The fathead minnow mortality data in Table 1 were analyzed to determine whether there is any correlation between streamflow and toxicity. The 7-day mortality data were correlated with Sacramento River flow at Freeport (from DAYFLOW). The analysis indicates that there is no relationship (r_2=0.02, p=0.49) between streamflow and toxicity. Although most of the samples are clustered around a flow of about 10,000 cfs, significant mortality was also present in two samples collected at flows over 40,000 cfs, suggesting that high flows do not dilute the toxicity.

The fathead minnow mortality data were also analyzed to determine whether there is any correlation between average larval fathead minnow mortality in May and June and striped bass abundance (fall midwater trawl index) and survival (38mm index). Striped bass was selected for this analysis because previous toxicity testing had demonstrated that the Sacramento River is periodically toxic to striped bass and it is the only species of concern that failed to respond to increased flows in 1995. This analysis indicates that there is no statistically significant relationship between either the midwater trawl index (r_2=0.13; p=0.55) or the 38mm index (r_2=0.04; p=0.76) and the SRWTP May/June larval fathead minnow mortality. This is not surprising because these are periodic grab samples and do not represent average mortality over the May-June period. Much more intensive sampling would have to be conducted to estimate average monthly toxicity.

In summary, since 1990, the Sacramento River below Sacramento has been toxic to fathead minnows about half the time. Of the 29 samples collected between December 1990 and February 1996, 14 caused significant larval fathead minnow mortality, killing 20-97 percent of exposed fish. Significant fathead minnow mortality has also been reported elsewhere in the Sacramento watershed and occurs up to 32 percent of the time in May. Based on tabulations of LC50s, most other fish appear to be more sensitive to chemicals than fathead minnows. Limited testing with larval striped bass indicates that the Sacramento River is also periodically toxic to this species. Therefore, surface water in the Sacramento River watershed may cause direct mortality to other larval fish a significant fraction of the time. This level of toxicity may have contributed to the decline of a number of species, and it may explain why striped bass failed to rally at the end of the drought in 1995.

The Central Valley Regional Water Quality Control Board and other agencies are developing a coordinated research program to expand the sampling program to define the temporal and spatial occurrence of fathead minnow toxicity, to extend the work to other fish species, and to identify the toxicant.

References

AQUA-Science. 1991a. *Phase II Effluent Variability Study, Report 1 (Dec-90 and Feb-91),* March 14.

AQUA-Science. 1991b. *Phase II Effluent Variability Study, Report 2 (May-91 and June-91,* July 7.

AQUA-Science. 1991c. *Phase II Effluent Variability Study, Report 3 (Aug-91 to Oct-91),* November 26.

AQUA-Science. 1992a. *Phase II Effluent Variability Study, Report 4 (Nov-91 and Feb-92),* March 18.

AQUA-Science. 1992b. *Phase II Effluent Variability Study, Report 5 (May-92 and June-92),* July 22.

AQUA-Science. 1992c. *Phase II Effluent Variability Study, Report 6 (Aug-92 to Nov-92),* December 17.

AQUA-Science. 1993a. *Phase II Effluent Variability Study, Summary Report, April 12.*

AQUA-Science. 1993b-1996. Test Reports for November 16, 1993; February 16, 1994; March 25, 1994; May 25, 1994; August 17, 1994; October 19, 1994; February 15, 1995; May 23, 1995; November 14, 1995; November 28, 1995; January 16, 1996; and February 21, 1996.

Aqua Terra Technologies. 1989. *Effluent Toxicity Characterization, Sacramento Regional Wastewater Treatment Plant.*

Bailey, H.C. 1988. *Response of Larval Striped Bass to Agricultural Drainage and Sacramento River Waters,* August 12.

Bailey, H.C., C.A. Alexander, S.I. Doroshov. 1989. *Toxicity of Water Samples from Colusa Basin Drain and the Sacramento River to Larval Striped Bass and Opossum Shrimp.*

Connor, V. 1995. Status of Urban Storm Runoff Projects. CVRWQCB Memorandum to Jerry Bruns, January 30.

Connor, V. 1996. Personal communication with Phyllis Fox. July 8.

Connor, V., L. Deanovic, C. Foe. 1993. *Sacramento River Basin Biotoxicity Survey Results: 1988 - 1990,* CVRWQCB Staff Report.

Foe, C. 1987. American River Urban Runoff Toxicity Test Results for the January 27-28th, 1987, Precipitation Event. CVRWQCB Memorandum to Jerry Bruns, March 19.

Foe, C. 1988. Results of the 1986-87 Lower Sacramento River Toxicity Survey, CVRWQCB Memorandum to Jerry Bruns, January 19.

Tomko, J., and J. Bumgardner. 1995. *Effluent and Receiving Water Quality and Toxicity Summary Report for 1991-1995 and Proposed Sampling Program for 1995/1996.* City of Sacramento Report Submitted to CVRWQCB.

USEPA. 1994. *Short-term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms.* Report EPA-600-4-91-002.

Research Enhancement Program

Randall Brown

For several years the Interagency Ecological Program sponsored a relatively modest Research Enhancement Program designed to stimulate research in the bay/delta ecosystem. The U.S. Environmental Protection Agency, through the San Francisco Estuary Project, contributed significant funding. The other funding came from Department of Water Resources, Department of Fish and Game, U.S. Bureau of Reclamation, and the State Water Resources Control Board.

The basic process was to solicit research proposals, obtain peer review, and award contracts based on peer review, management interests and available funding. Fifteen research contracts were awarded, with a total funding of about $802,000, of which $455,000 came from the Environmental Protection Agency.

All but three of the contracts are completed, and we received final reports from nine of the eleven completed projects. I have listed the nine final reports below, as well as some of the peer-reviewed papers that resulted either directly from the funding or from collaborative research that the funding helped make available. Contact Lisa (916/227-7541) to obtain copies of the final reports. Allow a few weeks for delivery so that Lisa can assess the overall demand for the reports before making copies.

The Research Enhancement Program has served its purpose, and it did stimulate research activities in the bay/delta. Unfortunately, agency budgets are pretty tight these days, and there is no money available to continue the program.

1. Harvey, James T., and Michael L. Torok. *Movements, Dive Behaviors, and Food Habits of Harbor Seals (Phoca vitulina richardsi) in San Francisco Bay, CA.* March 1994
2. Largier, John L. *Hydrodynamic Exchange Between San Francisco Bay and the Ocean: The Role of Ocean Circulation and Stratification.* July 1994
3. Bennett, William A., Laura Rogers-Bennett, and Peter B. Moyle. *Interactive Influence of Starvation and Predation on Mortality of Striped Bass Larvae: A Field Experimental Approach.* July 1993
4. Tjeerdema, Ronald S. and Donald G. Crosby. *Bioconcentration and Metabolic Fate of a Petroleum-Based Hydrocarbon in Striped Bass.* March 1993
5. Mager, Randall C., Serge I. Doroshov, and Joel P. Van Eenennaam. *Gonadal Development and Gametogenesis of Delta Smelt, Hypomesus transpacificus.*
6. Sobey, Rodney. *Hydrodynamic Influences on the Survival of Wetlands in San Francisco Bay.*
7. Collins, Joshua N., and Theodore C. Foin. *Evaluation of the Impacts of Aqueous Salinity on the Shoreline Vegetation of Tidal Marshlands in the San Francisco Estuary.* October 1992
8. Werner, Ingeborg, Kurt F. Kline, and James T. Hollibaugh. *Stress Proteins in Amphipods as Biomarkers of Sediment Pollution in San Francisco Bay.* (Technical Report 48). In press (likely available in August).
9. Orr, Michelle, and James R. Hunt. *Aggregation of Petroleum Hydrocarbons with Particles in Urban Runoff and Estuarine Water.* July 1996

Although we have not received final reports for three additional projects, they have generated several journal and otherwise peer-reviewed publications, as listed below. (These are examples I had on hand, and I suspect that the nine projects above also had publications.)

10. Daehler, Curtis, and Donald R. Strong. *Status Ecology and Potential Control of the Invasive Alien Cordgrass in San Francisco Bay* (final report pending).
    - ➔Daehler, Curtis C., and Donald R. Strong. *Status, Prediction, and Prevention of Introduced Cordgrass (Spartina spp.),* (in press).
    - ➔*Reduced Herbivore Resistance in Introduced Smooth Cordgrass (Spartina alterniflora) after a Century of Herbivore-free Growth* (in press).
    - ➔*Spread and Control of Alien Smooth Cordgrass in San Francisco Bay. Impact of High Herbivore Densities on Introduced Smooth Cordgrass, Spartina alterniflora, Invading San Francisco Bay, CA* (in press)
11. Flegal, Russell. *Pore Water Geo-Chemistry of Trace Elements in South Bay.* (final report pending).
    - ➔Flegal, A.R., I. Rivera-Duarte, S.A. Sañudo-Wilhelmy. *Silver Contamination in Aquatic Environments. Reviews of Environmental Contamination and Toxicology* (in press).
    - ➔Rivera-Duarte, I. and A.R. Flegal. *Porewater Gradients and Diffusive Benthic Fluxes from Relatively Pristine and Contaminated Sites in San Francisco Bay: Co, Ni, Cu, Zn, and Cd. Croatica Chimica Acta* (in press).
    - ➔Rivera-Duarte, I. and A.R. Flegal. *Microtechniques for the Determination of Nanomolar Concentrations of Trace Elements in ≤10mL of Sediment Porewater. Analytica Chimica Acta.* (in press).
    - ➔Sañudo-Wilhelmy, S.A., I. Rivera-Duarte, and A.R. Flegal. *Cycling and Distribution of Colloidal Trace Metals in the San Francisco Bay Estuary. Geochimica et Cosmochimica Acta* (in press).
    - ➔Sañudo-Wilhelmy, S.A., I. Rivera-Duarte and A.R. Flegal. *Cycling and Distribution of Colloidal Trace Metals in the San Francisco Bay Estuary. Geochimica et Cosmochimica Aca* (in press).

➛Flegal, A.R., I. Rivera-Duarte, P.I. Ritson, G.M. Scelfo, G.J. Smith, M.R. Gordon, S.A. Sañudo-Wilhelmy. *Metal Contamination in San Francisco Bay Waters: Historic Perturbations, Contemporary Concentrations, and Future Considerations,* In: Hollibaugh, J.T., ed., *San Francisco Bay: The Ecosystem,* Symposium papers from the 75th Annual Meeting of the Pacific Division of the American Association for the Advancement of Science (in press).

12. Ingle, James. *Pre-History of Salinity Record in San Francisco Bay.* (final report pending)

➛Ingram, B.L., M.E. Conrad and J.C. Ingle. *Isotope record of Late Holocene paleosalinity and discharge in San Francisco Bay, California. Earth and Planetary Science Letters,* v. 140 (1996) (in press).

➛Ingram, B.L., J. C. Ingle and M.E. Conrad. Isotopic records of paleosalinity in San Francisco Bay estuary. In, J.T. Hollibaugh, ed. *San Francisco Bay - the urbanized estuary, Second Edition.* American Association for the Advancement of Science, Pacific Division (1996) (in press).

➛Ingram, B.L., M.E. Conrad, and J.C. Ingle. *Stable isotope and salinity systematics in estuarine waters and carbonates: San Francisco Bay.*

➛Ingram, B.L., J.C. Ingle and M.E. Conrad. *A 2000 yr record of Sacramento- San Joaquin river inflow to San Francisco Bay estuary, California.*

➛Ingram, B.L., D.J. DePaolo. *A 4300 yr strontium isotope record of estuarine paleosalinity in San Francisco Bay, California.*

➛Ingram, B.L. and D. Sloan. *Strontium Isotopic Composition of Estuarine Sediments as Paleosalinity-Paleoclimate Indicator.*

➛Ingram, B.L., J.C. Ingle and M.E. Conrad. *Determining Prehistoric Salinity in San Francisco Bay with Stable Isotopes.*

13. Fisher, Nicolas, and Sam Luoma. *An Interspecific Comparison of Metal Bioavailability in San Francisco Bay: Comparison of Solute and Particulate Source Terms* (final report pending).

➛Luoma, Sam, Nicholas Fisher, Alan Decho, WenXiong Wang, Sarah Griscom and Byeong-Gweon Lee. *Pathway Model for Determining Bioavailability of Particulate Cadmium* (in press).

➛Decho, Alan W., and Sam Luoma. *Humic and fulvic acids: sink or source in the availability of metals to the marine bivalves Macoma balthica and Potamocorbula amurensis?* Marine Ecology Progress Series (1994).

➛Luoma, Sam and Nicholas Fisher. *Uncertainties in Assessing Contaminant Exposure From Sediments: Bioavailability.* In Sediment Risk Assessment, Workshop held at Asilomar, California, April 1995.

July Coordinators Meeting

Randall Brown, DWR

On the morning of July 11, the coordinators met with Pat Coulston to discuss several issues regarding future program direction. A couple of the agenda items may of interest.

Boat Safety

Overall, the Interagency Program has had an excellent boat safety record, but there have been accidents. The coordinators agreed to develop an interagency boat safety program; efforts will be led by USBR staff reporting to the Management Team. The program will also include automobile safety from the time the field crew leaves and returns to their homes or offices. The need for a formal program has become more pressing with the deployment of several boats and crews as part of the real-time monitoring program. The goal is to have the program in place before the October directors' meeting.

Long-Range planning

We agreed to set up a small subset of the coordinators and manangement team members to help determine where the program should be heading for the next several years. Leo Winternitz will be collecting names for potential members, and I may chair the group.

Data Management

The coordinators agreed that the data management group has done a great job bringing the program into the information age — and in such a relatively short time. We also agreed that Karl Jacobs and Chuck Armor are to continue directing the work of appropriate staff to enhance capabilities of the intergency web site. Karl, Chuck, and staff are developing a pilot test of a relational database using much of the FWS salmon dataset.

Observations of Larval Smelt and Splittail in a Dry Year and in a Wet Year

Johnson Wang (National Environmental Sciences, Inc)

In 1995, California had near record high rainfall. High sustained flow that winter and spring provided unusual spawning conditions for resident fish, which contrasted sharply with conditions in 1994, one of the driest years on record. I looked at differences in abundance and capture location between the two year types for four fish species: longfin smelt, a native that spawns in brackish water; delta smelt, a native that spawns in either brackish or fresh water; wakasagi, an introduced fish that usually spawns in fresh water farther upstream than the delta smelt; and splittail, a native that spawns in fresh water.

There are two purposes of this preliminary examination:

- To describe the pattern and trend of the occurrence of fish larvae in a very dry year and very wet year to hypothesize how the fish respond to environmental changes.
- To look at existing information from various baseline studies to gain a better understanding of resident fish.

This could benefit the design of future studies. Interagency Ecological Program staff will be analyzing these and other data in more detail.

Major sources of information used in this study include:

- Egg and larvae samples collected by DFG in Suisun Bay, Montezuma Slough, the confluence and lower Sacramento and San Joaquin rivers; Chipps Island; Cache Slough and North Bay Aqueduct; and lower Mokelumne River. (DFG examined 2,368 samples in 1994; I considered data from sampling stations comparable to those used in 1995. In 1995, 1,169 samples were examined.)
- Egg and larvae samples collected by DWR in the central and southern delta (1994, 537 samples; 1995, 250 samples).

Supplemental samples include:

- USBR egg/larvae entrainment study at CVP in 1994 and 1995.
- DWR egg/larvae and juvenile fish studies at agricultural diversion sites in 1994 and 1995.
- DFG egg/larvae study at Liberty Island in 1995.
- DFG 20mm fish survey (by modified tow-net) in 1995.
- PG&E egg/larvae and juvenile fish studies near Chipps Island in 1995.

Longfin Smelt

Data for longfin smelt larvae collected in 1994 and 1995 are summarized in Table 1. In 1994 (dry year), the larvae were concentrated in Suisun Bay, below Chipps Island, from February to April. Some larvae were found in Cache Slough and in the central/southern delta. In 1995 (wet year, with high freshwater flow and low salinity), it appears that longfin smelt may have spawned mostly in San Pablo Bay in February and March. Larvae were found upstream in Suisun Bay and upstream into areas such as in 1994, but they were quickly pushed back into San Pablo Bay by the high flow. Hieb (1995a) found juvenile longfin smelt to be abundant in central and lower San Pablo Bay.

Fish species showing similar larval distribution to longfin smelt in 1994 were Pacific herring, northern anchovy, jacksmelt, yellowfin goby, and shimofuri goby. In 1995, Pacific herring, northern anchovy, and jacksmelt failed to show up in Suisun Bay and the delta; yellowfin goby and shimofuri goby invaded both Suisun Bay and the delta slowly and in much less abundance than 1994.

Delta Smelt

Occurrence of delta smelt larvae is shown in Table 2. In March-May 1994, larvae were abundant in Suisun Bay upstream to Cache Slough and the central-southern delta. Apparently, the center of spawning was near Rio Vista to the river confluence, including the lower San Joaquin River. In 1995, larval distribution patterns were rather obscure. In May-June 1995, small concentrations of larvae were observed in Suisun Bay below Chipps Island and in the lower Mokelumne River. Cache Slough, heavily used for spawning in 1994, was apparently used only marginally in 1995. However, information from other baseline studies (Winternitz 1995) indicates that early juvenile stages of delta smelt were far more abundant than the larval stages shown in Table 2.

What happened to this upside-down "pyramid" scenario? It is suggested that a small number of delta smelt larvae observed in Suisun Bay and the capturing of delta smelt larvae and early juveniles in the lower Napa River and upper San Pablo Bay (by modified tow-net) indicate that areas around Suisun Bay were likely delta smelt spawning grounds and that similar areas in San Pablo Bay such as the Napa River could be another part of the spawning ground.