sampled at fixed stations instead of moving with the tide. We were able to do this because during the previous studies we learned that there was not much difference in response of zooplankton and larval fish among waters of different salinity, so differences in time at a fixed station could be assumed to be due mainly to tide or time effects, not salinity effects. This greatly simplified our sampling program, since we were working in water of nearly the same depth all the time. We further simplified it by taking all our plankton and larval fish samples with fixed nets of 200 micron mesh, sampled near the surface, near the bottom, and at an intermediate depth.

It will take about a year to work up the samples from the 1996 entrapment zone study. Data from the 1995 study are nearly ready for analysis, which should be finished this fall.

In addition, we have participated in monthly cruises on the RV *Polaris* since the beginning of the year, with sampling focused at three stations: Station 18 (Alcatraz Island, marine end-member), 2-5 PSU (EZ), and Rio Vista (fresh water end-member). Measurements have included particle size determinations by microscopy and particle counter, dissolved organic C, particulate organic C and N, chlorophyll, biochemical characterization of particles (total carbohydrate, protein, lipid), and abundance, productivity, metabolic characteristics, and phylogenetic diversity of particle-associated and free-living bacteria.

Initial findings are as follows. Dissolved organic C distribution seems to follow a conservative mixing curve, *ie,* only a small fraction of it is precipitated in the turbidity maximum. Particle-bound populations appear distinct by some metabolic characteristics, but surprisingly not by phylogenetic analysis. As found in our previous entrapment zone studies, a large fraction of the microbial biomass and production is associated with particles in the turbidity maximum.

Since most of our samples are from high-flow periods with no distinct turbidity maximum, we will continue sampling during the summer. In addition, we will be examining grazing by copepods on free-living and particle-bound bacteria to determine whether these particles are an important pathway for the transfer of bacterial production to higher trophic levels.

Estuarine Ecology Team

Wim Kimmerer

In the last quarter, the Estuarine Ecology Team finished a draft report on the so-called "fish/X2" relationships, which we broadly defined to include all relationships of abundance or survival of estuarine fish or invertebrates to X2, outflow, or streamflow. The purpose of the report was to describe what we believe to be the most likely causes underlying these relationships, with the ultimate aim being to design field programs to determine the causes. In addition, this provided a good opportunity to say what we know and what we believe to be true about these relationships, and also to exclude a lot of potential causes that we believe are probably not important. This report was submitted for consideration as an IEP technical report.

In addition, the Estuarine Ecology Team attempted to summarize the evidence regarding likely impacts of various limiting factors on diverse ecological features of the delta. Two tasks were completed with general consensus among the team:

- An assessment of whether there was evidence of an impact on each selected species for food limitation, contaminant concentrations in waterways, entrainment at pumping plants and elsewhere, and habitat limitation.
- Prioritization of each factor of its likely role in limiting recovery.

The resulting draft report has will be submitted to IEP Coordinators for approval and eventual transmittal to CalFed and others.

Data Available through the Internet

Karl Jacobs and Chuck Armor

Most of the program elements now have data on the IEP file server. Data are available using a web browser (URL http://www.iep.ca.gov/). Other data relevant to the Interagency Program also have been added to the server, and efforts are underway to place CVPIA/CAMP (Comprehensive Assessment and Monitoring Program) data on the server. A prototype of the CAMP database/home page, containing anadromous fish estimates for delta tributaries should be available soon.

We have made presentations to several project work teams and other bay/delta groups. Individuals and groups can take an active role in the file-server project by suggesting additional data that should be accessible on the server and improvements in data accessibility. We are working on comments received at previous presentations and have begun providing more data. We are also working on a database design that will improve data access. If you are interested in a presentation or information about the server, contact Murray Ng (916/227-1309 or mdng@water.ca.gov).

The Data Utilization Work Group meets monthly to provide a forum where biologists, engineers, and hydrologists can interact with computer technical staff and have an active role in data management.

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

Bernie May, UC-Davis

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

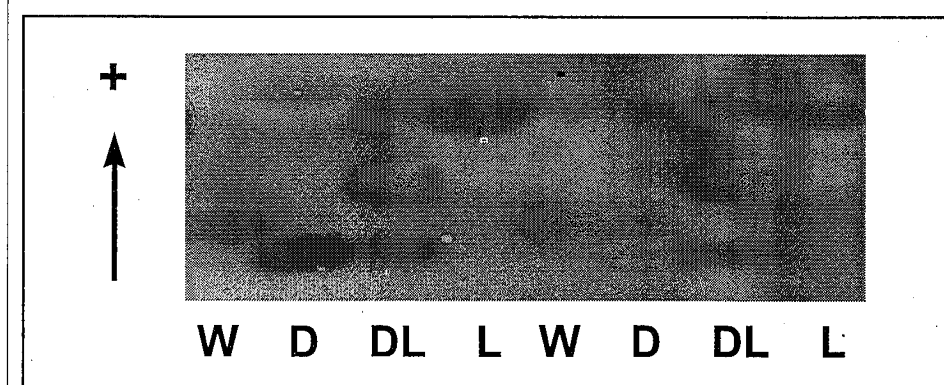

Figure 1

Creatine kinase activity in muscle extracts of wakasagi (W), delta smelt (D), delta smelt-by-longfin smelt F1 hybrid (DL) and longfin smelt (L).

All three species of smelt possess different alleles that code for alternate forms of the enzyme (allozymes), that is, the different allozymes migrate to different positions on the gel. Hybrid individuals are readily scored for this locus and other enzyme coding loci for which the parental species possess different alleles. Note how the DL hybrids share the L and D specific bands plus a heteromeric band.

Table 1
IDENTITY OF SMELT SAMPLES BASED ON ALLOZYME ANALYSIS

Site	Delta Smelt	Wakasagi Smelt	DxW Hybrids	DxL Hybrids
SWP	100	—	—	—
Chipps Island	100	—	—	—
Decker Island	99	—	—	1
Unknowns				
Chipps Island	—	1	—	3
American River	—	9	—	—
Unknown	—	—	—	1

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.

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Summer Tow-Net Survey: 1995 Young-of-the-Year Striped Bass Index

Stephen F. Foss and Lee W. Miller (DFG)

The summer tow-net survey provides an index of young-of -the-year striped bass abundance and has been conducted every year since 1959, except for 1966 when no boat was available. The index estimates abundance when the mean length of the catch equals 38mm (Turner and Chadwick 1972). Surveys require 5 days of sampling. They are conducted every second week, usually starting in late June and continuing until the mean length of 38mm is reached or exceeded. The index is usually set in mid-July, but it has been set as early as June 22 and as late as August 12. We sample 31 stations in Suisun Bay and the Sacramento-San Joaquin Delta (Figure 1). This report describes reasons for not measuring an index in 1995 and the evidence that abundance was unusually low for a wet year.

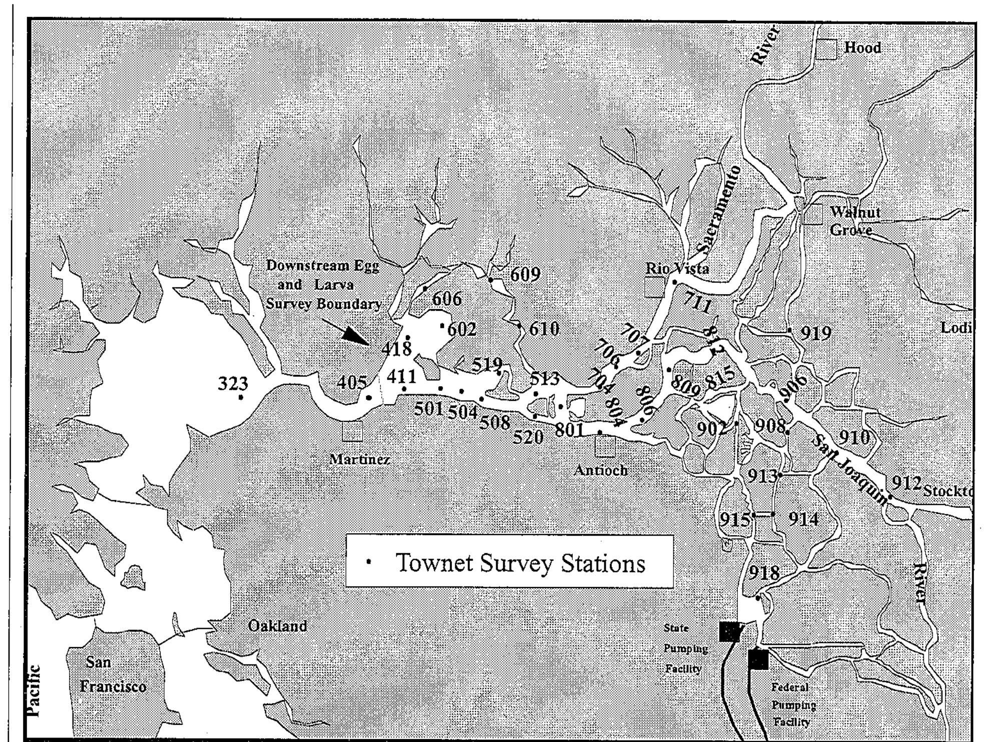

Figure 1
TOW-NET STATIONS AND LOWER BOUNDARY OF THE 1995 EGG AND LARVAL SURVEY STATIONS

1995 Index

The 1995 Tow-Net Survey consisted of five biweekly surveys. The first began July 3, and the last ended September 1, the latest ending date ever. No index was measured in 1995 because the mean length of fish in the sample did not reach the 38mm index size by the fifth survey, when no further sampling was justified because of low catches. The 1995 abundances for the first four surveys, though low, were not the lowest in recent years. Abundance for the fifth survey was, however, the lowest observed. An unusual nonprogression in the mean length also occurred between surveys four and five (Figure 2). The slow progression in mean length over all surveys was apparently caused by continued recruitment of small fish to the gear and relatively low abundance of large fish.

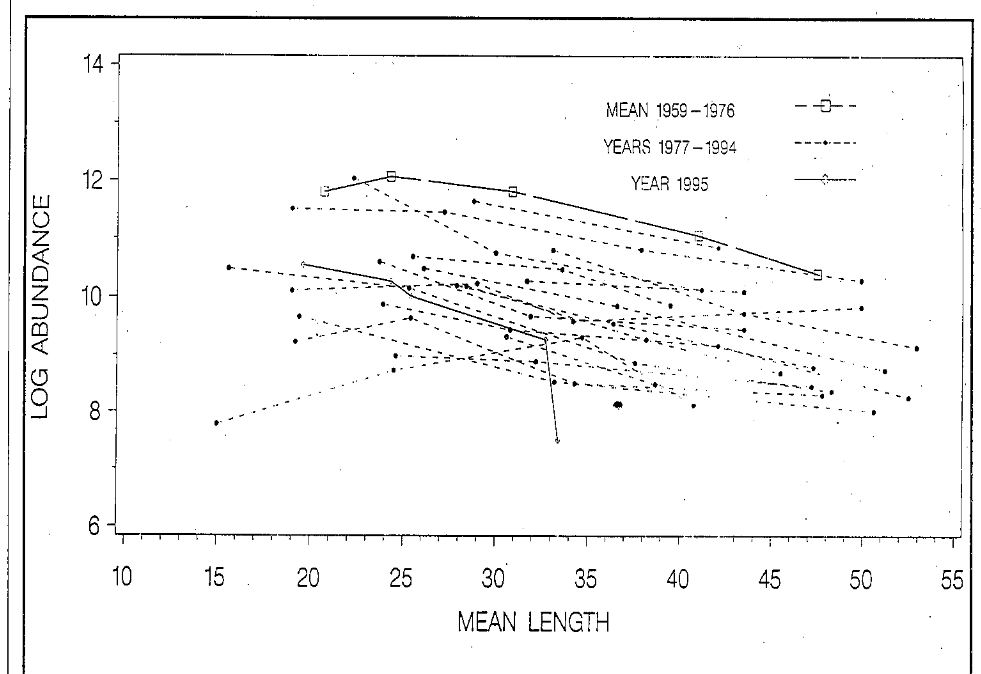

Figure 2
RELATIONSHIP OF LOG ABUNDANCE OF STRIPED BASS TO THE MEAN LENGTH OF THE CATCH SINCE 1977 AND THE AVERAGE FOR YEARS BEFORE 1977