the position of the LSZ in fall in recent wet years had been further landward than in previous wet years, as a result of a shift in export pumping from spring to fall. This resulted in a requirement to establish an adaptive management program for control of the salinity distribution in fall.

A portion of the population is present throughout the year in the Cache Slough- Liberty Island complex of the north Delta. This may be a case of alternative life histories within a population that can help a species survive in a highly variable environment (Sommer et al. 2011). The smelt are close to their thermal limits, and may be taking advantage of high turbidity and more abundant food (Sommer et al. 2011).

Abundance data for delta smelt are gathered by several long-term monitoring programs. The annual abundance index from the California Department of Fish and Wildlife's fall midwater trawl program shows abundance from 2004 to 2012, except for a pulse of high abundance in 2011, to be lower than in any year from 1967 to 2003. The moderately high abundance in 2011 coincided with late spring storms, high summer-fall freshwater flow, and more favorable conditions in several respects including higher then normal abundance of plankton. Although this rebound suggested some resilience in the population, it was short-lived and the conditions that apparently allowed for this rebound would be difficult to replicate during years with more normal seasonal hydrographs.

The putative link between delta smelt and marshes is that restored marshes may supply food for delta smelt. This is part of the reason why the Bay-Delta Conservation Plan (BDCP) calls for restoration of an area of tidal marshes that would exceed the wetted area of the Delta. The argument is that marshes are highly productive, that there is tidal exchange with the adjacent estuary, and that therefore some fraction of this productivity should be exported to subsidize the foodweb of the estuary.

The issue of connectivity between marshes and open waters is much broader, and has been analyzed far longer (Odum 1980), than can be addressed here (see main chapter on biota). In most cases primary production within marshes is likely to exceed consumption, resulting in some export of organic matter, but this organic matter may or may not be biologically available. The degree to which a marsh can provide a food subsidy to pelagic fish depends on a host of factors including the rate of tidal exchange, bathymetry, what benthic and littoral species become established, and the life histories of the particular fish.

Regardless of the particular mechanism linking delta smelt to marshes, there are two great uncertainties about this link. First, the ideas about tidal marsh restoration are more general than suggested above, and they include the idea of providing fish with a more diverse mix of habitats than the Delta in particular now provides. This idea is ecologically appealing, and if the BDCP's ambitious plans come to fruition there would certainly be more variety of habitats in the Delta and Suisun Marsh than there are now. There is little direct evidence that this will be effective for the specific purpose of supporting delta smelt. However, the use of the Cache Slough complex year-round by some delta smelt suggests that there is some value to alternative, more physically complex habitats.

The second consideration is the extent of colonization of shallow areas by unwanted organisms such as waterweeds and bivalves. Either of these could negate the benefits of a restored marsh, and both are likely in some areas.

REVIEW OF LONG-TERM EFFECTS

Delta smelt already appear to suffer from high summer temperatures. In late summer, when the temperature gradient through the estuary is largest, the low-salinity habitat of delta smelt is furthest landward. This suggests a habitat squeeze by which the smelt cannot apparently occupy water of higher salinity but do not survive or grow well at high temperature.

Turbidity is an important habitat attribute for delta smelt. Abundance of delta smelt is weakly related to turbidity at the point of capture. Young delta smelt will not feed in clear water. The pre-spawning migration of adult delta smelt in winter appears to be related to the first flush of turbid water coming down the rivers after the first storms of the fall-winter. Although the exact mechanisms of this sensitivity to turbidity are unknown, the decreasing turbidity in the estuary, particularly the Delta, may be a factor in the ongoing decline of delta smelt.

Food supply is also a limiting factor for delta smelt. The fundamental problem of low productivity of the open-water foodweb (see plankton case study) is unlikely to be solved by restoration in the Delta. The potential increase in productivity through upgrading the wastewater treatment plants remains speculative, but investigations are underway and planned.

OTHER STRESSORS

Losses of delta smelt to the south Delta export facilities may cause substantial mortality (Kimmerer 2008, 2011, but see Miller 2011). These losses may be eliminated by a change in the point of diversions, although the other consequences of that change (e.g., to hydrodynamics) have yet to be analyzed. There may be some effects of contaminants, but these are probably localized and episodic.

FACTORS THAT MAY AFFECT SPECIES RESILIENCE

As an annual species, delta smelt is highly vulnerable to episodic events.

LIKELY CLIMATE CHANGE IMPACTS AND RISKS

Declining abundance due to high temperature, more landward salinity distribution in summer-fall, and continuing low food supply.

MANAGEMENT ACTIONS TO BE CONSIDERED

None recommended for the region included under the Update.

UNCERTAINTY AND KNOWLEDGE GAPS

- Planned marsh restoration, changes in wastewater treatment, and the shift in the point of diversion may have effects on delta smelt but these are unknown.

- The suitability of habitat in the Napa and Petaluma Rivers for spawning and rearing, as an alternative to the Delta during wet years, is unknown but could be important for long-term maintenance of the population.

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