Identification of Smelt Species and Their Interspecific Hybrids in the Sacramento-San Joaquin Estuary by Allozyme Analysis

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One potential threat to long-term survival of the endemic, endangered delta smelt (*Hypomesus transpacificus*) in the Sacramento-San Joaquin estuary is habitat encroachment of the introduced Japanese wakasagi smelt (*H. nipponensis*). Although wakasagi were originally introduced into six warmwater reservoirs in California, far removed from the estuary, they now occur in large numbers in Lakes Folsom, Almanor, and Oroville and have been observed in Cache Slough, the lower American River, the Mokelumne River, and in the CVP/SWP salvage facilities (see Sweetnam 1995).

Wakasagi and delta smelt are difficult to tell apart morphologically. Allozymes have been used to confirm the identity of morphologically cryptic individuals and have, in fact, revealed two F1 hybrids between delta and wakasagi smelt (Trenham *et al* 1995). The relative proportions of wakasagi amidst delta smelt remained unknown because most samples for prior work were not drawn randomly but were, rather, chosen for difficulty in morphological identification. This current study was initiated to estimate the proportion of wakasagi and the delta-by-wakasagi smelt hybrid in the estuary.

Methods

DFG personnel collected three random samples of 100 smelt each from near Chipps Island, from Decker Island to Cache Slough, and from SWP. Additionally, FWS collected 4 morphologically cryptic smelt from near Chipps Island, 9 from the mouth of the American River, and one from an unknown location in the estuary. For comparative purposes, 5 wakasagi and 14 longfin smelt were also collected. Fish were placed on dry ice and shipped to the Genomic Variation Laboratory in the Department of Animal Science at UC- Davis.

All smelt were analyzed for allozyme variability by horizontal starch gel electrophoresis (May 1992). Allozymes are different forms of an enzyme (*eg,* lactate dehydrogenase) coded by a single genetic locus. Variations in allozyme banding patterns among individuals can be interpreted and genotypes assigned for single Mendelian loci, similar to the ABO blood group system (*eg,* A, B, O, AB).

Results

Initially, 21 smelt from Chipps Island, 5 wakasagi from the Feather River, and the 14 unknown samples were analyzed for 23 loci in eye, muscle, and liver extracts. All remaining samples were analyzed for eight loci in muscle, which distinguish the smelt species (Ac-1, Ac-2, Ada, Ck-1, Gpi-1, Ldh-1, Mdh-2, Pgd). All of the 300 randomly sampled smelt were delta smelt except one delta-by-longfin smelt F1 hybrid (Figure 1) from above Decker Island. Among the 14 smelt that were morphologically difficult to identify, those from near Chipps Island were three delta-by-longfin smelt F1 hybrids and one wakasagi, the nine from the mouth of the American River were all wakasagi, and the smelt from an unknown location was a delta-by-longfin smelt F1 hybrid (Table 1).

Discussion

The primary finding of this study was that wakasagi or their hybrids with delta smelt currently compose a small proportion of the overall smelt population in the estuary (*ie,* none observed in the 300 randomly sampled individuals). A single wakasagi was found in a morphologically cryptic individual near Chipps Island, and more were found at the mouth of the American River. At this time, the wakasagi would not seem to be impacting the delta smelt in the estuary as a whole.

Unexpectedly, hybrids between delta smelt and longfin smelt were encountered in this study. One reason for the existence of delta-by-longfin smelt hybrids may be the dramatic increase in longfin smelt available to spawn in 1995 (Baxter 1996) and the concomitant extension of the longfin spawning season to April and May (Sweetnam, personal communication), overlapping with that of delta smelt. The 1997 year class may include even more hybrid individuals because of the size of the 1995 longfin smelt year class. The relative size of the respective delta smelt population will also play a significant role.

We now know that hybridization takes place between delta smelt and both wakasagi and longfin smelt. No backcross individuals have been observed, suggesting that both F1 hybrids are infertile. Backcrossing is far more problematic than F1 hybridization because of the permanent flow of another smelt species' genes (introgression) into the gene pool of delta smelt. Interspecific hybridization among fish species is relatively common, even among endemic, sympatric species (Hubbs 1955; Schwartz 1972, 1981). The biggest concerns are that hybrids will compete for food and may compete for spawning space and mate availability with delta smelt.

Although hybridization and numbers of wakasagi in the estuary do not appear to be a problem at this time, the future remains unclear. Are the wakasagi spawning farther down in the estuary in each subsequent generation? If so, this situation will raise a number of additional questions. What is the limit to its spread? Is hybridization with delta smelt rare when both species are equally common? Do the wakasagi compete for food with delta smelt? Can the two species coexist in the estuary?

Similarly, major changes in abundance and spawning timing of longfin smelt may impact on the delta smelt population. Introductions of exotic organisms and alterations in the annual cycle of water flow in the estuary will likely have unexpected effects on indigenous species

in the estuary.

The spawning grounds are the key to production of the next cohort of smelt (Moyle *et al* 1992). All of the samples in this study and prior years' samples have come after significant movement of larval smelt. No sampling has been done during spawning. Over the next few years we need to concentrate sampling at several key spawning areas and to sample several hundred smelt from each site to more accurately portray spatially and temporally the numbers of non-pure delta smelt in the estuary.

Finally, the question of potentially different spawning populations of delta smelt should be addressed. While the null hypothesis that there is only a single estuary population seems most likely, rejecting this hypothesis with a finding of genetically differentiated spawning populations would alter dramatically how we perceive this organism and how we would manage it. An analysis of four populations from the extremes of the estuary would address this question.

Diversity of data types (water chemistries, water movement, plant abundance, predator abundance, smelt population structure, *etc*) is needed to understand and predict the long-term viability of delta smelt in the Sacramento-San Joaquin estuary.

References

Baxter, R. 1996. Splittail and longfin smelt. IEP *Newsletter*. Winter 1996.

Hubbs, C.L. 1955. Hybridization between fish species in nature. *Syst Zool* 4:1-20.

May, B. 1992. Starch gel electrophoresis of allozymes. Pages 1-27 and 271-280 in: *Molecular Genetic Analysis of Populations: A Practical Approach*. A.R. Hoelzel, editor. Oxford Univ. Press.

Moyle, P.B., B. Herbold, D.E. Stevens, L.W. Miller. Life history and status of delta smelt in the Sacramento-San Joaquin estuary, California. *Trans Am Fish Soc* 121:67-77.

Schwartz, F.J. 1972. *World Literature to Fish Hybrids, with an Analysis by Family, Species, and Hybrid*. Publications of the Gulf Coast Research Laboratory Museum, No. 32. 328 pp.

Schwartz, F.J. 1981. *World Literature to Fish Hybrids, with an Analysis by Family, Species, and Hybrid: Supplement 1*. NOAA Technical Report NMFS SSRF-750, U.S. Dept. of Commerce. 507 pp.

Sweetnam, D. 1995. Field identification of delta smelt and wakasagi. IEP *Newsletter*. Spring 1995.

Trenham, P., P.B. Moyle, H.B. Schaffer. 1995. *Electrophoretic Identification of Smelt of the Genus Hypomesus from the Sacramento-San Joaquin Delta*. Final Report to DWR. May 1995.