Contents

Interagency Ecological Program Fourth Quarter Highlights, October - December, 1998

Sturgeon Tagging

David Kohlhorst, Department of Fish and Game

We completed tagging legal-sized (117 to 183 cm) sturgeon captured in a trammel net in San Pablo Bay on 30 October 1998. We last tagged sturgeon in 1997 when 984 white sturgeon and eight green sturgeon were tagged in 37 days of fishing (26.6 white sturgeon tagged per day). This year, in 34 days of fishing, we tagged 1,233 white sturgeon (36.3 fish tagged per day), but no green sturgeon. Three legal-sized green sturgeon were caught and were taken alive to the University of California, Davis, in cooperation with researchers there. White sturgeon population size in 1998, based on a multiple-census, mark-recapture technique, was estimated to be over 100,000 legal-sized fish, but this estimate is probably biased by the small number of recaptures (4), the lack of random mixing of the tagged fish into the untagged population, and different catchability between untagged and recently-tagged fish. A Petersen mark-recapture estimate for 1997, based on nine tag recaptures during 1998 tagging, is 108,000 legal-sized fish. White sturgeon abundance estimates for the early 1990s were all less than 50,000 fish (and catch rates ranged from 6.1 to 16.2 fish per day) and suggest a substantial increase in sturgeon abundance in the estuary during the last five years. In both 1997 and 1998, application of an age-length key to the length data suggests that the 1982 and 1983 (and possibly the 1986), year classes are strong contributors to the population. Thus, the recent increase in abundance of white sturgeon in the estuary may be due to these strong year classes and return of fish from the ocean after the end of the persistent drought of the late 1980s and early 1990s.

Catches of other species in the trammel net were generally much lower in 1998 than in 1997; overall catch of other fish species decreased from 1,621 in 1997 to 360 in 1998. Elasmobranchs decreased notably, especially bat rays (from 727 to 31) and leopard sharks (from 100 to 44). Species with substantial increases in catch were fall-run chinook salmon (from 20 to 154) and white croaker (from 5 to 41). Mitten crabs (28) were captured for the first time in the trammel net in 1998.

Juvenile Sturgeon Setline Survey

Raymond Schaffter, Department of Fish and Game

The Juvenile Sturgeon Setline Survey targets juvenile sturgeon from 40 to 116 cm total length. Fish are captured with baited setlines, each with 80 hooks, fished overnight at 21 locations in the western delta to San Pablo Bay. Sturgeon become vulnerable to this gear during their second year of life and are probably fully recruited to this survey between the ages of three and ten. The length frequency of juvenile sturgeon captured in setlines, when aged using an age-length key, provides an earlier estimate of year-class strength than can be obtained from the adult tagging study (which targets fish 12 years of age) and augments the year-class index we have developed from the San Francisco Bay Outflow Study trawl data.

We conducted two surveys in 1998: August 10-19 and November 3-13. All 21 sites were sampled during the August survey; three sites in Suisun Bay were not sampled during the November survey. Catch during the August survey averaged 5.4 sturgeon/setline, similar to our 1996-1997 average of 5.3 sturgeon per setline. November catch was only 0.8 sturgeon per setline. The August catch per setline was not significantly different than 1996 and 1997 catches in all months ($F = 0.51$; $df = 2, 104$; $P > 0.60$, on square-root-transformed catch data to equalize variances). However, when both months of 1998 catch-per-setline data were compared with earlier years, the 1998 mean of 3.0 sturgeon per setline was significantly lower than 1996 and 1997 catches ($F = 6.29$; $df = 2, 122$; $P < 0.01$) due to low catches in November 1998.

The likely cause of unusually low catches in November 1998 was rapid loss of bait to the burgeoning population of mitten crabs in the western delta and Suisun Bay. In previous years, we had to cut old bait from most hooks before rebaiting and resetting. However, in August 1998, 20% to 80% of retrieved hooks were bare; the highest proportion of bare hooks was in the lower San Joaquin River and Suisun Bay. During the November survey, virtually all hooks were bare from all sites upstream of San Pablo Bay. In August, much bait probably lasted long enough for the normal twenty- to twenty-two-hour fishing period and resulted in average catches. By November, our effective fishing period was substantially reduced because of bait stealing by mitten crabs. The futility of fishing our gear in the area upstream of San Pablo Bay led to the decision to delete three Suisun Bay sampling sites in November.

We intend to spot sample in 1999 to determine if loss of bait to mitten crabs continues to prevent adequate sampling of juvenile sturgeon with setlines. If severe bait stealing continues, we will have to use other methods, such as beam or large otter trawls, to sample juvenile sturgeon.

Delta Flow Measurement, October-December 1998

Richard N. Oltmann, US Geological Survey

The transducer track at the San Joaquin River at Jersey Point UVM site that had been mysteriously broken off from the piling was replaced and the site was again operational on 6 October. The other UVM stations successfully collected data throughout the quarter except for a seventeen-day period at Dutch Slough and an eight-day period at San Joaquin River at Stockton.

Last quarter's report described the cooperative hydrodynamic study of the confluence area of the Sacramento and San Joaquin rivers by DWR and USGS that was initiated by deploying 16 velocity monitoring stations on 14 and 15 September 1998. On 14 and 16 December, all of the velocity monitoring equipment was successfully retrieved with preliminary data retrievals showing no major data gaps. The Middle Slough ADCP was found buried by about three feet of silt and sand, so although the instrument operated throughout the period, there is a period of unusable data. During the approximately three-month-long deployment period, over 1,500 tidal flow measurements were collectively made at the nine flow monitoring sites by USGS and DWR using downward-looking ADCP flow measuring systems. The flow measurements will be used to develop velocity ratings so that tidal flow time series can be computed. Following are the nine flow monitoring sites: (1) Sacramento River upstream of Point Sacramento; (2) San Joaquin River (Broad Slough) upstream of Point Sacramento; (3) Montezuma Slough near Sacramento River; (4) Middle Slough; (5) New York Slough; (6) Sherman Lake at Sacramento River; (7) Sherman Lake at Broad Slough (west side of Sherman Lake); (8) Mayberry Slough; and (9) Mayberry Cut.

USGS and DWR began discussions concerning the possible expansion of the existing tidal flow monitoring network using two-beam, side-looking ADCPs (SL-ADCP); refer to the last two quarterly reports for discussions of SL-ADCPs. The list of possible new tidal flow monitoring sites includes Grant Line Canal at Tracy Road Bridge, the intake channel to Clifton Court Forebay, Old River at head, San Joaquin River at Port of Stockton (Rough and Ready Island), Turner Cut, Columbia Cut, Connection Slough, and Little Potato Slough-Mokelumne River area.

DSM2 Project Work Team Progress

Chris Enright, Department of Water Resources

The Delta Simulation Model Project Work Team met twice during the quarter. The mission of the PWT is to produce (1) a consensus calibration of the DSM2 model along with calibration documentation and (2) a white paper on error bounds under alternative modes of planning analysis. Completion of the project has been promised to the IEP coordinators by December 1999. Staff and students from USGS, USBR, MWD, CCWD, DWR, Stanford University, and UC Berkeley are regularly contributing to the effort.

The group is presently working on several fronts to (1) collect flow data, (2) develop calibration protocols, (3) develop a model grid geometry, and (4) investigate the sensitivity of the model to various input parameters. Flow data will be used to guide grid geometry decisions and calibrate and verify the model. The calibration protocols are being designed to foster group participation in the calibration and provide goodness-of-fit measures. Model grid development is the art of resolving complex three-dimensional bathymetry data into a form with which a one-dimensional model can produce accurate results. Parameter sensitivity analysis is concerned with tuning the model for accurate results while minimizing computational effort, and determining the best methods for simulating complex features of the system like open water areas. As consensus decisions are reached on these issues, the group will document the decision process for the final report.

The PWT is planning a presentation for the Bay-Delta Modeling Forum and presenting a poster for the IEP Workshop at Asilomar in February.

Rock Slough Monitoring Program

Jerry Morinaka, Department of Fish and Game

We sampled fish entrained at the Rock Slough intake of the Contra Costa Canal once a week in October, November, and December using a sieve net. Threadfin shad (Dorosoma petenense), mean size = 54 mm fork length (FL), and white catfish (Ictaluras catus), mean size = 369 mm FL, were the predominant species captured in the sieve net. One winter-run-sized juvenile chinook salmon, 83 mm FL, was captured on 10 December. Fish entrainment sampling was suspended in mid-December due to the theft of essential equipment at the sampling site and will not resume until the equipment is replaced sometime in January.

Old River Fish Screen Facility (Los Vaqueros) Monitoring Program

Jerry Morinaka, Department of Fish and Game

We sampled fish entrained on the downstream side of the fish screens at the Old River Fish Screen Facility once a week in October, November, and December using a sieve net. During a four-week period in November and December, no entrainment sampling was conducted because repairs were made to the net and the pumping facility was shutdown due to high chloride levels in the water. Very few fish were captured in the sieve net during the three months. Comparing the size of the captured fish with the mesh size of the fish screens leads us to believe that these fish were most likely entrained at the larval stage and had grown up inside the facility. Bluegill (Lepomis macrochirus), mean size = 54 mm FL, and white catfish (Ictaluras catus), mean size = 57 mm FL, were the only species captured in the sieve net. Fish entrainment sampling will increase to up to three times a week from January through June.

Mallard Slough Monitoring Program

Jerry Morinaka, Department of Fish and Game

The Contra Costa Water District initiated pumping at the Mallard Slough intake on 10 December. No sampling was conducted in December at the pumping plant due to the intermittent pumping schedule. Sampling is scheduled to start during the first week of January and will continue once a week until the pumping is discontinued.

Splittail Investigations- Fall 1998

Randall Baxter, Department of Fish and Game

Field work for 1998-1999 began in earnest in December as personnel began hook-and-line fishing for splittail in the Sacramento River near Ryde (river mile 24.5). In 12 partial days of fishing through 30 December, 24 splittail were landed. Six of these fish were radio tagged and released, and nine others were transported to a holding facility at Hood to be used as either "dummy" tagged or untagged "control" fish. The remainder, too small to radio tag, received anchor tags and were released on site. Splittail catch peaked mid-month coincident with high river flows then dropped to zero on 29 and 30 December. Though initially less productive than we hoped, angling and tagging will continue through February.

Radio tracking conducted three days a week between Rio Vista and Hood, indicated that most if not all tagged fish dropped downstream below Rio Vista after tagging. However, we still need to download a fixed telemetry site at Hood to confirm that some of these fish did not move back upstream over the Christmas holiday.

Fish held at Hood are being checked two to three times per week to assess impacts of handling, tagging, and fish size on survival. Out of necessity some fish tagged will be smaller than recommended in the literature (in other words, larger tag weight to fish weight ratio), so we need to conduct our own assessment. So far of three internal tag, three external tag and three control fish, only one internally tagged fish has died. This fish flipped off the table during surgery, so its demise was expected.

By early February we expect to expand our tracking survey area to include the lower Yolo Bypass, American and Feather rivers, and the Sacramento River to at least Knights Landing. Sampling for adults and larvae on suspected spawning grounds will commence in mid to late February.

Estuarine Monitoring

Kathy Hieb, Department of Fish and Game

Preliminary 1998 abundance indices have been calculated for many of the commonly collected fish and crustaceans from the San Francisco Estuary. This article includes 1998 highlights for a subset of this group; a summary of the status and trends for the entire group will be included in the spring 1999 issue of the IEP Newsletter.

In 1998, the annual abundance index of juvenile bay shrimp, Crangon franciscorum, was the highest for the study period (1980-1998). This index has increased steadily since 1995, with indices of 195 in 1995, 337 in 1996, 508 in 1997, and 588 in 1998. This pattern is most likely a result of successive high freshwater outflow years. From May through July, densities of juvenile C. franciscorum were highest in San Pablo Bay; the center of distribution slowly moved upstream with decreasing outflow, and by October, densities were highest in Carquinez Strait and western Suisun Bay.

Abundance of age-0 longfin smelt increased substantially in 1998 from 1997 (the Bay Study midwater trawl index was 62,959 in 1998 versus 4,583 in 1997); this increase was also observed in the 1998 Fall Midwater Trawl Survey and Bay Study otter trawl indices. Age-0 longfin smelt were concentrated in San Pablo Bay through July and began to disperse in August. By November, they were collected from south of the Dumbarton Bridge in South Bay to the lower Sacramento River, with the highest catches from Suisun Bay to Sherman Island.

There has been a modest recovery of the starry flounder population in the San Francisco Estuary since 1995 (abundance was very low during the late 1980s and early 1990s); the 1998 age-0 index was very similar to the 1995-1997 indices while the 1998 age-1 index (1997 year class) was the highest since 1984. Although the age-0 fish were concentrated in San Pablo Bay 1998, they were widely dispersed. Fish were collected from the southern portion of South Bay to the San Joaquin River near Venice Island, which is the upstream limit of our sampling.

The 1998 Pacific herring age-0 index was relatively low, probably as a result of poor broodstock condition due to El Niño and transport of larvae from the estuary by high winter outflows. Northern anchovy abundance has been relatively stable from 1995 to 1998, with the annual indices ranging from 4,426 to 6,220. These recent indices are 30% to 45% of the highest index, which was 14,240 in 1993. Although Pacific sardine abundance was again high in 1998, the index was several orders of magnitude lower than the northern anchovy index. Interestingly, 80% of our 1998 Pacific sardine catch was from May. After a slight rebound in 1997, abundance of age-0 shiner perch was again low in 1998. This continues a trend of decreased abundance since the mid-1980s.

1998 Fish Treadmill Project Field Collections

Bob Fujimura, Department of Fish and Game

Field collection for delta smelt used in fish performance experiments at the UC Davis Fish Treadmill were initiated on 4 August 1998 and are scheduled to continue until early January 1999. The field collection method was the same used in fall 1997; live delta smelt were obtained using a small purse seine. Effort was taken to reduce delayed mortality by avoiding fish impingement or dewatering during the removal of fish from the net, reducing physical shocks during transport, and minimizing the transport time.

Fewer delta smelt were collected in 1998 compared to 1997. More than 1,700 delta smelt were collected in 1997 versus less than 1,500 smelt caught in 1998. Sampling effort was increased to obtain suitable numbers of fish for experimentation. Over twice the number of collection trips were conducted in 1998 and sampling was extended later in the calendar year. Most fish were collected from a broad area from Suisun Bay to Honker Bay. In the previous year, smelt were found mostly upstream in the Sacramento River near Sherman Island.

The field collection for juvenile splittail was discontinued in spring 1998. Suitable numbers of fish were obtained from fish salvage collections at the USBR Tracy Fish Facility. In 1999, juvenile splittail were caught using a beach seine from the Sacramento River near Sacramento. Collections of juvenile American shad were also made from the fish salvage operations at the DWR Skinner Fish Protective Facility in summer 1998.

Suisun Marsh Salinity Control Gates Salmon Passage Evaluation

Bob Fujimura, Department of Fish and Game

Field monitoring of fall-run chinook salmon passage at the Suisun Marsh Salinity Control Gates (SMSCG) began on 1 October and was completed in early November. Prior to the study, a detailed Quality Assurance Project Plan (QAPP) was written and later submitted to the SMSCG Steering Group. The purpose of the 1998 study was to monitor the adult salmon movement through the SMSCG during three operational phases. The three phases were performed to evaluate the effectiveness of flashboards with horizontal slots to enhance passage of migrating fish. At the beginning of each phase, 66 fish were caught with drift nets, tagged with ultrasonic transmitters, and released downstream of the SMSCG. Tagged fish were allowed a minimum of eight days to pass the SMSCG. A total of 198 adult salmon was fitted with ultrasonic tags. Fifty-four of these tags also transmitted the depth of the tagged fish. Stationary receivers and hydrophones were used to detect the approach and passage of tagged fish. Small battery-powered computers recorded the tag information and time-stamped each detection.

The raw data files from the stationary receivers have been converted to more useful data formats and the initial data editing and summarization has begun. Data entry and correction of supporting field (boat) monitoring observations are being currently performed. The percentage of fish that successfully pass during each operational phase, the mean passage time, and the depth of fish approaching or passing the SMSCG, is the primary information to be obtained from these data. Preliminary results and edited datasets are expected by mid-April. Additional analyses will be conducted to determine whether modified hydrophones can provide information on small scale movement at the SMSCG, and whether fish movement was associated with gate operations or environmental variables.

Juvenile Chinook Salmon Telemetry Evaluation

Bob Fujimura, Department of Fish and Game

The DFG Fish Facilities research staff is conducting the second year of research on the use of miniature telemetry transmitters to track juvenile salmon through the delta. In 1998, field trials indicated that ultrasonic tags had greater reception ranges than comparable radio tags when used at moderate depths or in brackish water. Captive fish implanted with dummy ultrasonic tags and held at the DWR Skinner Fish Facility suggested that fish no smaller than 150 to 160 mm could be tagged without excessive mortality or change in behavior.

Research in 1999 will focus on evaluating a smaller prototype ultrasonic tag for use on juvenile chinook salmon smaller than 160 mm. A preliminary field trial indicates that this tag has a suitable reception range. A holding facility for the second captive fish experiment has been built at the DWR facility at Hood. Dummy tags will be used on hatchery fish and held for 14 days. The survival and behavior of the tagged fish will be compared against control fish. Fish with surgical and gastric implanted tags will be examined. If the dummy tag results are favorable, a pilot field evaluation of released fish with active tags will be proposed.

Central Valley Chinook Genetics Project Update

Sheila Greene, Department of Water Resources

The Genetics PWT met on 2 December 1998. The principal investigator of the UCD genetics project, Dennis Hedgecock, presented results from their recent research activities. They have completed investigations for integrity within each run's baseline and prepared a preliminary updated genetic relatedness tree. There were a few interesting features: Feather River Hatchery fall-run chinook salmon and Merced in-river fall-run chinook salmon are slightly distinct from other Central Valley fall runs; Butte Creek spring-run chinook salmon are distinct from Mill and Deer creek spring-run salmon (as has been since the beginning); winter-run chinook salmon are relatively distinct from other Central Valley runs. Although there are reports of historical introduction of Feather River Hatchery spring-run chinook salmon into Butte Creek, there is no genetic evidence of introgression at this time.

Bodega Marine Laboratory completed genetic analysis of samples collected in 1995 from the delta export facilities and delta monitoring programs samples collected in 1995. They used the individual analysis to identify winter-run chinook. Winter-run length frequencies were plotted against time to examine size and temporal distribution. Most individual winter-run chinook were within or near the winter-run chinook length criteria range. There were also a lot of non-winter-run chinook in the winter-run chinook length range. There are a couple of interesting results: several fry-sized winter-run chinook salmon juveniles occurred in January (we traditionally consider these fall-run or spring-run fry); and a couple of smolt-sized winter-run chinook salmon occurred in May (we traditionally have considered these fall-run or spring-run smolts).

The PWT is reviewing the preliminary results and optimizing the tissue sampling program.

Central Valley Salmonid Team Update

Randall Brown, Department of Water Resources

The team met in December and, among other items, discussed the following:

- I proposed that the team include presentations by scientists at several locations around the Central Valley. The team accepted the proposal and the first two meetings will be held in Tiburon (NMFS research) and the Tuolumne River.
- The CALFED Comprehensive Assessment, Monitoring, and Research Program is charged to recommend additional studies to determine factors affecting juvenile salmon mortality in the delta and a constant fractional marking program for Central Valley chinook salmon hatcheries. Recommendations, including staffing and budget, are due this fall.
- We reviewed a USFWS proposal to tag and release up to 600,000 chinook salmon fry this year. Logistic concerns and the lateness of the proposal probably make it impossible to conduct this spring, although we may be able to do a pilot program with 200,000 tagged fry.
- We reviewed a DFG proposal to establish a standard sampling protocol for steelhead. The team approved the proposal and the protocol has been sent under a salmon team cover letter to scientists that may encounter steelhead in their sampling programs.

Salmon Stock Origin as Determined by Otolith Geochemistry

Peter Weber, UC Berkeley

From June 1998 to December 1998, we established a preliminary positive correlation between the isotopic ratio of strontium (87Sr/86Sr) in hatchery waters and the 87Sr/86Sr ratio in the otoliths of juvenile chinook salmon raised in those waters. If this relationship holds, strontium isotopic analysis will be a useful technique for determining salmon origin in the Sacramento-San Joaquin basin because there is a range of distinct 87Sr/86Sr ratios among the primary salmon rivers. We are conducting additional analyses to better understand this correlation and determine its robustness for management applications.

Tidal Marsh Study

Suzanne DeLeón, Department of Fish and Game

In summer and fall 1998, we continued to sample a variety of tidal marsh habitats in northern Napa-Sonoma Marsh and the lower Petaluma River marshes. The minifykes we designed in 1995 were fished in first-, second-, and third-order channels. Other quantitative sampling techniques included block net, beach seine, and cast net in the larger third order channels, and throw cage and fyke trap in vegetated areas. This year, sampling was also conducted in nearby open water habitats and in vegetation adjacent to open water. A beach seine, purse seine, beam trawl, and cast net were used to sample the fourth- and fifth-order channels and open water. A new gear type, the bottomless lift net, was designed and tested in emergent vegetation and in mudflats. Gear comparison tests were conducted for the cast net and throw cage in shallow water ponds and mudflats, and the fyke trap and lift net in emergent vegetation.

In the lower Petaluma River, yellowfin goby (Acanthogobius flavimanus), an introduced species, was common in all habitats sampled. Resident marsh species, including threespine stickleback (Gasterosteus aculeatus) and longjaw mudsucker (Gillichthys mirabilis) dominated the small, first- and second-order channels. In emergent vegetation next to open water, yellowfin goby and threespine stickleback were most abundant. In the open mudflat of the Sonoma Land Trust Marsh, splittail (Pogonichthys macrolepidotus), yellowfin goby, and Pacific staghorn sculpin (Leptocottus armatus) were most common.

In northern Napa-Sonoma Marsh, prickly sculpin (Cottus asper), threespine stickleback and the recently introduced shimofuri goby (Tridentiger bifasciatus) were most abundant in the first- and second-order channels. In the large, third-order channels, inland silverside (Menidia beryllina), prickly sculpin, and splittail dominated the catch. In emergent vegetation, shimofuri and yellowfin gobies were most abundant, and in a shallow water pond controlled by a tide gate, inland silverside and rainwater killifish (Lucania parva) dominated the catch.

Chinese Mitten Crab Project Work Team

Tanya Veldhuizen, Department of Water Resources

The IEP Management Team and Coordinators approved the formation of a Chinese mitten crab Project Work Team (PWT). The growing interest in the effects of a large and widely distributed Chinese mitten crab population has heightened the need for a forum to address concerns and coordinate research activities. The diversity of disciplines (for example, engineering, biology, and toxicology) required to address the various Chinese mitten crab issues (see next paragraph) and the participation of many organizations not normally involved in IEP activities (for example, Department of Food and Agriculture, Department of Health Services, Contra Costa Water District, reclamation districts, universities, and private consulting firms) favored the formation of a new stand-alone PWT as opposed to forming subgroups under existing PWTs. The new PWT will consist of a parent group and several satellite groups formed around relevant issues (for example, ecology, levee integrity, diversions, public health, agriculture, and so on). The parent group will facilitate communication and coordination among the satellite groups.

The Chinese mitten crab PWT is charged to address the following major issues:

1. Prevention or minimization of impact on federal and State fish salvage operations.
2. Disposal of crabs entrained at the fish facilities.
3. Assessment of burrowing activities on levee integrity.
4. Investigation of species-level and ecosystem-level effects.
5. Investigation of life history, physiological requirements and tolerances, and behavior.
6. Assessment of impacts on the rice industry.
7. Investigation of effects on restoration efforts.
8. Public health concerns relating to human consumption and handling concerns.
9. Population abundance and distribution monitoring.
10. Recommendations for point-of-impact and population-level control measures.
11. Risk assessment for spread and establishment in other estuaries.

The Chinese mitten crab PWT held its first meeting on 19 January 1999. For more information about the PWT contact Tanya Veldhuizen (tanyav@water.ca.gov) or Zachary Hymanson (zachary@water.ca.gov).

Juvenile Salmonid Monitoring Program

Erin Sauls, US Fish and Wildlife Service

Juvenile chinook salmon monitoring was conducted throughout the Central Valley. The following data covers efforts in Mill, Deer, and Butte creeks, at Red Bluff Diversion Dam in the delta, and at Mossdale on the San Joaquin River.

The upper Sacramento River tributaries of Mill, Deer, and Butte creeks were sampled for spring-run chinook salmon emigrants using rotary screw traps during fall 1998. The Big Chico Creek traps have been delayed but are scheduled to go in the second week of January. The traps in Mill Creek began sampling on 27 October, were out from 30 November until 11 December, and are now currently sampling. Chinook catches have been low on Mill Creek, with a maximum catch of three fish on 16 December. Deer Creek traps also began sampling on 27 October with the first chinook capture of five fish on 9 November. Numbers of mostly yearling-sized chinook were steady but low until 26 were captured on 23 November. The catch (more fry than yearlings) peaked on 14 December (74 fish) and has gradually decreased. The Butte Creek traps started sampling on 1 October and captured the first chinook salmon on 10 October. Low numbers were observed until 22 November when 39 fish were captured, then steadily increased with a peak of 9,882 fish observed on 14 December. About 1,000 fish per day have been seen since that date.

Rotary screw trap monitoring at Red Bluff Diversion Dam (RBDD) began on 1 September and was fully implemented at seven days per week starting in October. Concerns of exceeding our winter-run chinook salmon take necessitated the implementation of a nighttime subsampling regimen. The following interpretations are for catches through 5 December and have been extrapolated to nighttime periods that were not fished. Salmon captured in rotary screw traps at RBDD ranged in fork length from 28 to 173 mm. Over 90% of the chinook salmon captured were winter-run-sized, while late fall-run- (3.0%), spring-run- (2.8%), and fall-run-sized (1.3%) chinook salmon comprised smaller portions of the total catch. Brood year 1997 (BY97) fall-run chinook were observed throughout September and October at RBDD with the final BY97 capture occurring 12 November 1998. Relative abundance of winter-run chinook peaked in late September at over 550 fish per trap over a twenty-four-hour period. Abundance patterns in October and November were relatively static except for increases in abundance during periods of increased river flows and water turbidity during autumn freshets. Our total BY98 winter-run chinook take (n=15,754) by 5 December 1998 exceeded our total take of BY97 winter-run chinook by over 2,000 fish. Although take between years is not directly comparable because of different fishing intensities, it demonstrates the high abundance patterns observed this year for winter run. Other items of interest occurring during this period included the capture of a 335 mm Sacramento splittail on 28 October 1998. Additionally, naturally produced fall-run chinook salmon captured during January, February, and March 1999 will be retained, adipose fin-clipped, and marked with coded wire tags as part of a multiyear, wild-stock-tagging program being conducted by the Northern Central Valley Fish and Wildlife Office. For additional information on the screw trap monitoring at RBDD, please contact craig_martin@fws.gov.

Rotary screw traps at Knights Landing began sampling on 1 October. The first chinook salmon was captured on 5 October. Catches (mostly yearlings) were sporadic until 12 November when a catch of 21 chinook salmon was made. Chinook catches steadily increased (the traps were not fishing from 25 November until 30 November) to a peak of 260 (mostly fry) fish on 6 December. Catch numbers are currently decreasing at Knights Landing.

Sacramento Kodiak trawling began for the season on 3 September. Twenty-four late fall-run, 11 spring-run, 2 fall-run and 73 winter-run-sized chinook salmon have been captured through 28 December. This number of winter-run chinook is higher than last season's recoveries during the same period. Our first winter-run-sized capture occurred on 22 September in the beach seine at Clarksburg (river mile 43). The Delta Cross Channel closed on 8 September due to high flows and remained closed in order to protect emigrants from diversion off of the mainstem Sacramento River. The total delta winter-run-sized catch through December reached 393 fish (trawling and beach seining efforts combined).

Kodiak trawling three days per week on the San Joaquin River at Mossdale began on 4 November. No salmon were detected through the end of December. Winter-run-sized chinook salmon were first detected leaving the delta at Chipps Island on 1 December. A total of 12 chinook was captured at Chipps Island during this quarter. Incidental take of delta smelt started to climb in late October, which limited the trawling effort under Endangered Species Act restrictions. To avoid capturing delta smelt, sampling was conducted on a pilot basis at an alternate site near the Benicia Bridge in lower Suisun Bay with little success in capturing chinook salmon.

A late-fall chinook salmon, coded wire tag experiment is underway to evaluate the potential effects of State and federal project exports on juvenile chinook salmon survival through the central delta. These late-fall, hatchery chinook are used as surrogates for spring-run and winter-run chinook, which also emigrate during this period. Paired releases were made in early and late December at Ryde (Sacramento River mainstem) and Georgiana Slough, assuming that low to moderate outflow and low export levels (less than 2,000 cfs) following both sets of releases will provide good conditions in the south delta and result in similar survival indices for the Georgiana Slough groups relative to the Ryde groups. Two sets of releases under the same flow and export conditions will provide a replicate of this data point, which is difficult to achieve. The Delta Cross Channel will be closed during both test periods. A control group was released at Port Chicago on 22 December for independent survival verification by way of ocean recoveries. Preliminary recoveries of the first set of releases still show a significant survival advantage for the Ryde group. Due to heavy rainfall, flows in the lower Sacramento River were very high (up to about 60,000 cfs) during the recovery period, which changed the experimental conditions. Flows are expected to be much lower during the replicate. Survival indices will be calculated after all recoveries have been made. The salvage facilities at the State Water Project have recovered two Georgiana Slough fish and no Ryde fish from the first set of releases.

Delta Smelt Investigations

Dale Sweetnam, Department of Fish and Game

The third delta smelt workshop was completed on 1 and 2 October. Although it was not well attended, the conference offered quality research that was well received. A prioritized list of future delta smelt research needs including those of CALFED and the CMARP process was assembled by both agency and stakeholder representatives. A full description of the workshop is included in this newsletter. (See "The Third Delta Smelt Workshop".)

The fall midwater trawl survey was finally completed on 22 December. Numerous boat breakdowns and harsh weather resulted in only 77% of the scheduled stations being sampled in December. The index for December was 70.1. This sets the annual fall index (the sum of the September through December indices), at 417.6, slightly greater than the 1997 index of 360.8. Distribution was centered in Suisun Bay with few fish found in the San Pablo Bay and the lower Sacramento River. One interesting point about the 1998 index is that it breaks the "odd-even year" fluctuation that has been observed in the 1990s.

Mitten Crab (Eriocheir sinensis) Depletion of Dissolved Oxygen in a Confined Space

George Parker and Jane Arnold, Department of Fish and Game

In September and October, the number of mitten crabs (Eriocheir sinensis) entering the John E. Skinner Delta Fish Protective Facility (Skinner Fish Facility) was estimated to be over 20,000 per day. This large number of crabs impacted normal salvage fish operations and additional DWR and DFG staff were brought on to handle the extra work. To reduce the number of crabs in each truck load of fish, up to four fish hauls were done in a twenty-four-hour period and crabs were cleaned out of the holding tanks at regular intervals. Despite the best efforts of DWR and DFG staff to control the numbers of crabs, every crab could not be eliminated from the bucket used to load fish into the truck. At times, some fish died in the loading bucket, possibly because of the stress of being crowded by crabs, or because the amount of dissolved oxygen (DO) reached critical levels.

To test if mitten crabs could indeed deplete DO levels, some initial tests were performed by DFG staff at the Skinner Fish Facility. Various numbers of crabs were held for 90 minutes in a 439-liter tank of ambient water, while a control tank with no crabs was tested simultaneously. DO levels did drop markedly in the tank containing mitten crabs, especially when the test tank contained more than 70 crabs. These initial tests indicate as few as 1,600 mitten crabs in the fish-hauling truck (2,500 gallons) could reduce DO to lethal levels for salvaged fish. The bucket used to transfer fish from the holding tanks to the truck holds a mere 500 gallons, thus the fish mortality noted earlier may have been due solely to low DO levels rather than any direct interaction between fish and crabs. More tests are planned and a final report is expected by fall 1999.

Mysid Shrimp

Jim Orsi, Department of Fish and Game

A third species of east Asian mysid has been identified from specimens taken in San Pablo Bay by the Neomysis/Zooplankton Study. Dr. Richard Modlin of the University of Alabama searched the literature and determined that our specimens were Acanthomysis hwanhaiensis, a native of Korea. This species was found from South San Francisco Bay to San Pablo Bay in September 1997, our first lower bays survey and was the most abundant mysid present at this time. Its high abundance (maximum 36/m3) and widespread distribution indicate that it must have been introduced prior to 1997. We also caught A. hwanhaiensis in 1998. Prior to the 1997 sampling we had not sampled these bays since 1976, when we only caught a few Neomysis mercedis. Still unidentified are several juvenile mysids of still another species taken in San Pablo Bay last year. Adults are needed for species identification.

Prior to the catch of the Korean species we had one species each from China and Japan, as well as one species of cryptic origin, Deltamysis holmquistae. We also have six native mysids, only three of which have been taken in our samples.

Acanthomysis bowmani was surprisingly abundant in October in Suisun Slough; its abundance reached 179/m3. It was also abundant in November in the San Joaquin River at Stockton where 49/m3 were captured. Neomysis mercedis was rare; its greatest abundance was only 0.7/m3 at Stockton in November. It was found at only three stations in October and November, but this is an improvement since none were captured in these months in 1997.

ZOOPLANKTON

Jim Orsi, Department of Fish and Game

Limnoithona tetraspina was the most abundant copepod in October and November, but was much less abundant than it was in 1997. Pseudodiaptomus forbesi was second most abundant. Eurytemora began to appear in October as it normally does, but did not become abundant anywhere we sampled. Notable was the very low abundance of Tortanus, which was not found in San Pablo Bay as would be expected, but at Martinez and in western Suisun Bay instead. Acartiella sinensis was only about a tenth as abundant in 1997. Sinocalanus, Diaptomus, and Cyclops were the only copepods more abundant in 1998 than in 1997. Cladocerans and rotifers were somewhat more abundant in 1997.

- Shallow Water Habitat Workshop Summary

Carole McIvor (US Geological Survey), Larry Brown (US Bureau of Reclamation), and Zachary Hymanson (Department of Water Resources)

Introduction

On 24 June 1998 the IEP, representatives from the IEP Science Advisory Group (C. McIvor, J. Cloern, S. Monismith), CALFED, and several independent researchers held a day-long workshop on shallow water habitat. The meeting took place at the USGS office in Menlo Park, California and was attended by 27 people. The agenda was an ambitious one and included the following goals:

1. Develop a research strategy
2. Develop a consensus on a working definition of shallow water habitat
3. Identify processes and strategies for better integration, coordination of shallow water habitat studies and programs
4. Identify ideas and issues for monitoring restoration projects
5. Discuss the ecosystem impacts (both positive and negative) of restoring shallow water habitat.

This summary covers goals 2 and 4 explicitly, and goals 1, 3, and 5 peripherally and in less detail.

Issues

During the year prior to this workshop, several important issues have emerged concerning shallow water habitat in the estuary, which included the following:

1. A cornerstone of the CALFED Ecosystem Restoration Program Plan is to improve the estuary ecosystem through large-scale re-establishment of shallow water habitat in the delta. However, there are significant questions about the scientific basis for making large investments in the re-establishment of shallow water habitat, both in terms of the potential for effective implementation and the resulting effects on the ecosystem.
2. A common working definition for shallow water habitat applicable to all areas of the estuary is needed to ensure effective communication and coordination. Descriptions of the shallow water habitat types occurring within the estuary are also needed.
3. The IEP and others have several shallow water habitat studies underway or planned. Although specific questions are associated with each study, no one has developed an overall research strategy for shallow water habitat investigations. We need to develop a process to integrate the many ongoing programs related to this habitat to facilitate coordination, information transfer, and synthesis of a "big picture" level of understanding.
4. Through its Category III Program, CALFED has and is expected to continue to fund medium- to small-scale shallow water restoration projects in the estuary. Other restoration projects are also occurring to satisfy compensatory mitigation obligations or to fulfill other needs. A strategy for monitoring these projects is needed to ensure we answer the following: how/what/where should we measure site-specific and ecosystem responses to these projects? Such a strategy also needs to ensure that results among projects can be quantitatively compared.

This meeting was convened to provide a forum for the discussion (and in some cases resolution) of these issues. The meeting also served as a means to provide the IEP with input to help guide its work on shallow water habitat in the estuary.

Definition of Shallow Water Habitat

Larry Brown (USBR) presented working definitions of shallow water habitat relevant to the San Francisco Bay and the Sacramento-San Joaquin Delta. (Larry's white paper, along with an evaluation of the potential importance of shallow water habitat to fish and other aquatic organisms in the estuary, is available at www.iep.ca.gov/eet/.) According to Cowardin and others (1979), shallow water habitat is water less than 2 m, often coinciding with the limit of emergent vegetation. Conversely, the USEPA (1997) defines shallow water habitat as being water less than 4 m, including estuaries and coastal waters. Larry's recommendation was to use both definitions as follows: less than 2 m for marshes, wetlands, and sloughs; less than 4 m from open water shoals. The general consensus was one of agreement with this recommendation with some minor changes noted below.

A second consideration of Larry's presentation was the question of why there has been relatively little attention given to such shallow water habitats in past bay-delta monitoring and research. Three reasons were given. First, until quite recently, research and monitoring has focused on more open water species of concern (including striped bass and salmon), which are believed to use primarily deeper channel habitats. Second, the sampling gears used in the past for channel species were simply not appropriate for use in shallower waters. Third, is the perceived scarcity of good quantitative methods for sampling shallow water habitat, especially in and around vegetation. Overall, the lack of interest in shallow water habitats earlier in the IEP program was largely driven by interest in defining the roles of flow and diversions in controlling production of striped bass, salmon, and other species that were not believed to rely heavily on shallow water habitat for completion of their life cycles. Stated in another way, shallow water habitat was not believed to be a limiting factor on any of the populations of interest.

A third component of Larry's presentation was a proposed categorization of shallow water habitat to facilitate communication among researchers, managers, and the public. Larry proposed the following categories:

1. Perennial versus temporary inundation
2. Salinity regime (brackish, seasonally brackish, fresh)
3. Intertidal versus subtidal
4. Open water versus channel margins versus shallow sloughs
5. Soft versus hard substrate
6. Presence or absence of aquatic vegetation, the latter categorized as emergent, floating or submerged
7. Presence or absence of riparian vegetation bordering the water course

Whereas there was general acceptance and approval of the utility of these distinctions, there were questions about the geographic area covered by these definitions, especially in relation to plans for restoration. Are these categories only supposed to apply to the estuary (Sacramento-San Joaquin Delta, Suisun Bay, and San Francisco Bay) or were other areas included? This discussion was likely caused by the inclusion of Yolo Bypass in the draft white paper. The bypass is an important shallow water area but it is not (or barely) tidally-influenced during floods, when it is important to the ecosystem. The draft white paper will be revised to indicate that the general scope of the definition is the bay-delta estuary. The information on Yolo Bypass will be retained but it will be made clear that the bypass is a special case.

There was substantial discussion of scale issues. For example, the perennial versus temporary category can be interpreted in many ways depending on the time scale used. The intertidal zone can be viewed as a temporary habitat on the scale of hours. Some marshes can probably be considered temporary on longer time scales (10 years or longer) depending on geomorphic and other physical and biological processes. The intended scale of the first category was seasonal. The intent was to separate seasonally-flooded, shallow water areas from perennially-flooded, shallow water areas. This choice of time scale will be made explicit in the revised definition. There was a similar discussion of spatial scale. The point was made that a small marsh might function very differently from a large marsh. Similarly, a shallow water area associated with an upstream watershed might function very differently from a similar-sized marsh created from a flooded island surrounded on all sides by deep channels.

There was much discussion of hydrodynamic regime and how it could be incorporated into the list. The simplest method was to define "fast flow" and "slow flow" regimes; however, it is difficult to objectively define a breakpoint for such a category. The other suggestion was to classify areas as "flow-through" or "closed." For example, a flooded island with a single breach would be considered closed, whereas one with several openings allowing tidal flow through the area would be considered flow-through. No conclusion was reached on how best to incorporate these distinctions.

A more general discussion revolved around the idea that all of the attributes discussed were relative measures. For example, one could do a study entirely within the shallow water zone, as defined in the white paper, but still be comparing a relatively deep area with a shallow area. Further, the idea of relative measures applies to many of the ideas discussed such as fast versus slow, old versus young, big versus small, and so on.

There was also some discussion of the utility of general categories as proposed for the present definition of shallow water habitat versus very detailed typologies of habitat types based on both physical and biological attributes. The consensus appeared to be that detailed typologies are especially useful for tasks such as GIS habitat mapping. They can also be useful for facilitation of communication but such typologies require a significant effort on the part of knowledgeable people. Such an effort has been completed for the bay. Completion of a typology for the delta would require an expenditure of time and resources beyond the volunteer efforts completed to date. There also appears to be a much less extensive database available for delta shallow water habitat, which might make objective delineation of such a typology difficult.

A final suggestion was made that it might be useful to construct an attribute by species matrix for delineation of types of shallow water habitat associated with specific species or species' life stages. Though this exercise would be useful, the data base for completing such a matrix is currently incomplete and it is doubtful that a significant portion could be completed. For this reason, the draft white paper explicitly rejects this species-based approach at present. Nevertheless, such a matrix might be a useful tool for directing future research by identifying gaps in our knowledge.

At the end of the discussion, the group concluded that some clarifications and additions could improve the utility of the habitat classifications. With regard to the geographic area included, the scheme is intended to apply only to the tidal portion of the bay-delta estuary with several exceptions. Nontidal, shallow water areas within leveed areas are included, as are areas where tidal influence is muted or controlled by water management structures. The Yolo Bypass is included in the draft white paper because of its importance to estuarine production. Revisions to the actual definitions included the following: (1) adding nontidal to the intertidal versus subtidal category; (2) changing the perennial versus temporary category to permanent vs. seasonal; and (3) adding new categories.

The new categories added were as follows:

1. Hydrodynamic regime--stillwater versus single-opening breached levee versus multiple-opening breached levee allowing tidal flow-through versus non-leveed or minimal levees allowing broad exchange with channels;
2. Size--expressed in areal units (no categories defined at present); and

3. Connectivity--a statement of the proximity of similar and other types of shallow water habitat, and associations with upland habitats and watersheds.

Summary of Presentations

During this section of the workshop, we heard brief presentations of several studies or activities related to shallow water habitat. This was not meant to be a comprehensive description of all activities and studies relating to shallow water habitat occurring in the estuary. Instead, results from select activities or studies were presented to stimulate discussion of ideas, questions, and issues.

Terry Mills (CALFED) presented an overview of the Ecosystem Restoration Program Plan (ERPP) emphasizing that portion on shallow water habitat, a cornerstone of the restoration plan. The entire plan comprises two volumes. During ERPP development, CALFED looked at 65 restoration plans based on species, but chose to go with an ecosystem approach. In Volume 2 of the ERPP, CALFED broke the geographic area into 14 ecological zones. It is important to emphasize that this two-volume work is not a science plan, but rather a public disclosure document. The document was published in March 1998; CALFED restoration activities will take place over at least the next 30 years.

Recommendations in the ERPP regarding the delta include 125,000 acres of shallow water habitat. Increases in lower-bay emergent saline wetland habitat are also recommended. It is recommended that approximately 85,000 acres of restored shallow water habitat occur within the legal delta.

Terry pointed out that we still need answers to several important questions concerning shallow water habitat:

- Where and how does shallow water habitat fit into a mosaic of interconnected aquatic and terrestrial habitats? This question is very important in the context of the ERPP given that CALFED is taking an "ecosystem approach" to restoration.
- What physical (biophysical) processes are necessary to maintain shallow water habitat? Work underway by Si Simenstad (University of Washington) and others (see below) will lead to development of an initial conceptual model of the physical factors affecting the maintenance of shallow water habitat in the delta.
- What are the potential mechanisms linking shallow water habitat and energy and nutrient flow in the system?
- What temporal and spatial scales are necessary to evaluate the results of rehabilitating, protecting, or restoring shallow water habitat?
- What are the dimensions of a conceptual model for shallow water habitat?
- What are the appropriate testable hypotheses related to shallow water habitat restoration?
- What are the indicators of shallow water habitat health or condition? Several example indicators were provided focusing on ecological processes (for example, sediment supply or nutrient cycling), habitats (for example, fish spawning habitat or waterfowl feeding habitat), and species dependent (for example, resident native fishes or aquatic vegetation).

Meeting participants recognized that we do not have complete answers for any of these questions. Most thought that obtaining answers to these questions should occur before substantial funds are invested in the restoration of shallow water habitat. Jim Cloern (USGS) expressed concerns as well about the scientific basis for the restoration of shallow water habitat versus other restoration goals. He pointed out that there has been insufficient justification given for such great emphasis being placed on the re-establishment of these habitat types. For example, he asked what specific ecosystem functions will be enhanced by the establishment of these different shallow water habitats and will such enhancement increase the likelihood that target species will respond in a positive way? Additionally, Jim questioned how much a restoration program can alter the size and functions of shallow water habitat across the entire geographic domain of CALFED's restoration plan (in other words, how large is 7,000 acres of tidal, perennial aquatic habitat compared to the existing acreage of this habitat type? Is it reasonable to expect that this action might have a measurable impact? Pointing out that some ecosystem effects of restoration might be negative, Jim stated that we know very little about how newly-established shallow regions might alter the cycling, retention, and trophic transfer of toxic contaminants.

Kathy Hieb (DFG) reviewed the tidal marsh study. Its goal is to determine how fish, caridean shrimp, and brachyuran crabs use various marsh habitats in the San Francisco Estuary. Sampling has been concentrated in the lower Petaluma River and northern Napa Marsh where several ages or types of marsh are within close proximity. Researchers are using a variety of methods in a range of habitats--subtidal and intertidal, vegetated and non-vegetated. They are finding that the marsh plain is not flooded regularly, but that fish are definitely using vegetated edges. Additionally, the majority of native species have been taken in lower-order channels, with a mixture of native and exotic species in larger channels. Species captured behind tide gates are almost exclusively exotic species.

Jessica Lacy (Stanford University) reported on a study of the hydrodynamics of Honker Bay. There are two main components of the study: a series of drifter experiments and two seasonal deployments of instruments to measure time series of velocity, salinity, temperature, depth, and suspended sediment concentration. The drifter experiments revealed that the residence time of water in most of the bay is six hours or less. This fact is important for the passive retention of fish in the bay. Data analysis continues on the seasonal deployment data. However, there are differences in salinity on the order of 2 to 3 ppt over relatively short distances.

Bruce Herbold (EPA) reported on the UC Davis Suisun Marsh fish monitoring. This monthly trawl sampling program at 21 sites distributed among nine sloughs has been in effect since October 1979. (See Moyle and others 1986 and Meng and others 1994 for more detail.) Native species are more abundant in smaller, dead-end sloughs. Natives are more predictable than exotics in distribution and abundance. Exotic species are ubiquitous but highly variable. The edge community sampled by seines differs and includes salmon.

Dale Sweetnam (DFG) summarized the use of shallow water habitat by early life stages of delta smelt. Project goals are to compare densities between mid-channel areas and shallow areas, and between surface and bottom portions of the water column. Results to date indicate that larvae are surface-oriented, juveniles are exclusively so. Larval smelt are not found in higher densities along shallow shoreline zones. Future plans are to expand sampling to more geographic areas in the Estuary, and to deeper channels.

Amy Harris (Surface Water Resources, Incorporated), gave a preliminary report on the occurrence of juvenile fish in a natural versus a restored slough in the north delta. Pop nets are currently being using with mixed success. Qualitatively, it appears that there may be higher abundance of natives at the natural site.

Charles (Si) Simenstad (University of Washington) reported on the flooded island study. The study's design concept is to substitute space for time. A newly restored site goes through succession or a functional trajectory. Sixteen remnant wetland sites have been identified in the delta. Additionally, there are distinct geomorphological regions. Nineteen to 20 sites have been restored naturally or on purpose. These sites are nested within hydrogeomorphic areas. The study will look at fish use and food web parameters in the central sites. Physiochemical and hydrogeomorphic parameters will be measured at all sites. The study is paying particular attention to wetland edges. Additionally, a graduate student is looking at fish use of two types of floating vegetation (water hyacinth and a native pennywort).

Ted Sommer (DWR) reported on the Yolo Bypass study. The bypass is in the Sacramento floodplain, and covers 50,000 acres. Fish are using the region in large numbers and density estimates often exceed those from the adjacent Sacramento River. Researchers are finding chinook salmon, splittail, and steelhead (species of special concern) in the bypass. They have looked at agricultural, riparian, and native vegetation equally and have found that flow is more important in predicting fish usage than is vegetation type. Splittail are spawning in the bypass, as are Sacramento blackfish. In terms of rearing, growth is faster for a given species in the bypass than in the river, stomachs are fuller, and water temperatures are higher. Whereas some fish do strand in the bypass, substantial numbers make it back to the mainstem river as flood waters recede. In summary, native fishes seem to do well in this temporary habitat. Additionally, the research group believes that the Yolo Bypass area is a major source of organic carbon to the river.

Mike Chotkowski (DFG) described a new project that seeks to "mine" existing data on fish in shallow water habitats. The first goal is to determine what questions can be asked of the data, given how, when, and why it was originally collected. This work just started and results are expected by July 1999.

Amy Harris described a pilot shallow water habitat restoration project set to occur in the lower Sacramento River. The project is designed to establish approximately 50 acres of tidal wetland on Decker Island. The Port of Sacramento will remove sections of the river bank at the south end of the island to restore natural tidal regime. Approximately 3,000 to 4,000 lineal feet of graduated shallow water channels will be excavated to restore tidal shallow water habitat. Several mounds (upland refugia) will also be constructed from excavated material to enhance the microtopography of the tidal wetland zone and riparian and aquatic habitat diversity. Key technical questions they hope to address through the monitoring program include the following:

- Will Sacramento River and delta fish use tidal wetland habitats created in the interior of Decker Island? Specifically, during what period(s) of the year and to what degree will target fish species (for example, juvenile spring-run and winter-run chinook salmon and adult/juvenile life stages of splittail and delta smelt) use the restored habitats?
- What physical (flow), chemical (salinity and turbidity), and biological (fish composition and relative abundance) conditions within the Sacramento River near the river bank breach influence fish use of the restored habitats on the island's interior?

- If use of restored tidal wetland habitats occurs at Decker Island, will target fish species preferentially use certain restored habitat types over others?
- If species-specific and life stage-specific preferential habitat use is exhibited by fish, what physical, chemical, and biological aspects of the restored habitats are influencing habitat selection?

Collette Zemitis (DWR) described the Prospect Island restoration project and the resulting monitoring program. The purpose of the monitoring program is to document ecological processes and habitat use by targeted species in restored areas of Prospect Island. Approximately 1,200 acres of Prospect Island will be restored by creating wetland features--a deep channel, shallow dead-end sloughs, and small islands--and will then be flooded to a depth of approximately two feet. The proposed monitoring includes the following elements: fish, wildlife, water quality, vegetation, phytoplankton, zooplankton, benthos, bathymetry, and organic carbon. Conditions in the restored wetland, including species abundance and distribution, will be compared to adjacent channels. Each element of the monitoring program will provide data to address specific questions and objectives.

Results of Discussion of Research Questions

Defining research questions

The process of defining the research questions to guide the development of a research strategy involved several steps. First, several IEP Project Work Teams and other IEP staff involved in shallow water monitoring or research were asked to contribute questions about shallow water habitat. Larry Brown compiled the questions and sent them to the meeting participants prior to the workshop, requesting them to prioritize the questions. The participants were also asked to summarize the questions if they recognized general themes. Larry Brown compiled and summarized participant feedback into the questions and general comments listed below. These questions were presented at the meeting to stimulate a discussion and to refine a list of questions for guiding a research strategy. Additional questions were added to the existing list as new, broad and specific questions were presented at the meeting.

General comments on shallow water habitat questions

Respondents to Larry Brown's inquiry had several general comments on the conceptual basis of a research strategy. There was a general consensus that whereas general topics such as "biology" are appropriate for organizing thoughts, any monitoring or research programs should be interdisciplinary or cross-disciplinary in nature. Respondents were also cognizant of the importance of "scale" in investigations, in other words, the spatial scale of individual project response versus that of ecosystem response and short-term versus long-term temporal scales on which restoration success could and should be measured. Further, while recognizing the necessity and desirability of assessing the response of target species, they also felt that community and ecosystem response variables should be monitored as well. They recognized that introduced species are well established in the bay-delta ecosystem and that they will respond in possibly complex and unknown ways to restoration activities. Finally, respondents felt that a research strategy should focus both on the function of existing shallow water habitat and the design and monitoring of created habitat.

Revised List of Research Questions

BIOLOGICAL FUNCTION

Broad Question

- What is the relative importance of floodplains, tidal marshes, submerged aquatic vegetation, and open water habitat to native fishes in particular and to aquatic communities in general? All life history stages should be considered, as well as different temporal scales (tidal, seasonal, annual).

More Focused Questions

- Is shallow water habitat a limiting factor for any of the fish species of concern?
- How important is the Yolo Bypass to estuarine populations of fish and as a source of dissolved organic carbon, nutrients, and organisms to the estuarine food web? More generally, what are the relative benefits of permanent and seasonal shallow water habitat to those processes and others such as support of overall biodiversity?

- How do predation rates, particularly of introduced fishes on native fishes, vary with types of shallow water habitat and how important are contributing factors such as turbidity and submerged aquatic vegetation?
- How important are shallow water habitats associated with smaller watersheds such as the Napa River? More generally, how important are connections of shallow water habitat with upland habitats and smaller watersheds in determining their value to aquatic communities?

Broad Question

- Do rehabilitated shallow water habitats provide habitat for native fishes and other components of the aquatic ecosystem? How do relative abundance, survivorship, and growth rates in such habitats compare with natural shallow water habitats in similar geomorphic and salinity settings? Do these parameters vary over time?

More Focused Comments and Questions

- Temporal scale of studies should incorporate longer time scales (20 + years) to determine how the value of rehabilitated shallow water habitats evolve over time.
- Will knowledge obtained from initial small-scale rehabilitation efforts translate well to understanding large-scale, ecosystem-level effects?
- Are "reference" or "comparison" shallow water habitat sites necessary to assess the success of rehabilitation efforts or should project success be measured against conditions in the nearby channels before rehabilitation took place?
- Look for the existing "natural experiments" and previously rehabilitated shallow water habitats with non-existent or inadequate monitoring, study these experiments, and compare and contrast the results among them and with newly implemented projects.

Broad Questions

- What abiotic factors are most highly correlated with the microhabitat distribution and abundance of both native and introduced species in shallow water habitats? Using a combination of field and laboratory experiments, are there differences in microhabitat distribution, growth, or survival in the presence of introduced species?
- How productive are natural and rehabilitated shallow water habitats with regard to zooplankton, phytoplankton, and nutrients (including organic carbon) and how much of that production is exported out of the local area into deeper water areas, such as large channels and Suisun Bay?

More Focused Comment

- The indirect benefits of shallow water habitat to upper trophic levels should be quantified and explicitly compared to the direct habitat benefits. Interconnections of shallow water habitat with water quality and other physical processes should also be elucidated (also mentioned below as fluxes).

Design and Assessment of Rehabilitated Shallow Water Habitat

Broad Question

- Based on the present level of knowledge, can we develop some general guidance for design of shallow water restoration projects to maximize benefits to fish? Guidance could include size, depth, connectivity to major body of water (for example, size, location, and number of entrances), amount of tidal exchange, and range of elevations.

More Focused Question

- In systems where the ability to manage the system is maintained (for example, Suisun Marsh Salinity Control Gates), should the system be managed for mean conditions or the natural range of variability (salinity, inundation, and so on)?

Broad Question

- Can we develop a set of biological and physical parameters that should be measured in "restored" marshes or other shallow water habitat to assess the success of the restoration relative to fish (indicators)? What should be the frequency and duration of the post-construction monitoring?

More Focused Questions and Comments

- Can we develop food web indicators based on populations of copepods, mysids, or other organisms?
- Can historic conditions be reconstructed from paleo-type studies and, if so, is this a realistic research goal? Alternatively, the best existing conditions might be the best attainable goal. Historical studies can indicate processes that have produced existing conditions.
- Indicators should be habitat-specific.

Broad Question

- How can tidal marsh and other shallow water habitats be managed for the benefit of fish as well as for waterfowl or shorebirds? This question incorporates the community concept and refers primarily to managed waterfowl areas that presently have little or no fisheries benefits.

Physical and Chemical Processes

Broad Questions

- What are the water and material fluxes (including sediment) between shallow water areas and adjacent deep-water channels? Are there differences between existing and rehabilitated shallow water habitats?
- Will created or restored shallow water habitats be physically stable? Will levee breaches for created habitat areas remain open as designed, tend to close due to sedimentation, or be open further due to erosion or scouring?

More Focused Questions and Comments

- How do the number and locations of breaches affect hydrodynamics, sedimentation, and associated processes within breached levee projects?
- Do extensively "engineered" projects (for example, extensive contouring and planting) perform better than minimally engineered projects (for example, grading to prevent fish stranding, then flood)?
- There is a need to monitor hydrodynamic, sediment, and wind fetch processes in shallow water habitats. These data are required to understand the processes and then to guide the design of different-sized projects. If these data exist (perhaps with the US Army Corps of Engineers) they need to be easily accessible to project designers.

CONTAMINANTS

Broad Questions

- What effects will the creation of shallow water habitat have on the cycling, concentrations, and bioaccumulation of the major classes and species of contaminants that occur in the bay-delta system (for example, Hg, Se, Cd, insecticides, and herbicides)?

- Will rehabilitated shallow water habitats export dissolved organic carbon to the system? If they do, are the chemical characteristics of the organic carbon conducive to formation of trihalomethanes and other disinfection by-products?

DATA EXCHANGE AND ASSESSMENT (NEW CATEGORY)

- Data assessment should stress the relative importance of the direct (for example, habitat use) and indirect (for example, export of dissolved organic carbon) effects and processes identified above.

- Data assessment should include methodologies for integrating results obtained at the project level so that cumulative ecosystem effects can be assessed. This is one of the goals of the Comprehensive Monitoring, Assessment, and Research Program (CMARP), presently being developed for CALFED.

- To aid in the above task, a network of baseline-monitoring sites should be developed before implementation begins.

- A strategy is required to facilitate data exchange on sampling methods and results. The strategy should encourage the following: (1) attendance and information exchange at national professional meetings; (2) development of other mechanisms for data exchange with other researchers in other systems; (3) regular regional meetings for information exchange (for example, an annual CALFED symposium under CMARP); (4) creation of an inter-disciplinary IEP project work team for ongoing and proposed studies (under development); and (5) development of a web page.

- An initial synthesis of existing data on shallow water habitats is needed.

- A "recipe book" for methodologies and indicators is needed.

Miscellaneous Issues

The workshop concluded with an open discussion of a range of issues related to restoration of shallow water habitat, from the origin of the term (from Moyle and others 1992 where SHW is used as synonymous with shoals as opposed to channels), to a reminder that as a group we are interested in something much more difficult than what shallow water habitat is, rather we are ultimately interested in trying to assess habitat quality (Denise Reed, University of New Orleans). One researcher pointed out that some very effective sampling techniques (for example, electrofishing) are now discouraged because of concern for threatened and endangered species, and expressed the hope that study-specific agreements might be reached allowing use of such techniques. Jessica Lacy (Stanford University) asked if there are other ways of promoting species by using flows, for example. Someone else pondered about the appropriate balance in restoration funding for construction versus funding for monitoring. Si Simenstad pointed out that the portion of our summary of research questions dealing with primary production needs to be expanded: at present it appears to be hidden under nutrient cycling. Zachary Hymanson (DWR) voiced a general concern: "What if restored shallow water habitat ends up benefiting exotic species?" Bruce Herbold states that the white paper points out that some shallow water habitat does benefit native species.

Other discussion involved the time frame necessary to judge the success of restoration. Si Simenstad asked if we can tolerate the 50-250 year time-frame needed to achieve "restoration." Voters and society want instantaneous gratification, in other words, instant native species response. Si knows of no engineered system that has responded to restoration goals in even 30 years. Leo Winternitz (DWR) states that Category III funds are an inherent problem in that they allow for only three years of monitoring. Thus, one gets a picture of a new system only in its infancy.

A recurring theme involved what is perceived to be a narrow criterion for success of restoration of shallow water habitat, in other words, two target fish species (delta smelt and winter-run chinook salmon). Leo Winternitz expressed concern that if these two species identified by CALFED as targets do not respond to restoration efforts, CALFED would interpret that result as a failure of restoration. Si Simenstad pointed out that the factors affecting salmon performance are varied and numerous, and operate at scales from the Sierra in California to Japan. He noted that the fish populations could go up or down for reasons totally unrelated to shallow water habitat. Pete Rhoads (MWD) pointed out that it is crucial to have multiple indicators of restoration success. At all costs, avoid thinking solely of two fish species. Further, it is clear that we must look at trends, not just success or failure, and that we must think long-term.

Jim Cloern added a more expanded perspective along these same lines. Jim posited that the call for restoration of shallow water habitat is based on the implicit belief that in the current condition of the delta, shallow water habitat limits the recruitment or maintenance of certain fish populations. This presumption may or may not be true. However, an alternative hypothesis is that fish stocks are declining in this ecosystem because of the interacting effects of multiple stressors, including habitat limitations, manipulations of inflow-outflow, disturbance caused by exotic species, disturbance caused by toxic chemicals, and changes in the coastal ocean (for migratory species). The scientific community is far from fully understanding how all these stressors interact to cause fluctuations in stocks of fish. Let us hope we are not going down a path in which we make major investments to restore certain habitat types, judge performance only on the basis of changing fish stocks, and then conclude that restoration actions were a failure if these stocks do not recover within a certain period of time. Rather, we must take a broad enough perspective to include other kinds of performance criteria. For example, if we have identified certain shallow water functions as being critical to the recruitment of target species, then a more balanced set of performance criteria would measure those functions directly. Perhaps a meaningful set of performance measures would include things like: secondary production of forage species such as amphipods or mysid shrimp or native copepods; the number of river miles of riparian habitat; or the acreage of habitat suitable for spawning by the target species.

Formation of New Shallow Water Habitat Project Work Team

It was clear from the presentations and discussion of the research questions that the IEP has enough involvement in shallow water habitat to warrant the formation of a new project work team. Such formation was suggested during the workshop and there was broad support for the formation of an interdisciplinary team focusing on shallow water habitat. A Shallow Water Habitat Project Work Team was subsequently formed and first met in December 1998. One of this team's initial tasks is to continue the refinement of the research questions needed to formulate a research strategy. Contact Mike Chotkowski (mchotkow@delta.dfg.ca.gov) for more information.

References

Cowardin LM, V Carter, FC Golet, and ET LaRoe. 1979. Classification of Wetlands and Deepwater Habitats of the United States. Washington, DC: US Fish and Wildlife Service. FWS/OBS-79/31. 103 p.

Meng L, PB Moyle, and B Herbold. 1994. Changes in abundance and distribution of native and introduced fishes of Suisun Marsh. Trans. Am. Fish. Soc. 123:498-507.

Moyle PB, RA Daniels, B Herbold, and DM Baltz. 1986. Patterns in distribution and abundance of a noncoevolved assemblage of estuarine fishes in California. Fishery Bulletin 84(1):105-117.

Moyle PB, B Herbold, DE Stevens, and LE Miller. 1992. Life history and status of delta smelt in the Sacramento-San Joaquin Estuary, California. Trans. Am. Fish. Soc. 121:67-77.

USEPA. 1997. Proceedings of the second marine and shallow water science and management conference. Philadelphia, PA: US Environmental Protection Agency. EPA/903/R/97009.

A CALFED-supported Study of the Delta's Foodweb Base

Jim Cloern, US Geological Survey

Scientists from six universities and the US Geological Survey (USGS) have begun a new project to characterize the food resource which supports secondary production in different habitats of the Sacramento-San Joaquin Delta. The project is supported by CALFED Category III, USGS, and the IEP; it is designed to answer basic questions about the organic matter which supports biological production at the lowest trophic levels. We know, from the excellent long-term records of IEP agencies, that the abundance of zooplankton (especially native species) has declined dramatically in the past three decades. We do not understand the underlying mechanisms of these declines, but it is likely that they are the result of multiple, interacting stressors. One potential limitation of secondary production could be a sub-optimal food resource, manifested either as low quantity or poor nutritional quality of the available pools of organic matter. Some past studies support this possibility, especially for the case of benthic macroinvertebrates. The project was conceived to do the following:

1. Identify the potential sources of organic matter (for example, phytoplankton, vascular plants, agricultural sources) in different habitats;
2. Determine the relative food quality of each of these different sources for secondary producers, either directly or after microbial processing; and
3. Assess the habitats and environmental conditions that provide the maximum food resources for secondary producers.

This information is essential for determining the most effective ecosystem restoration or rehabilitation strategies, particularly for restoring those services or functions provided by the secondary producers such as cladocerans, copepods, rotifers, amphipods, and insect larvae. These services include production of forage for priority fish species listed in the CALFED Ecosystem Restoration Plan.

This new collaborative project addresses questions that are difficult to answer because there is no simple assay or measurement that can definitively identify the sources, quantity, quality, or utilization pathways of organic matter in aquatic ecosystems. We will approach this problem through a combination of (a) numerical modeling of the delta ecosystem, (b) analysis of trends of change using results from the IEP observational program, and (c) a new field study. The field study will be conducted by the following researchers:

1. Professor Elizabeth Canuel and graduate student Vicki Pilon (The College of William and Mary), who will use two geochemical indicators (stable isotopes and lipid biomarkers) to identify the sources of particulate organic matter in the water and sediments of different habitat types. They also will measure indicators of food quality: total proteins, carbohydrates, and lipids. (See the following article.)
2. Dr. Anke Mueller-Solger, Professor Charles Goldman, Dr. Dörthe Muller-Navarra (UC Davis) and Professor Michael Brett (University of Washington), who will use zooplankton growth assays as indicators of the quantity and quality of the suspended particulate matter collected in different habitat types.
3. Professor (James) Tim Hollibaugh and graduate students Amy Bennett (University of Georgia) and Laura Fandino (Scripps Institute of Oceanography), who will use a variety of microbial assays to characterize the value of the large pool of dissolved organic matter, including the potential of this pool to support secondary production.
4. Jim Cloern, Brian Cole, Jody Edmunds, Jean-Marc Guarini and colleagues at USGS, who will measure primary production of phytoplankton and benthic microalgae, and bulk measures of the seston (particulate organic carbon and nitrogen, chlorophyll, total suspended solids) and the dissolved organic matter (dissolved organic N and C).

The sampling program is designed to apply these approaches across the full spectrum of habitat types within the delta, including flooded islands, the Sacramento and San Joaquin rivers, small delta sloughs, marsh creeks, intertidal habitat of Suisun Bay, and the delta-estuary interface (at X2). We plan to sample these habitats under a range of hydrologic conditions and over the seasonal growth cycles of the primary producers. For example, one target condition will be an event of high flow when the Yolo Bypass is flooded and delivers large quantities of organic matter from the Sacramento River basin flood plain.

This new field study is just one component of the larger group project, which includes the following: retrospective analysis of the long-term IEP data set (led by Professor Alan Jassby, UC Davis); development of a three-dimensional numerical model of delta hydrodynamics (Stanford University Professors Jeffrey Koseff and Stephen Monismith and graduate student Nancy Monsen); and a coupled model of hydrodynamics and phytoplankton-nutrient dynamics in the delta (Dr. Lisa Lucas, USGS, in collaboration with all other partners of this group project). Beginning with this issue of the IEP Newsletter we will describe the components of this CALFED-supported project of focused research.

Sources of Organic Matter in the Delta as Inferred through the Use of Biomarkers

Elizabeth A. Canuel, The College of William and Mary

In many marine and aquatic systems, production at higher trophic levels (for example, fish yield) generally increases as rates of primary production increase. In open water marine systems, primary production is essentially equivalent to phytoplankton production. However, in freshwater and estuarine systems primary production is carried out by a diverse community that can include phytoplankton, macroalgae, benthic microalgae, submerged and emergent plants, and riparian vegetation. In the Sacramento-San Joaquin Delta (hereafter referred to as the delta), for example, there is a tremendous diversity of habitats and each is characterized by different primary producers. In addition, organic matter, potentially usable as food by higher trophic levels, is delivered to the delta from the surrounding watershed through rivers. At present, however, there is not a clear understanding of how production at higher trophic levels is supported in the diverse ecosystems that encompass the delta.

Our goal is to identify those primary producers that are most important in supporting production at higher trophic levels in the habitats encompassing the delta. As part of the CALFED supported study described above, Vicki Pilon (Ph.D. student) and I will use geochemical indicators (biomarkers) to identify the sources and quality of particulate organic matter (POM) in the water and sediments of the different environments characteristic of the delta. Lipid biomarker compounds and naturally occurring stable isotopes will be used to identify the plant types and habitats that produce the most utilizable sources of suspended and sedimentary POM. In addition, we will use bulk biochemical measurements (total lipid, protein, and carbohydrate) to assess the potential usefulness of this organic matter as sources of energy and nutrition to organisms living in the delta. This article summarizes the approaches we are using as part of this work.

Chemical "signatures" present in environmental samples provide useful information about sources of organic matter important to freshwater, estuarine and marine ecosystems. This information can be present in elemental ratios, the presence of specific organic compounds, and the natural isotopic ratios of both biologically-important elements (C, N, S) and organic compounds.

Collectively, these geochemical tools are termed "biomarkers." Biomarkers have important characteristics: (1) their source specificity and (2) the predictable ways that compounds stabilize or degrade such that degradation products can be traced to specific source organisms. In general, the source specificity of a biomarker increases along a continuum from the bulk or elemental levels to molecular levels. For example, molar ratios of carbon to nitrogen (C:N) may provide insights regarding the relative importance of marine versus terrestrial sources of organic matter while specific compounds may allow one to differentiate between phytoplankton of diatom versus dinoflagellate origins. However, it is important to note that as biomarkers become increasingly specific, they also represent a smaller fraction of the total organic matter.

Although no single chemical tracer can be used to characterize the composition of POM completely, molecular biomarkers offer the following advantages over bulk chemical properties such as elemental and stable isotopic composition:

1. The diversity of biomarker compounds allows for better resolution of source contributions.
2. In some cases, biomarker compounds can provide additional information such as environmental conditions at the time the compounds were synthesized (for example, water column temperature) or under what conditions the sediments were deposited (for example, oxic versus anoxic).
3. Molecular-level analyses offer greater sensitivity.

One additional advantage is that multiple potential sources can be assessed through the analysis of single compound classes. However, because information on the composition of living organisms is incomplete and can vary in response to environmental conditions, it is important to assess the composition of primary producers within the system being studied. While it may not be possible to extrapolate from biomarker compounds to quantitative assessments of source inputs, due to the unknown effects of degradation, molecular level tracers (particularly when used in conjunction with elemental and isotopic techniques) can identify sources of organic matter that would not otherwise be possible.

Recently, biomarkers have been used in studying the sources of organic matter associated with water column particles and surficial sediments in complex, estuarine and coastal systems. Although amino acids and simple carbohydrates can provide limited source information, lipids are the most useful biochemical class for identifying the origins of POM. Lipids provide better source characterization than other biochemicals due to the number of unique biosynthetic pathways organisms use to produce these compounds, as well as their relatively high geochemical stability. As part of this interdisciplinary study supported through CALFED, we will use several lipid biomarker compounds to examine the origins and infer the reactivity of POM in suspended and surficial sediments. Two classes of lipid biomarker compounds (fatty acids and sterols) will be targeted. These compound classes were selected because they include compounds derived from organisms of likely importance as sources of organic matter to this system (for example, phytoplankton, benthic algae, terrestrial plants, and bacteria). Combining information derived from several independent indicators of the origins of organic matter has proven to be a reliable approach in addressing questions of organic matter source and reactivity.

Naturally occurring, stable isotopes of carbon and nitrogen will be used to further evaluate the sources of organic matter. Stable carbon isotopes allow us to differentiate between phytoplankton and land plants because the sources of inorganic carbon used by each of these primary producers (dissolved HCO3- and atmospheric CO2) have different isotopic signatures. In addition, the ratio of 13C to 12C varies for different photosynthetic pathways, allowing one to distinguish between organic matter produced by plants utilizing C3 (for example, needlerush; Juncus) versus C4 (for example, cordgrass; Spartina) pathways. Because the isotopic signatures of single elements (C, N) can have overlapping values in different groups of primary producers, we will use dual isotope analysis (in other words, C and N) to resolve potential source contributions. To aid in interpreting the isotopic signatures found for the seston and sediment samples collected as part of our study, we will also determine the isotopic signatures of various primary producers that could be potential sources of the POM. An effort will be made to carefully examine isotopic variability in representative plant groups over a range of spatial and temporal scales.

Data obtained through this study will provide considerable insight into the sources and reactivity of organic materials produced within the delta. This information will tell us, for example, whether production is primarily supported by phytoplankton, terrigenous or marsh vascular plants, submerged aquatic vegetation (for example, Egeria), or inputs from the rivers draining into the delta. In recent years, we have used lipid biomarker compounds and naturally occurring stable isotopes to identify the composition of POM, particularly those sources that fuel heterotrophic processes in the San Francisco Bay Estuary (Canuel and others 1995; Canuel and Cloern 1996). In this study, we will attempt to extend these findings to the delta region of San Francisco Bay thus providing additional information about aquatic food quality in this area of the bay, as well as a means of comparing food quality in the delta with other regions of this estuary. By identifying what habitats are most important in supporting productivity in the delta, our findings can guide managers and policy makers in future restoration efforts.

References

Canuel EA, JE Cloern, DB Ringelberg, JB Guckert, and GH Rau. 1995. Using molecular and isotopic tracers to examine sources of organic matter and its incorporation into the food webs of San Francisco Bay. Limnol. Oceanogr. 40:67-81.

Canuel EA, and JE Cloern. 1996. Regional differences in the origins of organic matter in the San Francisco Bay ecosystem:

Evidence from lipid biomarkers. In: JT Hollibaugh, editor. San Francisco Bay: The Ecosystem. San Francisco, CA: Pacific Division of the American Association for the Advancement of Science. p 305-24.

Another Problem Mussel Headed Our Way?

Randall Brown (Department of Water Resources), by way of Peter Moyle (UC Davis)

In a recent article, Ricciardi (1998) documented the global range expansion of an Asian mussel (Limnoperna fortunei). The mussel has already caused fouling problems in Hong Kong, Korea, Japan, Taiwan, and South America. Biologically, the Asian mussel is quite similar to the zebra mussel, but with a broader salinity tolerance. In 1991 it became established in Rio de la Plata Estuary in Argentina, probably by ballast water (Darrigran and Pasotorino 1995) and within two years up to 82,150 mussels per m2 were found in the littoral zone. Increasing shipping traffic between Asia and South America enhances the likelihood that the Asian mussel will reach the USA. This threat emphasizes the need for ballast water control.

References

Ricciardi A. 1998. Global range expansion of the Asian mussel Limnoperna fortunei (Mytilidae): Another fouling threat to freshwater systems. Biofouling 13(2):97-106.

Darrigran G, and G Pastorino. 1995. The recent introduction of a freshwater Asiatic bivalve, Limnoperna fortunei (mytilidae) into South America. Veliger 38:171-75.

Water Year 1998 DAYFLOW Data Availability

Dawn Friend, Department of Water Resources

DAYFLOW is a computer program developed in 1978 as an accounting tool for estimating historical Sacramento-San Joaquin Delta boundary hydrology. DAYFLOW output is used extensively in studies conducted by the Department of Water Resources (DWR), the Department of Fish and Game (DFG), by other State and federal agencies, and private consultants.

The DAYFLOW program presently provides the best estimate of historical mean daily flows: (1) through the Delta Cross Channel and Georgiana Slough; (2) past Jersey Point; and (3) past Chipps Island to San Francisco Bay (net delta outflow). The degree of accuracy of DAYFLOW output is affected by the DAYFLOW computational scheme and the accuracy and limitations of the input data. The input data include the principal delta stream inflows, delta precipitation, delta exports, and delta gross channel depletions. These data include both monitored and estimated values as described in the DAYFLOW program documentation. Currently, flows are not routed to account for travel time through the delta. All calculations involving inflows, depletions, transfers, exports, and outflow are performed using data for the same day.

DAYFLOW output data are updated every water year and are available from Water Year 1956 through Water Year 1998. The complete DAYFLOW program documentation, computational scheme, and output are available on the IEP website at http://iep.water.ca.gov/dayflow. To be notified by e-mail when updates are available, please contact Dawn Friend at dfriend@water.ca.gov or (916) 227-7612.

Density Dependent Growth and Diet Changes in Young-of-the-year Striped Bass (Morone saxatilis) in the Sacramento-San Joaquin Delta

Russ Gartz, Department of Fish and Game

Introduction

Kimmerer (1997) presented analyses that suggest that the mortality and survival of young-of-the-year striped bass (Morone saxatilis) in the Sacramento-San Joaquin Delta is density dependent. If density-dependent mortality and survival are observable then density-dependent growth could also be observed in the same population.

To investigate this issue I examined the growth rates of young-of-the-year striped bass, between midsummer and fall, for density dependence. I also examined past and recent diets of young-of-the-year striped bass caught in the Department of Fish and Game (DFG) Fall Midwater Trawl Survey (FMTS) to determine if diet changes have occurred.

Methods

I calculated growth rates for young-of-the-year striped bass caught in the September, October, November, and December FMTS from 1969 to 1997 except for: November, 1969, September and December, 1976, (no FMTS conducted), 1974 and 1979 (no FMTS done for the entire year), 1983 (no young-of-the-year 38 mm index calculated), and 1995 (young-of-the-year 38 mm index was estimated but not measured). I used the following equation to calculate the growth rate for each month:

Growth rate (mm/day) = [Average fork length (in a given month) - 38 mm]/(Midday of survey - Date of 38 mm townet index)

I regressed the growth rate on the 38 mm young-of-the-year index calculated from the DFG Midsummer Townet Survey. Density-dependent growth would be suggested if the slope parameter was negative and if the P value was less than or equal to 0.05. All four months were analyzed to determine if there was a particular time that growth rate became density dependent.

I analyzed diet data on young-of-the-year striped bass caught in the September, October, and November FMTS for the two periods 1968-1972 and 1996-1997. I summed these data by month for each time period and calculated the total number of bass sampled, the percentage of striped bass with food in the stomach, and the average number of major prey items per striped bass with food in the stomach.

Results

The only statistically significant linear relationship was found between the November growth rate and the 38 mm young-of-the-year index (Figure 1):

Growth rate (mm/day) = 0.526 - 0.001*(38 mm index) (standard error) (0.019) (0.0005) with r2 (adjusted) = 0.22 and P £ 0.0106 (with 23 degrees of freedom).

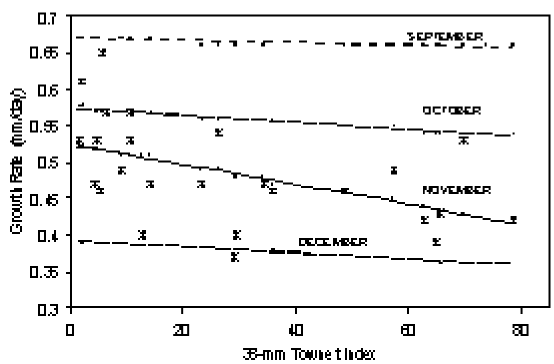


Figure 1 Linear relationship of growth rate and 38 mm Townet Survey Index of young-of-the-year striped bass (Morone saxatilis) caught in the September, October, November, and December midwater trawl. Calculated growth rates for the November FMTS are displayed as *.

Table 1 Percent of young-of-the-year striped bass (Morone saxatilis) with food in the stomach and average number of major food items for striped bass caught in the midwater trawl for the months September, October, and November in the years 1968-1972 and 1996-1997a

			Food Items					
			Mysids			**Amphipods**		
Years and Months	**Number of Stomachs**	**Percent with Food**	**Neomysis**	**Acanthomysis**	**Other**	**Corophium**	**Gammarus**	**Other**
1968-1972								
Sep	1,627	80	3.54	0.00	0.00	2.67	0.00	2.75
Oct	1,737	74	5.63	0.00	0.00	1.11	0.00	0.00
Nov	1,430	55	3.12	0.00	0.00	0.60	0.00	3.80

1996-1997								
Sep	291	63	0.02	0.68	0.10	0.56	11.37	0.00
Oct	155	73	0.00	0.73	0.90	0.37	24.47	0.00
Nov	79	63	0.00	1.89	0.41	0.87	2.30	0.00
a No data available for November, 1969. All food items are for bass that had food in the stomach.								

A statistically significant quadratic relationship was found between the December growth rate and the 38 mm young-of-the-year index [R2 (adjusted) = 0.19, F = 3.795 with 2 and 22 degrees of freedom]. However, this relationship is not biologically realistic and was not considered further.

The diet analysis revealed that there has been a shift in young-of-the-year striped bass diet and that young-of-the-year striped bass (in the size range caught by the FMTS) are able to utilize non-native prey species (Table 1). During the earlier period (1968-1972) striped bass diet was primarily composed of the mysids, Neomysis spp., and amphipods, Corophium spp. and others. During the more recent period (1996-1997) the diet had shifted to other sources; mainly the introduced mysids Acanthomysis spp., and greatly towards the introduced amphipods Gammarus spp. with some contribution from Corophium spp. In the most recent period Gammarus decreased by an order of magnitude from October to November (see Table 1).

Food consumption, as indicated by the percentage of bass with food in the stomach, did not vary greatly between time periods. It was higher during the earlier period for September and October but lower in November (see Table 1).

Discussion

Meaningful density dependent growth of young-of-the-year striped bass is not evident from this study. The growth rate analysis for November is suggestive; however, the slope and r2 values were small. Hence, these results do not concur with Kimmerer (1997) findings of density-dependent mortality.

Density dependence suggests a carrying capacity is being exceeded. Competition for food is the most likely cause of density dependence; however, significant correlation between food resources and carrying capacity are not evident. Although Neomysis (a staple food for striped bass in the earlier period) has declined (Orsi and Mecum 1996) other food items have taken its place and the percentage of striped bass with food in the stomach is not much different between the two time periods (see Table 1). The effect these new food sources have had on carrying capacity and growth have yet to be determined.

This research was done for the IEP/COMPMECH Striped Bass Workshop held on 10 and 11 August 1998, in Stockton, California.

References

Kimmerer WJ. 1997. Flow effects and density dependence in striped bass. IEP Newsletter 10(4):11-15.

Orsi JJ, and WL Mecum. 1996. Food limitation as the probable cause of a long-term decline in the abundance of Neomysis mercedis, the opossum shrimp in the Sacramento-San Joaquin Estuary. In: JT Hollibaugh, editor. San Francisco Bay: The Ecosystem. San Francisco, CA: Pacific Division of the American Association for the Advancement of Science. p. 375-401.

- Peer-Reviewed Papers Accepted or Published in 1998

Aasen G, DA Sweetnam, and LM Lynch. Establishment of the wakasagi, Hypomesus nipponensis, in the Sacramento-San Joaquin Estuary. California Fish and Game 84:31-35.

Feyrer F, and R Baxter. Fecundity and egg size of splittail. California Fish and Game 84:119-126.

Gartz R, R Fujimura, L Miller, and P Smith. Measurement of larval striped bass, Morone saxatilis, net avoidance using evasion radius estimation to improve estimates of abundance and mortality. Accepted by the Journal of Plankton Research.

Orsi JJ, and S Ohtsuka. Introduction of the Asian copepods Acartiella sinensis, Tortanus dextrilobatus (Copepoda:Calanoida), and Limnoithona tetraspina (Copepoda:Cyclopoida) to the San Francisco Estuary, California, USA. Accepted by Plankton Biology and Ecology.

Other Publications

Orsi J (Editor), R Baxter, S DeLeon, K Fleming, and K Hieb. Report on 1980-1995 fish, shrimp, and crab sampling in the San Francisco Estuary. IEP Technical Report 63 (Due for publication in 1999).

- The Second Annual IEP Monitoring Survey of the Chinese Mitten Crab in the Sacramento-San Joaquin Delta and Suisun Marsh

Anna Holmes and Jennifer Osmondson, Department of Fish and Game

Since its discovery in South San Francisco Bay in 1992, the Chinese mitten crab population has increased exponentially and its distribution has expanded rapidly in the San Francisco Estuary and Central Valley. To track the relative abundance of age-0 mitten crabs in the delta and Suisun Marsh, IEP initiated an annual juvenile mitten crab survey in summer 1997. This survey complements the adult crab (age-1+) data collected in fall by the USBR and DWR fish salvage facilities and the IEP fisheries monitoring program (for example, the Bay Study otter trawl survey). In fall 1998 we also conducted two small special studies for juvenile mitten crabs: a survey along the salinity gradient from Suisun Bay to the western delta and a survey of water hyacinth in the delta.

Our 1998 monitoring survey included four Suisun Marsh stations and 14 delta stations (Figure 1). Of the 14 delta stations, 10 are core and 4 are peripheral. Core stations were sampled once in July and once in August, four weeks apart, while peripheral stations were sampled once in August. Changes from 1997 included dropping the peripheral station at Middle River at Wing Levee Road and adding a peripheral station at Consumnes River Preserve in the northeast delta and at Mossdale Crossing County Park in the southeast delta. A core station was added in the western delta at Marsh Creek near Big Break and the Venice Island station was changed from a peripheral station in 1997 to a core station in 1998.

Stations were sampled at a minus low tide when a maximum area of bank is exposed. At each station all burrows, root tunnels, ponded water, overhanging vegetation, debris, and driftwood were searched for mitten crabs from the high tide mark to the water line along a 5 m transect. Physical parameters measured were the same as for the 1997 survey (Veldhuizen 1997).

Figure 1 Juvenile mitten crab monitoring stations in Suisun Marsh and the delta, summer 1998

As in 1997, mitten crab densities were higher in Suisun Marsh than the delta. In Suisun Marsh, mean density (average of both surveys) was highest at Suisun Slough and lowest at Denverton Slough (Table 1). From the first to the second survey, densities increased at Hill Slough, Suisun Slough, and Montezuma Slough, and decreased at Denverton Slough. The highest sample density (not a mean) was 3.33 crabs/m2 at Suisun Slough in August. Mean size was 11.2 mm carapace width (cw) for the first survey (n=20) and 17.6 mm cw for the second survey (n=23).

Table 1 Juvenile mitten crab densities (crabs/m2) in 1997 and 1998

Station	Mean 1997	Mean 1998	July 1998	August 1998
Suisun Marsh				
Suisun Slough	1.46	3.04	2.73	3.33
Hill Slough	1.34	0.27	0.25	0.29
Montezuma Slough	0.42	0.11	0.00	0.18
Denverton Slough	1.65	0.19	0.23	0.07
Sacramento-San Joaquin Delta				
Cliffhouse	0.28	0.08	0.00	0.20
Sevenmile Slough	0.00	0.00	0.00	0.00

Windmill Cove	0.00	0.00	0.00	0.00
Middle River/Jones Tract	0.35	0.00	0.00	0.00
Old River/Clifton Court	0.00	0.00	0.00	0.00
Big Break/Marsh Creek	n.s.	0.00	0.00	0.00
Rock Slough	0.00	0.00	0.00	0.00
Tracy Oasis	0.18	0.00	0.00	0.00
Sherman Island	0.19	0.68	0.90	0.40
Venice Island	0.00	0.17	0.00	0.38
Hogback	0.00	0.00	n.s.a	0.00
Walnut Grove	0.00	0.00	n.s.	0.00
Middle River	0.00	n.s.	n.s.	n.s.
Mossdale Crossing	n.s.	0.00	n.s.	0.00
Cosumnes River	n.s.	0.00	n.s.	0.00
a n.s. = not sampled				

In the delta, crabs were found at only three stations in 1998: Venice Island, Cliffhouse, and Sherman Island (see Table 1). Mean density was highest at Sherman Island, followed by Venice Island and Cliffhouse. From the first to the second survey, densities increased at Cliff House and Venice Island and decreased at Sherman Island. The highest sample density was 0.90 crabs/m2 at Sherman Island in July. Mean size of age-0 crabs was 13.0 mm cw for first survey (n=3), and 18.4 mm cw for the second survey (n=8). During the first survey, we found five age-1 mitten crabs at the Sherman Island station ranging from 31 to 36 mm cw.

Comparison of data between 1997 and 1998 shows a decrease in abundance at three of our four Suisun Marsh stations (see Table 1). Densities decreased at the Hill Slough, Montezuma Slough, and Denverton Slough stations with the greatest decrease at Denverton Slough. There was a large increase in density from 1997 to 1998 at the Suisun Slough station. The salinity in the marsh was substantially lower this year, as it ranged from 0.34 to 1.27 in 1998 compared to 4.4 to 7.2 in 1997.

In the delta, crabs were found at two of the same stations, Cliffhouse and Sherman Island, in 1997 and 1998. Density increased at Sherman Island from 1997 to 1998 and decreased slightly at Cliffhouse (see Table 1). Although mitten crabs were also found at the Venice Island station in 1998, in 1997 they were found further south at the Middle River and Tracy Oasis Marina stations.

A special study was conducted in fall 1998 along the salinity gradient from Ryer Island in Suisun Bay to Sherman Island to determine if mitten crab densities west of the delta differed from densities in the delta. We sampled three days within two weeks in late October and early November. Traveling west to east, four sites were sampled each day, but the sites sampled each day varied with weather conditions and time constraints with low tide. Chipps, Browns, and west Sherman islands were sampled all three days while Ryer, Snag, and east Sherman islands were sampled only one day. The site at east Sherman Island coincides with our Sherman Island station from our land-based monitoring survey. With the exception of shortening the transect length to 3 m and the use of a small boat to access the sites, sampling methods were identical to our land-based monitoring survey.

From our salinity gradient survey, we found that the average density of juvenile mitten crabs was higher west of the delta than in the delta. Average density of crabs was 4.52 crabs/m2 at Chipps Island, 1.03 crabs/m2 at Browns Island, 2.86 crabs/m2 at west

Sherman Island, and 1.67 crabs/m2 at east Sherman Island. Salinity ranged from 3.86 at Ryer Island to 0.10 at east Sherman Island. In general, size increased as we traveled eastward: average size was 22.3 mm cw at Chipps Island (n=19), 27.1 mm cw at west Sherman Island (n=16), and 29.0 mm cw at east Sherman Island (n=3).

We also conducted a special study for juvenile mitten crabs in water hyacinth in October 1998. Small crabs have been reported in beds of aquatic plants in the delta, including water hyacinth and the Brazilian water weed, Egeria densa. We believe vegetation may offer protection from predators and desiccation and could be an important habitat for juvenile mitten crabs in the delta. A 1 m2 dip net was constructed from PVC pipe and 0.3 mm mesh netting. We sampled Browns Island, west Sherman Island, Mandeville Island, and Holland Tract. At each station, three samples were taken and we searched the roots, stems, and leaves for crabs. Although no mitten crabs were collected, we did find many other species residing in or directly underneath the plants. Crayfish were common and ranged from approximately 2 to 50 mm in length. We also collected mosquitofish, juvenile largemouth bass and bluegill, dragonfly larvae, arachnids, amphipods, and one frog.

Two studies of juvenile mitten crabs in the delta are planned for 1999. Tanya Veldhuizen of DWR will investigate habitat use by juvenile mitten crabs at several delta locations. She plans to compare mitten crab densities along bank, littoral, and channel habitats. The distribution study will be complemented by a survey for juvenile crabs in different vegetation types, such as water hyacinth, submerged aquatic vegetation (for example, Egeria densa, Potamogeton spp., and Myriophyllum spp.), and emergent vegetation. Brian Blease, a San Francisco State graduate student, has proposed to study mitten crab densities and burrowing along a longitudinal gradient from Suisun Bay through the delta in spring and summer 1999.

Acknowledgments

We would like to thank Kathy Hieb of DFG and Tanya Veldhuizen of DWR for the opportunity to collaborate on the continuation of this monitoring study as well as guidance on sampling methods and new site recommendations, DFG personnel who provided valuable advice on locations of potential monitoring sites, and Paul Raquel, Don Bright, Rich Reiner of The Nature Conservancy, Tracy Oasis Marina, and Windmill Cove for access to their property. This work is part of the Mitten Crab Studies program element, funded and supported by the Interagency Ecological Program.

References

Veldhuizen T. 1997. First annual IEP monitoring survey of the Chinese mitten crab in the delta and Suisun Marsh. IEP Newsletter 10(4):21-22.

Perry Herrgesell--Moving on to Bigger Things

Randall Brown, Department of Water Resources

In December, Dr. Perry Herrgesell stepped down as chair of the IEP Coordinators. He has been promoted to Chief, Central Valley Bay-Delta Branch. Alan Baracco is the new chair.

Perry has been at the Bay-Delta Branch since 1979. He created and led the Delta Outflow/San Francisco Bay Study before assuming the role of Study Manager in 1990. With Pete Chadwick's retirement in 1993, Perry began his coordinator assignment.

Hopefully, Perry will continue some level of IEP involvement. As part of his responsibilities as Alan's supervisor, he may have to step in and urge the coordinators to stop the endless chitchat and make a decision. We also need an occasional reminder to read the red book (a 1993 review of the IEP) in those rare instances when the coordinators appear to be drifting and unclear of where the IEP is heading. We all wish Perry good luck in his new position and thank him for 20 years of direct involvement in the Bay-Delta Program.

The Interagency Ecological Program--Recent Changes and a New 1999 Program

Chuck Armor, Department of Fish and Game

Development of a New 1999 IEP Program

On 28 October 1999 the IEP Directors approved the 1999 IEP Program and associated budget. The 1999 Program has over 65 separate monitoring and special study elements covering a broad spectrum of physical and biological subjects. The 1999 Program has an estimated cost of $14.1 million. Table 1 highlights the agencies contributing to the program and the agencies that are doing the work.

Table 1 1998-1999 Proposed interagency funding transfers and approximate agency self-funding levels associated with the completion of proposed Interagency Ecological Program monitoring and special study activities. (Values are in thousands of dollars.)

	Contributing Agency											
Receiving Agency	**DWR**	**DFG**	**SWRCB**	**USBR**	**USFWS**	**USGS**	**USEPA**	**NMFS**	**USACE**	**CVPIA**	**Other**	**Total**
DWR	1,793	0	0	813	0	0	0	0	0	250	59	2,916
DFG	2,498	1639	0	1,705	0	0	0	0	0	177	546	6,546
SWRCB	0	0	10	0	0	0	0	0	0	0	0	10
USBR	0	0	0	1,030	0	0	0	0	0	0	0	1,030
USFWS	524	0	0	479	181	0	0	0	0	128	0	1,312
USGS	372	0	0	420	0	798	0	0	0	0	41	1,631
USEPA	0	0	0	0	0	0	20	0	0	0	0	20
NMFS	0	0	0	0	0	0	0	405	0	0	0	405
USACE	0	0	0	0	0	0	0	0	10	0	0	10
Other	169	0	0	60	0	0	0	0	0	0	0	228
Total	5,356	1,639	10	4,506	181	798	20	405	10	555	646	14,126

The 1999 Program is the result of a ten-month process that included the participation of principal investigators, project work teams (PWTs), the Management Team, the Coordinators, the Management Level Advisory Group (MLAG) and the Directors. The program development started with the Management Team revising the Long-term Planning Considerations document. This document defined in a broad sense what work the IEP should undertake. The Management Team sent this document to all of the PWTs, which, in turn, shared it with potential principal investigators. Based on these long-term planning considerations and a knowledge of what work needed to be done, principal investigators prepared pre-proposals and submitted them to the PWTs for review and consideration. The PWTs assembled all of the pre-proposals and sent them, along with recommendations on priority, to the Management Team. The Management Team compiled and reviewed the recommendations of the PWTs and, based on program budget considerations, long-term planning considerations, and perceived program information priorities, developed an integrated, overall conceptual program. The Coordinators reviewed the conceptual program and directed the Management Team to make revisions to the proposal based on the responsiveness of the program to agency information needs, priorities, and budgets. This conceptual program was reviewed by the MLAG for their input and recommendations, after which it was revised and finalized by the Coordinators. The Coordinators presented this conceptual program to the Directors and with their approval it became the 1999 IEP Program.

Several general themes are emphasized in the 1999 IEP Program. All program elements that produce data will submit their data for storage on the IEP server within six months of collection. All products identified in the pre-proposals will be specified by the type of scientific paper to be produced and a date by which a draft will be submitted for review. All program elements will have an assigned review team consisting of at least two individuals who may be from the PWT, IEP, or outside the IEP. These review teams will be responsible for the first level of review of all products produced by each program element. All field activities for the delta smelt shallow water studies, delta smelt and wakasagi identification research, and fall Kodiak trawl have been stopped to allow biologists sufficient time to complete their analysis and reports. Field activities on the Suisun Bay hydrodynamics data collection and analyses efforts will be limited to allow for the timely production of reports.

As in past years, the proposed program is comprised of a mixture of "monitoring" and "special study" activities. Special studies consist of new programs and on going, multi-year programs. Changes in program elements fall into three categories: (1) a continued emphasis on shallow water investigations; (2) expanded investigations into exotic species; and (3) renewed emphasis of fish facilities work. Considerable effort has been directed towards investigations for the understanding of shallow water habitat in the delta. These efforts include the following: development of baseline larval fish samples to judge the status of any restoration efforts on Prospect Island; contributing to and participating in the University of Washington flooded island investigations; shallow water marsh sampling program; the funding of a new land-margin larval fish sampling program; and the completion of the shallow water fisheries data analysis element. All of these efforts will provide valuable information on what shallow water habitat is, how it is used, by whom and when. The Chinese mitten crab and green crab investigations were re-focused to drop the monitoring aspect and concentrate on defining the habitat relationships of the Chinese mitten crab. A new gelatinous zooplankton, jellyfish, investigation was added this year in response to the appearance of recently introduced hydromedusa from the Black Sea and other locations. All of the information gathered by these efforts will be critical for the design and monitoring of CALFED restoration efforts.

The IEP Fish Facilities Program was revised by establishing a parallel group to the Management Team and PWTs. This team, the Fish Facilities Coordination and Review Team, will oversee all of the fish facilities related work and will report to the Coordinators. Fish facilities work with UC Davis on the development of fish screens and screen criteria continues. New fish facilities work includes "Evaluation of the effects of collection and transport on the acute survival of delta smelt and splittail from the State Water Project," "Evaluation of telemetry methods for tracking juvenile salmon," "Adult salmon tracking study in the San Joaquin River," and "Developing a methodology to accurately simulate the entrainment of fish by agricultural diversions." CALFED Category III grants will fund $400,000 of the last two programs.

In 1998, IEP has provided considerable personnel resources towards the CALFED CMARP process and this commitment will be extended into 1999 as Stage I nears implementation. The IEP Coordinators and Management Team view this as a high priority.

As IEP elements involve multiple agencies, the infrastructure that supports them must also be integrated. One major part of this infrastructure is the research vessels used. Several of these vessels are over 30 years old and can no longer be used in adverse conditions, while other boats are no longer safe to use under any circumstances. An IEP Research Vessel Replacement Plan has been approved by the Coordinators and Directors and is being implemented. This plan details what actions should be taken for each IEP vessel and when they should occur. This will allow the Management Team and Coordinators to know in advance what the annual funding needs are for vessel replacement and major repairs. This plan covers the period from 1998 to 2012 and will be updated every two years.

One problem with drawing field staff from multiple agencies is to insure everyone is knowledgeable of field procedures and safety protocols. To address this need, the IEP has adopted a policy that states, "All permanent boat operators will complete the Department of Interior boat operator safety certification course and all other individuals who operate IEP boats will pass a boat operator evaluation given by a permanent boat operator using a standardized procedure." The IEP field operations have an excellent safety record and the field staff work hard at maintaining it.

Recent Changes in the IEP

There have been changes in the membership of the Management Team and Coordinators in 1998. Pat Coulston, the IEP Program Manager transferred to a position with DFG Region 3 in Monterey and Chuck Armor (DFG) was chosen to serve as IEP Program Manager. Mark Pierce (USFWS) and Dale Sweetnam (DFG) have joined the Management Team and Kevin Urquhart (DFG) has left. Among the Coordinators, Victoria Whitney has replaced Jerry Johns as the State Water Resources Control Board representative and Alan Baracco has replaced Perry Herrgesell as the chair of the Coordinators and the DFG representative.

Three new PWTs were added in 1998, one for shallow water investigations, chaired by Mike Chotkowski, and one for mitten crab work, chaired initially by Zachary Hymanson, and a parent hydrodynamics team, chaired by Pete Smith. If you have an interest in working on either of these teams, please contact the chair.

1999 Switzer Environmental Leadership Grants–Call for Proposals

Jane Rogers, Program Executive, The San Francisco Foundation, 225 Bush Street, Suite 500, San Francisco, California 94104-4224 (http://www.sff.org)

The San Francisco Foundation announced the call for proposals for 1999 Switzer Environmental Leadership Grants. The Robert and Patricia Switzer Foundation established its Environmental Leadership Grant Program in 1990 to serve three goals: (1) to contribute to environmental problem solving; (2) to encourage emerging environmental leaders to do public interest work; and (3) to help nonprofit and government agencies to secure the services of highly trained professionals, particularly scientist.

The Switzer Directory is now on the web at www.switzernetwork.org. It contains a complete listing and description of interests of all 273 Switzer Fellows. If there is a match between the work of your organization on an environmental issue and the skills and interests of a Switzer Fellow, we encourage you to apply to the Switzer Environmental Leadership Grant Program. It is important to know that Switzer Environmental Leadership Grants are only awarded to organizations working with a Switzer Fellow. Projects are expected to reflect the active participation and commitment of a current Switzer Fellow or Switzer Fellowship alum. Therefore, the Switzer Fellow's involvement should be secured before the proposal is submitted and, ideally, before the project is fully designed.

We will accept one-year proposals for up to $25,000 and multi-year proposals for up to $50,000. Organizations with annual budgets of more than $5 million will be eligible for one-year grants only. We expect a grants budget of approximately $165,000 for 1999. In the past, some successful proposals for Switzer Environmental Leadership Grants have originated with Switzer Fellows. Other projects have been conceived by leaders of eligible organizations who subsequently recruited Switzer Fellows to work with them.

Please contact Jane Rogers, Program Executive, or Sondra Wuthnow, Program Assistant, at (415) 733-8500 to request the following information or if you have any questions:

- A list of California grants awarded for the past two years;
- A Switzer Foundation brochure describing both the Fellowship and Leadership Grants programs;
- A hard copy version of the Switzer Directory listing all Switzer Fellows; and
- A complete application with procedures and guidelines.

Grant applications will be accepted once in 1999, postmarked by Friday, February 19, 1999. Please send six copies of the complete proposal and attachments. Notification of awards is expected by mid-May 1999.

- Sediment Inflow to the Sacramento-San Joaquin Delta and the San Francisco Bay

Richard N. Oltmann, David H. Schoellhamer, and Randal L. Dinehart, US Geological Survey

An article in the spring 1996 IEP Newsletter presented data on suspended-sediment loads entering the Sacramento-San Joaquin Delta, California, from the Sacramento and San Joaquin rivers for water years 1960-1995. This article updates that article with suspended-sediment data for water years 1996 and 1997.

The US Geological Survey (USGS) recently began monitoring suspended and bedload sediment transport in the delta. The objective of the study is to describe the movement of sediment and its availability for habitat restoration. This article presents information about bedload movement in the delta from this new study and also presents suspended-sediment inflow to San Francisco Bay from the delta for 1994 through 1996.

Suspended Sediment Inflow to the Delta from the Sacramento and San Joaquin Rivers

The USGS routinely measures the daily suspended-sediment load entering the delta with the flows of the Sacramento and San Joaquin rivers. Most of the suspended sediment that flows into the delta is carried by these two rivers, but some sediment also enters from the Yolo Bypass, the Mokelumne, Calaveras, and Cosumnes rivers, as well as from several smaller streams. This article presents the suspended-sediment data for the Sacramento and San Joaquin rivers collected during the 1996 and 1997 water years [USGS California District Office, Automated Data Processing System (ADAPS)] and compares it to statistically analyzed data from the long-term record.

Daily suspended-sediment records are nearly continuous since Water Year 1960. The Sacramento River data have been collected at two locations: for water years 1960-1979 at Sacramento and for Water Year 1980 to the present at Freeport. The San Joaquin River data have been collected at Vernalis. The data are suspended- sediment loads only and do not include sediment moving along the channel bottom as bedload. The time series of daily-mean suspended-sediment load from these two 38-year-long records were reduced to monthly and yearly values for this article. The only gaps in the data occur during February 1966 for the Sacramento River, and during April and June 1966 and Water Year 1969 for the San Joaquin River. Suspended-sediment data are shown in units of tons per month or tons per water year.

Figure 1 shows the maximum, minimum, median, and mean monthly suspended-sediment loads for both rivers for 1960-1995 (ADAPS).

Also included on Figure 1 are the monthly loads for both rivers for 1996 and 1997. Note that the mean-monthly sediment loads are about one order of magnitude greater for the Sacramento River than for the San Joaquin River.

The monthly suspended-sediment loads for January through May 1996 for the Sacramento River (Figure 1A) were considerably above the 1960-1995 long-term mean, and the March through May loads were close to the maximum-monthly loads for the period of record. During Water Year 1997, only the December and January loads were significantly above the long-term mean; the January load was slightly less than the historical maximum monthly load (January 1978). The January 1997 flows were extremely high and were immediately followed by an unusual drought condition. The March through June loads were well below the long-term means.

The San Joaquin River monthly suspended-sediment load pattern was similar to that of the Sacramento River with the February through May 1996 monthly loads considerably above the long-term mean (Figure 1B). The February load was slightly less then the historical maximum monthly load (February 1983). During Water Year 1997, the December load was slightly less than the 1964 historical maximum December load, and the February monthly load was slightly less than the 1983 historical maximum February load. The January 1997 load resulted in the highest monthly load ever recorded at the Vernalis site. (March 1983 was the previous maximum monthly load.) It exceeded the previous January maximum monthly load (1980) by nearly 50%. The April through September loads were below the long-term means; drought conditions existed during this period.

Figure 1 Monthly suspended-sediment load statistics for 1960-95 compared with 1996 and 1997 monthly suspended-sediment loads for the (A) Sacramento and (B) San Joaquin rivers, California

Figure 2 shows the ratio of the yearly (water year) suspended sediment load (in tons) to yearly river flow (in acre-feet) for the period of record for both rivers. The average yearly ratios are nearly equal at 0.12 tons/acre-foot for the Sacramento River (Figure 2A) and 0.11 tons/acre-foot for the San Joaquin River (Figure 2B). The Sacramento River plot indicates a slight downward trend with time; however, the high-flow years of 1996-1997 deviate from that trend. The flow also was high for the San Joaquin River; however, the sediment-flow ratios are not elevated as they are for the Sacramento River.

(X)

Figure 2 Annual ratios of suspended sediment-load and river flow for the (A) Sacramento and (B) San Joaquin rivers, California

Suspended Sediment Flow in the Delta

During summer 1998, the USGS established a network of five sites in the delta where suspended-solids concentration (SSC) is monitored. Optical backscatter sensors are deployed at each site to collect measurements at fifteen-minute intervals (Buchanan and Schoellhamer 1998). Water samples are collected periodically and analyzed for SSC. The results of these analyses are used to calibrate the sensors. Sensors have been installed on the Sacramento River at Freeport and Rio Vista, San Joaquin River at Stockton and Jersey Point, and Threemile Slough. The USGS is presently monitoring flow at each of these sites.

Bedload Inflow to the Delta

Acquisition of bedform profiles in the delta has provided much qualitative information about bedload movement and some preliminary bedload rates. Bedload is the movement of sediment (usually sand in the delta) along the bottom of waterways which creates bedforms such as dunes. Bedload rates can be estimated from bedform movement. Bedform profiles are recorded by a boat equipped with high-accuracy digital sonar cruising along pre-planned grid lines. Using a Global Positioning System receiver, the grid lines are followed on a map of the measuring site and the position and corresponding depth are recorded every second.

Bedform profiles collected on the Sacramento River in October 1997 and March and July 1998 show contrasts in bedform heights and lengths. The change in bed elevation for that period averaged three feet or less, even in reaches that showed bar topography of ten feet or more in height. Sand is transported through these reaches over long bar forms that may be stable even at the highest flows.

Surveys during storm flows are planned to assess their stability.

Bedform monitoring in the Sacramento River near Garcia Bend has shown that in July 1998 bedform transport was measurable at a flow rate of 20,000 cubic feet per second.

In Threemile Slough, bedforms longer than 300 feet with crest heights of ten feet or more were measured several times in March and June 1998. The bedforms have steep fronts facing the San Joaquin River, indicating dominant transport from the Sacramento River to the south. The overall profile of the reach shows increasing bed elevation near the southern end of the slough at the San Joaquin River. Tidal action in the slough also causes minor effects on bedform profiles, including the formation of symmetrical bedforms in parts of the channel affected more by northerly currents. The largest bedforms with steep fronts facing south also acquire minor, superposed bedforms with steep fronts facing north.

(X)

Figure 3 Bedform profile of Threemile Slough, California. The southern endpoint is near the San Joaquin River and the profile proceeds north toward the Sacramento River.

In the San Joaquin River (Figure 4), bedform profiles around the meander east of Threemile Slough document the complexity of sediment transport through this junction. Bedforms wash out at the deepest part of the channel, while large sand waves migrate west farther up on the point bar. Nearest the shallow side of the channel, smaller bedforms migrate east. Sequences of bedform profiles have been planned to determine the pathways of bedload delivered to the San Joaquin River from Threemile Slough.

(X)

Figure 4 Bedform profile of San Joaquin River east of Threemile Slough, California

Suspended-sediment Inflow to the Bay

The USGS established a network of eight sites in San Francisco Bay where SSC is monitored (Buchanan and Schoellhamer 1998). A site at Mallard Island has been in operation since February 1994. The time series of SSC three feet below the water surface from February 1994 to September 1996 is shown in Figure 5B. Gaps in the data are caused by sensor fouling and malfunction and power outages, often caused by vandals. At this scale, tidal variations in SSC appear as a fuzzy black band. To better observe trends in the data at time scales greater than the tidal time scale, a running median SSC (Schoellhamer 1997) is shown in Figure 5C. A 30-hour averaging window was chosen to remove most of the diurnal and semidiurnal tidal variation, producing a residual time series of SSC. Ideally, a numerical filter to remove the tides would be applied to the data (Schoellhamer 1996), but data gaps make this difficult. If the majority of data is invalid in each 30-hour window, then the median is not computed.

Delta discharge (DWR 1986) (Figure 5A) during winter 1994 was low compared to other winters and SSC showed no obvious effect of discharge. During nonwinter months, delta discharge typically is much less than during the winter and has no discernible effect on SSC. The maximum SSC during the period of record was concurrent with large delta discharge in January and March 1995. The first large runoff of winter creates the greatest SSC at Mallard Island because this "first flush" transports erodible sediments from the Central Valley watershed into the bay and leaves less erodible sediment for future storms (Goodwin and Denton 1991). Excellent examples of the effect of the first flush occurred in 1995 and 1996, which may have been missed in 1994. Sediment transport from the delta to the bay is relatively large during the first flush because discharge and SSC are large at that time. Small SSC occurred a few weeks after the SSC maxima in 1995 and 1996, following releases of water with low turbidity from reservoirs. Stronger winds during summer increase residual SSC due to increased wind-wave resuspension in shallow water and transport by currents (Krone 1979). The spring/neap cycle accounts for variation of residual SSC with a fourteen-day period. Seasonal wind and spring/neap effects on SSC also have been observed in South San Francisco Bay (Schoellhamer 1996).

(X)

Figure 5 (A) Estimated delta discharge, (B) 15-minute suspended-sediment concentration, and (C) residual suspended-sediment concentration at Mallard Island, California

Acknowledgments

Support for collection of SSC time series at Mallard Island has been provided by the Interagency Ecological Program, San Francisco Regional Water Quality Control Board, USGS Federal/State Cooperative Program, San Francisco Bay INATURES Program, and Toxic Substances Hydrology Program. Support for the study of sedimentation in the delta is provided by CALFED.

References

Buchanan PA, and DH Schoellhamer. 1998. Summary of suspended-solids concentration data, San Francisco Bay, California, Water Year 1996. US Geological Survey Open-File Report 98-175. 59 p.

California Department of Water Resources. 1986. DAYFLOW Program documentation and DAYFLOW data summary user's guide.

Goodwin P, and RA Denton. 1991. Seasonal influences on the sediment transport characteristics of the Sacramento River. In: Proceedings of the Institute of Civil Engineers, part 2, volume 91, p. 163-172.

Krone RB. 1979. Sedimentation in the San Francisco Bay system. In: TJ Conomos, editor. San Francisco Bay: The Urbanized Estuary. San Francisco, CA: Pacific Division of the American Association for the Advancement of Science. p. 85-96.

Schoellhamer DH. 1996. Factors affecting suspended-solids concentrations in South San Francisco Bay, California. Journal of Geophysical Research 101(C5):12087-95.

Schoellhamer DH. 1997. Time series of suspended-solids concentration, salinity, temperature, and total mercury concentration in San Francisco Bay during Water Year 1996: 1996 Annual Report of the Regional Monitoring Program for Trace Substances. p. 65-77.

Health Assessment of Merced River Fish Facility and Feather River Hatchery Juvenile Fall-run Chinook Salmon Released at Mossdale and CWT Fish Recovered at Chipps Island - 1998

Kenneth Nichols, US Fish and Wildlife Service, CA-NV Fish Health Center

Summary

The overall health of all fish examined appeared good. Infectious Hematopoietic Necrosis Virus, and evidence of low hepatic glycogen reserves were detected in asymptomatic Feather River Hatchery fish. Light infections of Renibacterium salmoninarum were found in asymptomatic Merced River Fish Facility fish.

Methods

Fall-run chinook salmon from the Merced River Fish Facility (MRFF) and Feather River Hatchery (FRH) were sampled at Mossdale Boat Ramp on the San Joaquin River on 17 and 24 April 1998, respectively [river kilometer (rkm) 5]. These fish were cohorts of marked chinook released from this site 24 hours earlier. Fish were removed from the live box in groups of 10, euthanized in MS222, measured for length, weighed, and rated for external features. They were then bled and rated for internal features. Also at this time, pathogen samples were collected.

Chinook salmon were captured by midwater trawl on the Sacramento-San Joaquin Delta near Chipps Island (rkm 29) by the Sacramento-San Joaquin Estuary Fishery Resource Office. Thirty-three adipose clipped chinook were sampled in nine tows. Data and samples were collected using the methods mentioned for Mossdale. The scale would not operate properly aboard the boat so weights were not taken. Blood data from the Chipps Island trawl samples are suspect due to an equipment problem which postponed centrifugation up to four hours.

Two condition factors (K=[Wt/L3]*105) were calculated for each fish based on fork length (KFL) and total length (KTL). Fish were scored on quantity of visceral fat and abnormalities of the skin, eye, and gill (Table 1). Hematocrit and leukocrit measurements were performed and blood plasma was frozen. Blood plasma was latter analyzed for glucose and/or total protein levels. Glucose stress response was measured for MRFF and FRH fish at Mossdale by holding the fish out of the water in a net for 30 seconds, returning them to the water, and collecting blood 30 minutes later (Barton and others 1986). Blood was also collected from four FRH fish at 50 minutes after stress. Percent lipid was measured by extracting lipid from a frozen carcass and expressed as percent of wet weight (Free and Foott 1998). Statistical analysis between release groups was performed using Student's t-test (Glantz 1992).

Table 1 Explanation of organosomatic criteria scores used in examination of chinook salmon

Skin	0 = normal scale number no lesions
	1 = some scale loss, 5%-20% of body surface
	2 = focal hemorrhages, scale loss 21%-40% of body
	3 = open wound, scale loss >40% of body surface
Eye	0 = no abnormalities
	1 = missing one eye, diminutive, external abrasion, some opacity
	2 = exophthalmic `pop-eye', cataract, bubbles, parasites
	3 = hemorrhage, rupture

Gill	0 = normal condition, color
	1 = pale
	2 = clubbed, frayed, nodules, mild parasite load
	3 = necrotic zones, fungi or bacterial lesions, hemorrhagic
Silver	0 = fully silver, no parr marks visible
	1 = partial silver, parr marks visible
	2 = little to no silvering - full parr marks
Visceral Fat	0 = no visceral fat on pyloric caeca or peritoneal cavity
	1 = <50% coverage of caeca and/or cavity fat diameter < caeca volume
	2 = <50% but not covering caeca and/or cavity fat diameter equals caeca volume
	3 = caeca and cavity complete filled with fat, organs obscured by fat

Results and Discussion

ORGANOSOMATIC DATA

Organosomatic and blood data are summarized in Table 2. Examination of FRH and MRFF at Mossdale indicated no skin (no scale loss) or gill abnormalities. Five percent of FRH fish (1 fish) had an unidentified abnormality in the eye. Based on silvering, both groups appeared to be undergoing smoltification. MRFF fish were larger than FRH fish (P<0.05), and condition factors were not significantly different (KTL: P=0.09; KFL: P=0.08). No significant health problems were seen by histological examination in either group. While the kidney parasite PKX was seen in MRFF fish in 1996 (True 1996) no parasites were seen this year or in the 1997 release fish (Foott 1997).

Of the 33 fish captured at Chipps Island, coded-wire tag (CWT) data showed 14 fish (42.4%) were from the MRFF, ten fish (30.3%) were from the Mokelumne River Hatchery, five fish (15.2%) were from the Coleman National Fish Hatchery, three fish (9.1%) were from the FRH, and one fish (3.0%) was of unknown origin (lost CWT). All organosomatic scores were normal for these fish, except for scale loss consistent with the sample method. Three of 14 MRFF fish were from the April 16 Mossdale release group. None of the three FRH fish were from April 23 Mossdale release. Due to the small number of recaptured fish, we did not compare pre- and post-release groups.

BLOOD DATA

While hematocrit, leukocrit, and plasma total protein scores were statistically greater (P<0.05) in the MRFF fish than the FRH group at Mossdale, both groups were within normal ranges (Wedemeyer and Chatterton 1971). The tendency toward higher hematocrit scores in MRFF fish was also seen in 1996 (True 1996) and 1997 (Foott 1997). Unfortunately, blood data are not available from the Chipps Island trawl, so these groups could not be compared after release.

STRESS RESPONSE

Plasma glucose levels from stressed fish, measured 30 minutes after stress, showed nine of nine Mossdale MRFF and two of five Mossdale FRH fish with a normal glucose response (90 mg/dL 1). None of the four Mossdale FRH fish sampled 50 minutes after stress demonstrated a normal glucose response. Poor glucose stress response suggests low hepatic glycogen, and histological review of Mossdale FRH fish also indicated low glycogen reserves in the liver. Both groups sampled at Mossdale received similar treatment, and therefore, observed differences were most likely due to conditions during the twenty-four-hour holding period on site, during transport, or during rearing conditions at the hatchery. Visceral fat was lower in Mossdale FRH fish (P<0.05), yet percent lipid was not significantly different (P=0.12). Low visceral fat in 1996 FRH stocks did not correspond to poor glucose stress response (True 1996) and may not be related to low glycogen stores.

PATHOGENS

Infectious Necrosis Hematopoietic Virus (IHNV) was detected in three of five kidney samples (5 fish pools) from asymptomatic Mossdale FRH fish. No virus was found in six samples (5 fish pools) from Mossdale MRFF, nor in 11 samples (3 fish pools) from Chipps Island. IHNV was reported at FRH prior to release (Dr. Bill Wingfield 1998, pers. comm.).

Table 2 Organosomatic and blood data of chinook juveniles from Merced River Fish Facility (MRFF) and Feather River Hatchery (FRH) held for 24 hours at Mossdale Landing on the San Joaquin River and fish captured by midwater trawl near Chipps Island on the Sacramento-San Joaquin Delta. Data reported as Mean (Standard Error of Mean) and number of samples.

Variable Measured	MRFF	FRH	Chipps Island Trawl

Sample Date	4/17/98	4/24/98	4/27/98
Total Length [TL] (mm)	90.4 (1.1) n = 25	84.9 (1.2) n = 26	97.1 (1.1) n = 33
Fork Length [FL] (mm)	84.2 (1.1) n = 25	78.8 (1.1) n = 26	90.2 (1.1) n = 33
Weight [Wt] (g)	5.89 (0.23) n = 25	5.06 (0.23) n = 26	NAa
Condition Factor KFL = (Wt/FL3)*105	0.79 (0.01) n = 25	0.82 (0.01) n = 26	NAa
Condition Factor KFL = (Wt/FL3)*105	0.98 (0.02) n = 25	1.02 (0.01) n = 26	NAa
Visceral Fat Score	2.1 (0.2) n =20	1.3 (0.2) n = 20	1.4 (0.2) n = 12
Body Percent Lipid (%)	8.34 (0.93) n = 5	6.29 (0.76) n = 6	8.46 (0.65) n = 5
Hematocrit (%)	46 (1) n = 19	35 (1) n = 30	NAb
Leukocrit (%)	0.77 (0.03) n = 19	0.21 (0.04) n = 30	NAb
Plasma Total Protein (g/dL)	2.6 (0.1) n = 10	2.1 (0.1) n = 18	3.4 (0.2) n = 10
Plasma Glucose (mg/dL)	103 (2) n = 9	67 (14) n = 10	NAb

a Fish not weighed. Condition factors could not be calculated.

b Blood could not be centrifuged immediately after sampling. Hematocrit, Leukocrit, and Plasma Glucose not measured for these samples.

c Elevated results suspect. Whole blood samples stored up to four hours before centrifugation

d Combined two groups tested at 30 min (82 23) and 50 min (49 9) after stress.

No significant bacterial fish pathogens were found in cultures of kidney samples. Direct Fluorescent Antibody Test (DFAT) of kidney samples for Renibacterium salmonirarum found 2 of 30 asymptomatic Mossdale MRFF fish with light infections, and no R. salmoninarum in 25 Mossdale FRH fish. DFAT of fish captured at Chipps Island found 2 of 30 fish with infections of R. salmonirarum. One of these R. salmoninarum positive fish could be identified by CWT as originating from MRFF. The other infected fish is most likely from a MRFF CWT group, but this cannot be confirmed.

References

Barton BA, CB Schreck, and LA Sigismondi. 1986. Multiple acute disturbances evoke cumulative physiological stress response in juvenile chinook salmon. Trans. Am. Fish. Soc. 115:245-251.

Foott JS. 1997. Health assessment of Feather River Hatchery (FRH) and Merced River Fish Facility (MRFF) juvenile chinook held for 48 hours at the Dos Reis Ramp, May 1 1997. Anderson, CA: US Fish and Wildlife Service.

Free DL, and JS Foott. 1998. Health and Physiology of Broodyear 1996 Coleman National Fish Hatchery Fall Chinook (Oncorhynchus tshawytscha). Anderson, CA: US Fish and Wildlife Service.

Glantz SA. 1992. Primer of Biostatistics. New York: Mcgraw-Hill. 440 p.

True K. 1996. Health Monitoring Component of South Delta Salmon Study-Spring 1996. Anderson, CA: US Fish and Wildlife Service.

Wedemeyer G, and K Chatterton. 1971. Some blood chemistry values for the juvenile coho salmon (Oncorhynchus kisutch). J. Fish Res. Bd. Can. 28(4):606-8.

Notes

Wingfield, Bill. 1998. In-person conversation. Personal communication.

- 1998 Monitoring of the Endangered Salt Marsh Harvest Mouse in Suisun Marsh

Patty Finfrock, Department of Water Resources

Introduction

The endangered salt marsh harvest mouse (Reithrodontomys raviventris halicoetes) (SMHM) inhabits the diked and tidal wetlands of the Suisun Marsh. Water projects of the Department of Water Resources (DWR) and the US Bureau of Reclamation (USBR) have impacted populations of the mouse in the marsh, and mitigation efforts include the establishment of seven set-aside areas and monitoring of mouse populations. The seven set-aside areas plus the Peytonia Slough Ecological Reserve were set with live traps in 1998 to determine if the mouse was present at these eight areas (Figure 1).

Habitat and Description

The SMHM is endemic to tidal marshes of the San Francisco Bay Estuary. Optimal habitat for the SMHM is described as 100% cover about 30 cm high, consisting primarily of pickleweed (Salicornia sp.) (USFWS 1984). Approximately 80% of the historical tidal marsh in the estuary has been lost to diking, fill, and development (SFEP 1998). As a result of this loss of habitat and declining populations, the SMHM was listed as an endangered species by the US Fish and Wildlife Service (USFWS) in 1970 and the Department of Fish and Game (DFG) in 1971.

(X)

Figure 1 Department of Fish and Game lands set aside as Salt Marsh Harvest Mouse habitat and Peytonia Slough Ecological Reserve

There are two subspecies of the SMHM; R. r. raviventris occurs in the southern part of the estuary around San Francisco Bay, and R. r. halicoetes is found in the northern estuary around San Pablo and Suisun bays. The work discussed in this article was conducted in Suisun Marsh on R. r. halicoetes.

R. r. halicoetes is a small reddish brown mouse with a grayish white belly, large eyes and a long tail. The SMHM feeds on green vegetation and seeds, and can drink water ranging from brackish to sea water. They do not burrow, but will construct ball-like nests of dry plant matter on the ground or in vegetation. They swim calmly and well, an important characteristic for a small mammal native to an environment that is frequently inundated. The SMHM is usually docile when handled, so much so that behavior is used as a secondary characteristic in identifying them to species (Fisler 1965).

Regulatory Framework

The water projects of DWR and USBR have caused changes to the amount and timing of delta outflow, which has impacted salinity in Suisun Marsh channels. To mitigate those impacts, the Plan of Protection for the Suisun Marsh (DWR 1984) and the

Suisun Marsh Preservation Agreement (SMPA) (USBR and others 1987) outlined plans for physical facilities, a monitoring program, and implementation of management plans and a cost-share program for marsh landowners. There were concerns that these actions would have a negative impact on endangered species such as the SMHM. The USFWS Biological Opinion for the Plan of Protection required several actions to protect SMHM populations in the marsh, including:

- Set aside 1,000 acres of State lands for SMHM habitat; and
- Conduct systematic surveys of SMHM populations every three years.

These actions were to be funded by DWR and USBR, and completed by DFG in consultation with USFWS.

In 1987, DFG set aside as SMHM habitat 1,063 acres on seven parcels of State land (see Figure 1). Five of the areas are diked wetlands; Joice Island and Hill Slough East are tidal wetlands. These seven set-aside areas were to be trapped every three years to assess whether SMHM were present on the areas. Baseline trapping was conducted in 1987 but the set aside areas were not surveyed again until 1996.

In 1995 the signatories to the SMPA began negotiating Amendment Three to the agreement. This amendment would expand activities within the managed wetlands. The USFWS is concerned that the expanded management activities may adversely affect the SMHM, and that past mitigation and monitoring requirements should be met before implementing additional actions with potentially adverse impacts to SMHM. In response to these comments, efforts are currently underway to come into full compliance with permit requirements for SMHM mitigation and monitoring in the Suisun Marsh, and an interagency team, the SMPA Environmental Coordination Advisory Team (ECAT), has been formed to assure that permit requirements are met. As part of this effort, the seven set-aside areas plus the Peytonia Slough Ecological Reserve (see Figure 1) were surveyed during August and September 1998, by DFG and DWR staff.

1998 SMHM Trapping Methodology

The goal of trapping in 1998 was to determine whether SMHM were present at the areas surveyed. One-hundred Sherman live-traps were set for three consecutive nights at each area. The traps are 3" 3.5" 9.25" aluminum boxes that close when a rodent enters and activates a pressure-sensitive treadle. Tail/body ratio, tail characteristics, and behavior were used to identify harvest mice (Reithrodontomys sp.) to the species level (Shellhammer 1984). SMHM were hair-clipped so that recapture rates could be assessed. All trapped rodents were released at the capture site.

Results

SMHM were captured at all areas surveyed except at the two tidal set-aside areas, Joice Island and Hill Slough East. Trapping results are shown in Table 1.

Table 1 Results of trapping at Suisun Marsh SMHM set-aside areas, 1998

Trapping Location	Date	Number of Traps	Trapnights	SMHMa	WHMb	Musc	Voled	Other
Crescent	8/5/98 - 8/7/98	100	300	4 + 1				
Pond 15	8/4/98 - 8/6/98	100	300	5 + 2	1			1 unidentified HM
Joice Island near bridgee	8/11/98 - 8/13/98	35	105			3		
Joice Island S of bridgee	8/11/98 - 8/13/98	65	195			12		1 shrew
Hill Slough W	8/11/98 - 8/13/98	100	300	6 + 2		3	1	1 unidentified

Benicia Industrial	8/18/98 - 8/20/98	100	300	25 + 8	2	45	29	12 unidentified HM, 3 shrew, 1 rat
Hill Slough E	8/18/98 - 8/20/98	100	300			17		
Hill Slough Ef	8/25/98 - 8/27/98	50	150			14		
Joice Island, S of bridgef	8/25/98 - 8/27/98	50	150			1		
Pond 1	9/15/98 - 9/17/98	100	300	9 + 4		1		
Peytonia Slough	9/15/98 - 9/17/98	100	300	12 + 4		7	9	3 unidentified HM

a Numbers denote number of SMHM captured + number of recaptures

b WHM = western harvest mouse, Reithrodontomys megalotis

c Mus = Mus musculus, house mouse

d Vole = meadow mouse, Microtus sp.

e A total of 100 traps placed in two areas approximately 1/2 mile apart

f Trapping done a night during high tide, after no SMHM were captured during initial trapping

Discussion

Large areas of Suisun Marsh were flooded in early 1998 when exterior levees along Suisun Bay breached in several places. Pond 1, which usually is drained by the end of February, was flooded until May, and Crescent Unit was flooded until April, about six to eight weeks longer than usual. Other set-aside areas were not directly impacted by the flooding, although precipitation and high tides may have increased water depths or duration of flooding.

The prolonged flooding appeared to have affected rodent populations at both Pond 1 and Crescent Unit. In previous trapping efforts at Pond 1, either SMHM, western harvest mice, and house mice, or house mice only were captured. Nine SMHM and one house mouse were captured in 1998; it appears that SMHM survived the flooding at Pond 1 where western harvest mice and house mice did not. At Crescent Unit, recent trapping efforts have consistently captured SMHM (up to 14%). Western harvest mice, house mice, and voles have also been captured at this site. In 1998, only SMHM were captured, with trap success at less than 2%. It appears that prolonged flooding depressed the numbers of all rodent species and SMHM have begun to repopulate this area.

Although no SMHM were captured at the tidal areas at Hill Slough East and Joice Island, trap success was good at a third tidal area, Peytonia Slough. The most notable difference between these areas is patch size. The area trapped at Peytonia Slough was fairly large, about 50 x 120 m. The patch sizes were small at Joice (35 x 50 m and 20 x 100 m) and narrow at Hill Slough (about 24 m wide), and it is possible that the mice are either absent, at very low densities due to habitat size or quality, or are also using other habitat types within the tidal areas, and are widely dispersed through the pickleweed areas trapped. Perhaps the last few years of high precipitation and runoff have favored the occurrence of less salt tolerant vegetation to the detriment of halophytes like pickleweed, and that drier conditions are needed to provide habitats of adequate size for the SMHM in tidal areas.

Trap success was highest at Benicia Industrial Unit. This area has been trapped several times over the years, but until 1997, trapping efforts usually resulted in no SMHM. This area was trapped twice in 1997; in June, one SMHM was captured in 492 trap nights, but in August, 18 were captured in 798 trap nights. SMHM may have moved into the area when adjacent areas were flooded by a broken tide gate. In addition to the 18 captured on-site in 1997, 28 SMHM were released at Benicia in 1997. These mice had been trapped at the Morrow Island Distribution System, about three miles north of the Benicia site. In 1997 the MIDS was dredged and SMHM trapped in the area designated for dredge spoils were released at the Benicia site.

Continuing Research

The current survey protocol for the SMHM was written by DFG and approved by ECAT, and includes three years of presence/absence surveys at the set-aside areas plus other State and private lands to be determined by DFG and the Suisun Resource Conservation District. The 1998 trapping was the first of these surveys. The second phase of the survey protocol will include mark-recapture trapping in sub-optimal habitat types, such as levee banks, upland grasslands, and wetland vegetation dominated by species other than pickleweed. This trapping effort will attempt to determine which habitats are used as refugia, SMHM use of sub-optimal habitats, and population levels of selected populations.

References

California Department of Water Resources. 1984. Plan of Protection for the Suisun Marsh Including Environmental Impact Report. 176 p. plus appendices.

Fisler GF. 1965. Adaptations and speciation in harvest mice of the marshes of San Francisco Bay. Univ. California Publ. Zool. 77:1-108.

San Francisco Ecosystem Project. 1998. San Francisco Estuary Baylands Ecosystem Goals, Draft Report for Public Review. Prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. 26 June 1998. 124 p. plus appendices.

Shellhammer HS. 1984. Identification of salt marsh harvest mice, Reithrodontomys raviventris, in the field and with cranial characteristics. Calif. Fish and Game Bull. 70(2):113-120.

US Bureau of Reclamation, California Department of Water Resources, California Department of Fish and Game, and Suisun Resource Conservation District. 1987. Suisun Marsh Preservation Agreement. 2 March 1987.

US Fish and Wildlife Service. 1984. Salt Marsh Harvest Mouse and California Clapper Rail Recovery Plan. Portland, OR: US Fish and Wildlife Service. 141 p.

- The Third Delta Smelt Workshop

Larry R. Brown (US Bureau of Reclamation) and Rick Sitts (Metropolitan Water District)

This is a summary of the third delta smelt workshop, held on 1 and 2 October 1998. A more complete summary (which includes a ranking of potential resource topics) can be obtained by contacting the authors. The purpose of the first day, held in Sacramento, was primarily to present new information collected since the previous May 1996 workshop. The purpose of the second day, held in Stockton, was to update the research strategy developed in 1996 and to provide a prioritized list of ongoing and potential studies.

On 1 October, researchers presented 11 major technical presentations on delta smelt topics ranging from diet and growth to the status of culturing efforts. In addition to the technical presentations, there was a panel discussion at the end of the day, giving the audience an opportunity to question the presenters. Abstracts of nine of the presentations are available on the IEP web page (http://iep.water.ca.gov/resfisht/). A bibliography of 102 articles, which provide information on delta smelt is also available at the same address.

Following are some major points from the presentations.

Dale Sweetnam (DFG) provided a context for the workshop based on prior and ongoing research, and the need to develop a clear picture of delta smelt habitat needs. Optimal habitat remains unclear and we have only weak statistical relationships of fall abundance with X2 and with January flow in the Yolo Bypass. Some of the unique aspects of delta smelt as indicated by research to date include the following:

- not a strong relationship between abundance and flow;
- a limited diet;
- a poor swimmer;
- low fecundity; and

- lacks a strong stock-recruit relationship.

Jenni Lott (DFG) and Matt Nobriga (DWR) presented data that support the idea that prey availability affects the abundance of delta smelt. They made the following points:

- Larger larvae, juvenile, and adult delta smelt eat copepods.
- When available, delta smelt use the native copepod Eurytemora as prey.
- Eurytemora abundance declined after the exotics Potamocorbula (a clam) and Pseudodiaptomus (a copepod) appeared.
- Adult delta smelt are shorter now and feed less on Eurytemora.
- There may be a narrower window for larvae survival.

Lenny Grimaldo's (DWR) presentation of otolith microstructural data for summer 1996 indicated that delta smelt grew as they moved downstream. Delta smelt from Suisun Bay were larger than individuals collected near the confluence and lower Sacramento and San Joaquin rivers because they were older. On average, delta smelt from Suisun Bay were 11 days older than individuals found in the lower rivers. Lenny suggested several factors including food, salinity, and temperature may cue the downstream movement of delta smelt.

Responses to audience questions about how diet changed downstream were that diet diversity appears to increase downstream and Pseudodiaptomus and mysids increase in the diet. Thus, there appears to be enough prey to support considerable numbers of young delta smelt on their way downstream, at least in years like 1996.

Geir Aasen (DFG) pointed out that shallow water habitat data are limited and our understanding of the importance of shallow water habitat is poor because most sampling occurs in mid-channel and shallow habitat sampling is difficult. He went on to present 1997 data testing an experimental plankton net design and examining differences in delta smelt abundance in shallow (less than 3 m) versus shore habitat. Results indicate that larval delta smelt are surface oriented and are not found in significantly greater numbers in shore areas. The absence of juveniles in shallow bottom samples suggests that juveniles that have better developed air bladders are more buoyant and consequently are even more surface oriented than larvae.

Among other questions, participants asked, "What next?" Responses included expanded sampling to compare shallow and shore areas to mid-channel water columns. Also, future analyses could include examination of the recent data on other species collected during 1997.

Laboratory data presented by Paciencia Young (UCD) indicated that delta smelt are poor, slow, unsteady swimmers. Many fish (42%) were unable to swim adequately in swimming performance test chambers. The endurance of able fish exceeded six hours at water velocities of 5 and 10 cm/s, about one hour at 15 to 25 cm/s, and only about ten minutes above 30 cm/s. The 5 and 10 cm/s velocities equate to 0.16 and 0.33 ft/s. Swimming performance was worse in the dark at night than during the day. Maybe they "rest" at night in the wild and are less susceptible to predation.

Some participants speculated that delta smelt may move slowly in bay-delta waters to avoid detection by predators. Perhaps in support of this speculation, Bill Bennett commented later in the workshop that delta smelt are rare in stomach contents of its predators. Thus, the "poor swimmer" phrase may be misleading and the paradigm should relate to predator avoidance, in other words, perhaps they swim "well" for this purpose. If so, other factors that enhance detection of still or slow fish, such as increased water clarity, may be detrimental.

Several questions for Paciencia and other swimming performance researchers related to the mortality and other effects of keeping fish in the lab for ten days prior to testing. The holding process represented the best technique at the time and is improving. Also, these researchers cautioned others about the hazards of extrapolating from the lab to the field. Unfortunately, we are in a situation where we only have laboratory data to apply to field problems. For example, much of the swimming performance research is being used to determine criteria for screening diversions.

Joe Cech (UCD) provided data on delta smelt environmental tolerance in his presentation. Upper temperature tolerance limits for delta smelt acclimated to 21 °C were 28 and 29 °C, in fresh water and brackish (4 ppt salinity) water, respectively. Minimum temperature tolerance limits for fish acclimated to 12 and 21 °C in fresh water were 6 and 7 °C, respectively. The chronic salinity tolerances of freshwater-acclimated delta smelt exposed to 2 ppt half-day steps ranged up to 19 ppt. As with the swimming trials, there were challenges in keeping delta smelt alive after capture in the field. Adding salt to the holding water seemed to increase survival.

Addressing another aspect of survival (the interaction of fish screening and swimming performance), Christina Swanson (UCD) presented data on delta smelt swimming behavior and performance in multivector flows similar to those that occur near screened water diversions. In all approach velocity combinations tested, except the control (0 cm/s), delta smelt experienced frequent contact with the screen. In most combinations including velocities >6 cm/s (0.2 ft/s), some were impinged for some period of time or died while on the screen.

A contact velocity near 0 cm/s increases the challenge to imaginatively develop effective measures to minimize delta smelt impingement and entrainment losses. One might pursue research on measures to reduce such losses, and study intakes deep and below surface-oriented delta smelt, if they really are surface-oriented.

Bill Bennett (UCD) described how predacious exotic inland silversides may affect delta smelt. Silversides may consume delta smelt larvae and compete for resources with juvenile and adult delta smelt. These interactions can occur in shallow backwater areas inhabited by both species, such as backwaters of the Cache Slough area.

Bill commented on the management implications of trying to separate delta smelt and silversides. Evidence indicates the potential benefit of maintaining adequate freshwater outflow and a suitable X2 position, to transport young delta smelt away (for example, downstream) from habitats co-occupied by silversides (for example, the Cache Slough area). However, Bill also made the point that outflow and certain restoration actions to benefit delta smelt may conflict. For example, he considered the restoration of shallow backwater habitats for delta smelt spawning, noting how little we understand spawning requirements. Should such restoration inadvertently and disproportionately benefit co-occurring inland silversides, then greater silverside abundance would mean greater predation on larval delta smelt.

Joan Lindberg (UCD) described progress on incubating eggs and rearing larvae, and on supplying delta smelt to various research projects. Small-scale larval feeding experiments indicate that at least three to four million algae cells per milliliter produce an initial feeding response in delta smelt larvae (in other words, the "green water effect"). Cultured delta smelt eggs and larvae supported an aquatic herbicide toxicity study and studies of growth rates and tissue and genetic conditions. She also reported that spawning occurs as water temperature approaches 14 to 15 °C, typically from early April to mid-June.

According to Tara Smith (DWR), one can study the positioning of delta smelt in the delta with the Particle Tracking Model (DSM2-PTM). The model simulates the transport and fate of individual "particles" traveling throughout the delta. The model takes one-dimensional hydrodynamic values, and by utilizing velocity profiles and mixing creates a three-dimensional environment for the particles to move. One can evaluate effects on particle movement of different inflows, exports, diversions, and structural changes, such as barriers.

The current particle tracking model permits the addition of characteristics or behaviors so that particle movement more closely mimics the behavior of a species, such as delta smelt. The model is ready to run for delta smelt pending input from other studies on behavioral characteristics. In response to questions about DSM2-PTM availability, Tara said the model is available and can be downloaded from http://wwwdelmod.water.ca.gov/. A training course is available if more than 20 students enroll.

Bill Bennett (UCD) discussed two key problems related to understanding the ecology of delta smelt: (1) teasing out concurrent multiple effects and (2) understanding how population regulation works. He described a population model for delta smelt and the role of monitoring and science. Among suggested research topics were the following:

- population abundance calculations to deal with salvage, CALFED actions, and other factors;
- growth rates;
- risk spreading; and
- spawning habitat identification.

The risk spreading discussion included the concept of linked subpopulations. The idea is to protect subpopulations in a few, well-chosen locations during catastrophic events. (The DSM2-PTM could be very useful in examining risk spreading.)

The audience debated the use of population abundance estimates in assessing fish salvage numbers. There was some support for the idea that a population abundance estimate would allow some quantitative perspective on the meaning of salvage levels. However, others suggested that it is too difficult to reliably estimate delta smelt abundance. Interpretation of delta smelt salvage levels in terms of population effects remained unresolved.

Dale Sweetnam mentioned we just missed meeting the 5-year recovery criteria for delta smelt as one year fell short. Under the current criteria, a new clock started in 1998.

This recent proximity to recovery and the growth in new knowledge led some to discuss revisiting the Delta Smelt Recovery

Plan. Experts drafted the plan in 1992, when much less information existed about delta smelt. The USFWS published the plan in 1995, with only modest revision. Further, there was speculation that if delta food web productivity for fish has indeed declined, then present recovery criteria may be unachievable.

A panel of the speakers and the audience focused primarily on research needs. Research ideas or lessons learned regarding field biology, facilities, or modeling included the following:

Field Biology

- Explore shifts in delta smelt feeding selectivity, including feeding studies at the SWP culture facility.
- Study density dependence and fluctuations of abundance of delta smelt and its prey.
- Document and map historic losses of shallow water habitat.
- Design studies to determine if the delta smelt's small size or its "poor" swimming make it difficult for predators to locate.
- Add abundance sampling or alternative sampling methods for delta smelt.

Facilities

- A screening criterion of less than 0.2 ft/s approach velocity may avoid delta smelt impingement.
- Study the vertical distribution of delta smelt mid-channel and in deeper water, as intakes in deeper and more nearshore areas may minimize entrainment or impingement.

Models

- Develop a more user friendly hydrodynamics model.
- Provide delta smelt behavioral data for more effective DSM2-PTM use.

On the second day, the group focused on revising the 1996 Research Agenda (available at http://iep.water.ca.gov/resfisht). The process included reviewing progress since 1996, reviewing ongoing and proposed research, and finally, re-evaluating and re-prioritizing the research agenda. The day culminated a draft research agenda for ranking by workshop attendees and resident fish PWT members.

Some of the habitat research on the 1996 list is underway while some remains unfunded. Shallow water habitat is being addressed with staff assigned to do analysis next year instead of fieldwork. The otoliths analysis and downstream movement work is complete. Spawning habitat identification remains undone, as it has not been a high priority. Limited efforts have not resulted in the collection of any delta smelt eggs.

Behavioral studies related to distribution, movement, and swimming performance have progressed. However, lack of staff hinders progress. Horizontal and vertical distribution studies during the day or night remain undone because staff are Particle Tracking Model (PTM) is ready for trial application to delta smelt movement. However, the model needs field data (from other tasks) to calibrate the PTM to properly reflect the behavior of delta smelt larvae. Treadmill studies are underway for another season.

Horizontal and vertical distribution data would aid in understanding where delta smelt go in Suisun Bay, identifying migration corridors, and understanding how they use shallow areas. To solve the lack of staff and secure timely data, how about contracting for data collection? One could contract on a long-term routine basis to meet IEP and contractor needs. This provides the data rather than delaying important information and understanding needed by decision makers, managers, and other scientists.

Completed population studies on the 1996 agenda include diet studies and bioassays on mercury and Komeen, an aquatic herbicide. Although there is interest in competition, predation, toxics, and other studies, proposals on some items were not prepared or not funded. In a few cases, such as agricultural diversion effects, results were still out on the proposals.

Ongoing studies include the following:

- Swimming performance evaluations related to fish screen criteria.
- Culture of delta smelt at the SWP site.
- Population viability analyses.

- Analyses of pesticides in Cache and Lindsey sloughs.
- Analyses of vertical distribution data for shallow habitats.

We also reviewed the status of proposals or anticipated proposals, which included the following:

- An agricultural diversion simulation proposal that CALFED funded.
- IEP will not fund a research proposal for a laboratory study of habitat preferences and competition with wagasaki this year. An indirect effect of the lack of funding is the departure of highly knowledgeable and trained postdocs.
- Culture work was proposed to IEP in order to continue study until December 1999; however, IEP did not allocate 1999 funds to this project. Culture work is funded by CALFED only until June 1999. Other funding is being pursued. This winter, UC Davis researchers may develop a proposal for a full-life-cycle, individual-based population model linked to physics.
- Delta smelt hatch date and cohort analyses were proposed (and funded for 1999 by IEP).
- Approved rearing habitat identification research remains unfunded.

Obviously, being on the long-term research agenda does not guarantee funding, although it may help.

Summary

The workshop communicated a considerable amount of new information on delta smelt. We see progress on topics with important implications for delta smelt survival including food availability, inland silverside predation, tolerable water temperature and salinity, and swimming performance. However, we still need more information on distribution of delta smelt in different habitat types. Additional data are needed for the particle tracking model. Understanding of delta smelt growth has increased. Data confirmed that delta smelt grow as they move downstream; however, other data indicated difficulty in switching prey and reduced adult size. Lastly, we remain uninformed about spawning requirements, while facing the potential loss of the delta smelt culture operations.

Research continues and the new agenda is in preparation. The new list stems from several data-rich presentations and discussions among a group of informed scientists. These discussions focused on studies to improve our knowledge to support recovery and maintenance of delta smelt.

- What is the Impact of the Introduced Brazilian Waterweed Egeria densa to the Delta Ecosystem?

Lenny Grimaldo and Zachary Hymanson, California Department of Water Resources

The Brazilian Waterweed Egeria densa, native to South America, is a submerged macrophyte that has successfully invaded shallow water habitats in the central and south delta. The impact of this invasive pest on the delta ecosystem is not understood, however, preliminary data collected from shallow water habitat fish investigations during the Sacramento-San Joaquin Delta Wetland Breach (BREACH) study show Egeria densa can substantially alter the surrounding physical and biological environment. In this article we present a brief life history of the plant, provide some preliminary data, and discuss the potential impact to habitats invaded by Egeria.

Egeria densa is a dioecious, freshwater perennial with adventitious roots. It usually dominates still water environments through vigorous growth, resulting in homogenization of the environment (Cook and Urmi-Konig 1984; Getsinger and Dillon 1984). Consistent with the other areas invaded by Egeria, we found it was the dominant submergent vegetation type in shallow water areas of the central delta. Proliferation of Egeria in this estuary is most likely aided by the increase in water clarity over the last 25 years (DWR 1996). Increased light penetration into the water column increases photosynthesis and promotes faster growth rates (Haramoto and Ikusima 1988; Cook and others 1984). We observed dense stands of Egeria growing in water depths up to 3.5 meters in many areas of the central delta.

Water clarity was also higher in the Egeria stands compared to nearby shallow water areas without vegetation. In Franks Tract (not a routine BREACH study site) we observed secchi depths over 2 m in a dense stand of Egeria during the first week in September (Figure 1). Normally a turbid area because of wind fetch and boat wakes, this measurement is very high for Franks Tract (Figure 2). We attribute higher water clarity to sedimentation of suspended particles by reduced water movement in the Egeria densa. (Lars Anderson 1999, pers. comm.). How sedimentation rates and subsequent marsh formation will be affected by

Egerias' dense colonization is unknown. It is likely Egeria will change the rate at which these ecological processes occur (Denise Reed 1998, pers. comm.).

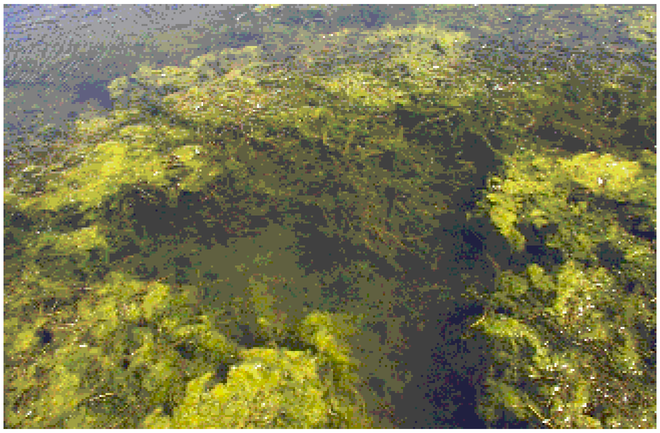


Figure 1 A dense mat of Egeria densa in Franks Tract, September 1998. The secchi depth was over 2 meters.

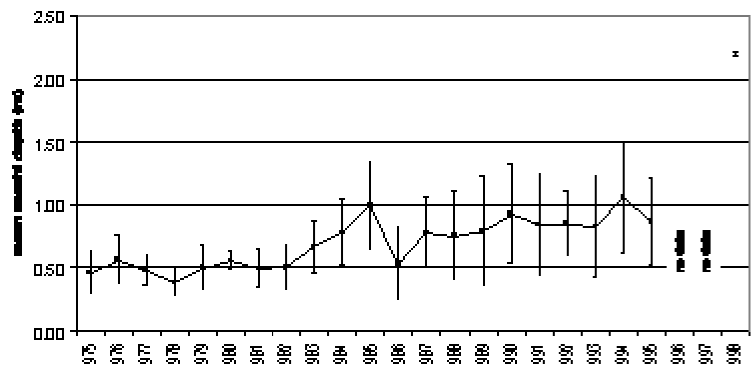


Figure 2 Mean Annual Secchi Depth in Franks Tract 1973-1995. * 1998 data point represents one measurement taken in September during BREACH study. No monitoring data was collected during 1996-1998.

Egeria can also affect water temperature and dissolved oxygen. In areas covered by expansive Egeria stands, the upper few inches of the mats will absorb heat from the sun during the day and block heat loss during the night (Lars Anderson 1999. pers. comm.). Low dissolved oxygen could also occur in dense mats at night and during early morning hours when respiration by the plant is high. These changes in the physical environment could potentially effect diel distribution of local biota.

Preliminary biological data from the BREACH study show that introduced fish species and Chinese mitten crabs were most abundant in Egeria densa stands compared to other submerged macrophyte habitat types and open water. In contrast, native fish were far less frequent inhabitants of the Egeria. The exact mechanism as to why fewer native fish were found in the Egeria compared to the introduced fish is unknown. Although this relationship could simply reflect differential habitat selection, we hypothesize competition or predation pressures from introduced fish will limit native fish use in shallow water habitats invaded by Egeria.

The local impacts of Egeria on the delta ecosystem are substantial. What is not known is how local and possibly intense changes in the abiotic and biotic environment will affect ecological processes on a larger scale. Also of concern is the potential for Egeria to invade and alter newly created or restored shallow water habitats in delta. We think further research is warranted. A task force of managers and researchers led by the Department of Boating and Waterways is currently investigating potential eradication treatments and associated impacts of Egeria removal in the delta (Mike Trouchon 1998, pers.comm.). Lars Anderson (United States Department of Agriculture), will initiate Egeria densa phenology and life history studies in 1999. Biological and physical monitoring will continue during the BREACH study until June 1999. As we learn more about Egeria, we anticipate that we will begin to answer many of the currently pressing questions and, in the process, ask new ones.

References

California Department of Water Resources. 1996. Water Quality Conditions in the Sacramento-San Joaquin Delta 1970-1993. Sacramento, CA: California Department of Water Resources.

Cook CDK, and K Urmi Konig. 1984. A revision of the genus Egeria (Hydrocharitacea). Aquatic Botany 19:73-96.

Getsinger KD, and CR Dillon. 1984. Quiescence, growth and senesence of Egeria densa in Lake Marion. Aquatic Botany 20:329-38.

Haramota T, and I Ikusima. 1988. Life cycle of Egeria densa Planch., an aquatic plant naturalized in Japan. Aquatic Botany 30:389-403.

Obreski S, T Irwin, and J Pearson. 1998. Effects of Control Methods on the Egeria densa Community. Report to the Department of Boating and Waterways.

Notes

Anderson L. Telephone conversation. January 1999.

Trouchon M. In-person conversation. January 1999.

Reed D. In-person conversation. December 1998.

Comparative Swimming Performance of Native (Delta Smelt and Splittail) and Introduced (Inland Silverside and Wakasagi) Delta Fish

Paciencia S. Young, Christina Swanson, Turid Reid, and Joseph J. Cech, Jr., University of California, Davis

Approximately 2,240 water diversions are located throughout the Sacramento-San Joaquin Delta, and entrainment and impingement of fish eggs, larvae, and juveniles at these diversions are considered major factors contributing to the decline of many delta fish. We studied individual swimming performance of two native (delta smelt and splittail) and two introduced (inland silversides and wakasagi) delta fish to determine their comparative vulnerability to entrainment and impingement near water diversion structures. Delta smelt (Hypomesus transpacificus) is a small estuarine osmerid that is listed as a threatened species under both the federal and State endangered species acts. Splittail (Pogonichthys macrolepidotus) is a cyprinid that was proposed for listing as a threatened species under the Endangered Species Act by the US Fish and Wildlife Service. Inland silversides (Menidia beryllina), a small atherinid native to the eastern United States, made their way to the delta after being introduced illegally into Clear Lake, California. Inland silversides and delta smelt are similar in size, morphology, and eating habits, making them potential competitors. Because silversides are voracious larval predators, hatching larval delta smelt may be extremely vulnerable to schools of foraging silversides (Bennett 1995). Wakasagi (Hypomesus nipponensis), another small osmerid, was originally introduced from Japan into six warm water reservoirs in California, and is suspected to be a threat to the survival of the endemic delta smelt because of its potential habitat encroachment. The wakasagi and delta smelt are morphologically so similar that they are difficult to visually tell apart. F1 hybrids between delta and wakasagi smelts have been found (May 1996), although hybridization between the two does not appear to be a management concern at this time (Stanley and others 1995).

Methods

Individual swimming performance was measured using a modified Brett-type recirculating swimming flume incorporating a pump with a calibrated variable speed motor. The upstream and downstream screens of the swimming chamber (9 cm diameter, 25 cm long) were polyethylene with 3 4 mm mesh size. All fish were acclimated at 17 °C for at least seven days before an experiment, and none of the fish were used more than once. Swimming performance was measured during the day between 0800 to 1700 Hours at 50-60 lux light intensity. Swimming performance was measured in terms of critical swimming velocity (Ucrit), the maximum velocity a fish can maintain for a specified period of time. The end point of the experiment was fatigue; in other words, three impingements on the downstream screen of the swimming flume. Some fish swam to the front of the chamber and attached themselves to the screen that defined the front of the chamber by biting with their jaws. Biting on the front screen enabled the fish to "catch a free ride", maintaining their position in the chamber without swimming. In instances where the fish bit on the front screen, the timer was turned off to exclude biting time from swimming time. An experiment was terminated when a fish bit for >120 s or swim time between bites was <20 s.

Three to six fish per species were over-anesthetized in MS-222, fixed in 95% alcohol, and placed in 1% aqueous potassium hydroxide to dissolve the tissue, stained with alizarin red S, and stored in glycerin in preparation for skeletal examination. This was done for jaw examination to investigate the biting behavior of some fishes.

Results

Some of the results on delta smelt and splittail in this study have been published in our previous papers (Young and Cech 1996; Swanson and others 1998). Results from this study showed that Ucrit increased with size in all species ($P<0.001$) except in delta smelt (Figure 1). Splittail regression slope (7.16) was higher than silversides and wakasagi slopes (3.43 and 3.82, respectively) indicating greater increase in splittail Ucrit as fish size increased. To facilitate comparison of swimming performance among different species, Ucrit of each species were sorted according to size classes of 1 cm standard length intervals (Figure 2). For the class sizes 2.1 to 3.0, and 3.1 to 4.0 cm standard length (SL) no significant differences in Ucrit were observed among the different species. However, for delta smelt, mean Ucrit in size classes > 4 cm SL was significantly lower than those of wakasagi; in size classes > 5 cm SL, significantly lower than those of splittail; and in size classes > 6 cm SL, significantly lower than those of silversides. Silversides mean Ucrit was also significantly lower than those of splittail in size classes > 6 cm SL.

Delta smelt and inland silversides were observed to nip on the upstream screen but were unable to hold on for 2 s or more. Generally, at high velocities (including velocities near Ucrit) some splittail and wakasagi were observed to burst forward and orally attached themselves to the upstream screen with their jaws. Examination of the jaw morphology in 4 to 5 cm SL fish showed that delta smelt and wakasagi have tiny, pointed teeth on the upper and lower jaws; silversides have longer pointed teeth on the upper and lower jaws; while splittail have no teeth present in the jaws. This demonstrates that presence of teeth in the jaws does not indicate potential screen-biting behavior.

Implications

The lack of a significant size effect on delta smelt swimming performance may suggest that juvenile, subadult and adult delta smelt have equal vulnerability to entrainment and impingement near water diversions. At size <5 cm SL, all four species have comparable swimming performance. However, at size >5 cm, young-of-the-year splittail, silversides, and wakasagi are capable of higher levels of swimming performance and possibly less vulnerable to entrainment and impingement than delta smelt.

Some young-of-the-year splittail and wakasagi were observed to bite the upstream screen of the flume at high water velocities. Young-of-the-year splittail screen-biting activity was first reported in our previous study (Young and Cech 1996). Screen-biting obviated swimming-related body undulations, presumably decreasing the energy requirements while avoiding impingement on the downstream screen. Oral attachment to vegetation or other structures at high water velocities may represent adaptive behavior by minimizing displacement and decreasing energy requirements. This adaptive behavior may give splittail and wakasagi an advantage over delta smelt and silversides in maintaining position near water diversion structures.

(X)

Figure 1 Critical swimming velocity of different species at different standard lengths

(X)

Figure 2 Mean critical swimming velocity (SEM) of different species at different size classes (asignificantly < wakasagi; bsignificantly < splittail and wakasagi; csignificantly < other species; dsignificantly < splittail)

Acknowledgments

We acknowledge financial support from the California Department of Water Resources, facilitated by R. Brown, D. Hayes, T. Frink and S. Mayr. The delta smelt collection was made possible with assistance from the California Department of Fish and Game, through the cooperation of D. Sweetnam, G. Aaasen, J. Lott, K. Urquhart, R. Fujimura, P. Macias, R. Soto, D. Killam, G. Edwards and the bay-delta boat crew. We thank M. Danley, M. Lee, C. Meloni, D, Shigematsu, S. Cummings, C. Porter, J. Schmidt, T. Mussen, C. Meloni, J. Murray, J. Hsu, S. Katzman, for technical assistance. We are indebted to D. Hinton and R. Cole for guidance and assistance in skeletal preparation. We are grateful to P. Lutes and W. Bentley of the UCD Aquaculture and Fisheries Program for their facility-related assistance.

References

Bennett WA. 1995. Potential effects of exotic inland silversides on delta smelt. IEP Newsletter Winter. p 4-6.

May B. 1996. Identification of smelt and their interspecific hybrids in the Sacramento-San Joaquin Estuary by allozyme analysis. IEP Newsletter 9(3):9-10.

Stanley SE, PB Moyle, and HB Shaffer. 1995. Allozyme analysis of delta smelt, Hypomesus transpacificus, and longfin smelt, Spirinchus thaleichthys, in the Sacramento-San Joaquin Estuary, California.

Swanson C, PS Young, and JJ Cech, Jr. 1998. Swimming performance of delta smelt: maximum performance, and behavioral and kinematic limitations of swimming at submaximal velocities. J. Exp. Biol. 201:333-45.

Young PS, and JJ Cech, Jr. 1996. Environmental tolerances and requirements of splittail. Trans. Am. Fish. Soc. 125:664-78.

Results of 1998 Complementary VAMP Salmon Smolt Survival Evaluation

Mark Pierce and Patricia Brandes, US Fish and Wildlife Service

Introduction

The objective of the Vernalis Adaptive Management Plan (VAMP) is to evaluate the influence of flow and export on coded wired-tagged (CWT) smolt survival through the Sacramento-San Joaquin Delta (hereafter, delta) when the head of Old River barrier (HORB) is in place. In 1998, high flows on the San Joaquin River prevented installation of the HORB, hence smolt survival in the delta was measured without the barrier. This study was developed as part of survival investigations complementary to VAMP, as described in Appendix A of the VAMP conceptual framework.

Evaluation of smolt survival in the south delta has been done under the IEP since 1985. Results of this work have been reported in past newsletters and annual reports of the South Delta Temporary Barriers Project (IEP Newsletter, Volume 11, Number 1, winter 1998). This report is limited to juvenile chinook delta survival and net pen mortality studies. Results of other study components such as water quality, dye studies, and physiological health evaluations will be reported elsewhere. (See article in this newsletter.)

Methods

During the spring of 1998, two sets of mark and recapture experiments using CWT chinook salmon were conducted to measure the survival of chinook smolts through the delta without a barrier at the head of upper Old River.

Test period

Survival was evaluated from 16 April to 30 May 1998.

Delta hydrological conditions

Flows on the San Joaquin River at Vernalis were high during the recovery period for both sets of releases, averaging about 22,000 cfs for the first set and 18,500 cfs for the second set. Average combined exports at the SWP and CVP were about 1,500 cfs for the first set and about 1,800 cfs for the second set.

CWT release strategy

The first set of release groups was made using fish from the Merced River Fish Facility (MRFF) beginning on 16 April, with releases on the San Joaquin River at Mossdale and Dos Reis (above and below the confluence of Old River) and at Jersey Point (Figure 1). Because fish availability at MRFF was limited in 1998, the second set of releases used fish from the Feather River Hatchery (FRH) and began on 23 April, with release sites similar to the first set, plus an additional release near the mouth of the Mokelumne River (Lighthouse Marina). There was one additional group of Feather River fish released at Mossdale on 6 May, which provided an additional index of survival over the last part of the evaluation period. Total release numbers per site are provided in Table 1. Average fork length of fish among the release groups ranged from 78 to 91 mm.

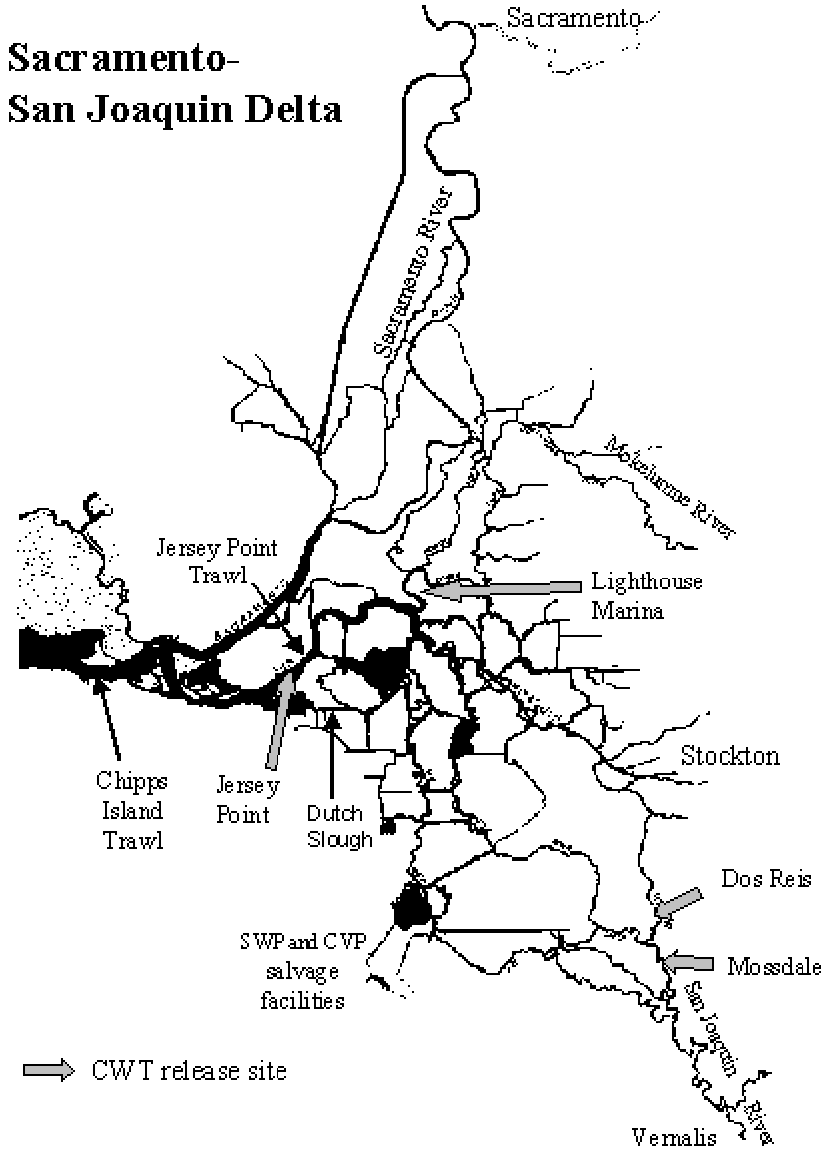


Figure 1 Coded wire-tagged (CWT) release and recovery sites used in the Sacramento-San Joaquin Delta during 1998

Table 1 Chipps Island and Jersey Point coded wire-tagged chinook salmon recovery summary, survival indices, absolute survival estimates (indices), expanded SWP and CVP salvage, and adjusted Chipps Island survival indices based on observed mortality in net pen studies

			Chipps Island			**Jersey Point**			**Expanded Recoveries**		
Source Hatchery	**Release Site and Date**	**Number Released**	**Number Recovered**	**Survival Index**	**Mossdale to Jersey Point Ratio**	**Number Recovered**	**Survival Index**	**Mossdale to Lighthouse Marina Ratio**	**SWP**	**CVP**	**Adjusted Chipps Island Survival**
Merced	Mossdale	26465	25	0.47	0.30	20	0.14			12	
	4/16/98	25264	31	0.60		17	0.13			24	
		25926	32	0.61		33	0.24			12	
	Total	77655	88	0.56		70	0.17			48	0.56
Merced	Dos Reis	26215	34	0.64		56	0.40				
	4/17/98	26366	25	0.47		40	0.29				
		24792	34	0.67		39	0.30				

	Total	77373	93	0.60		135	0.33				0.60
Merced	Jersey Pt.	24598	87	1.75							
	4/20/98	25673	100	1.94							
	Total	50271	187	1.84							1.87
Feather	Mossdale	15559	2	0.06	0.15	6	0.07	0.11		72	
	4/23/98	18400	5	0.13		6	0.06			120	
	Total	33959	7	0.10		12	0.06			192	0.11
Feather	Dos Reis	23849	8	0.16		9	0.06				
	4/24/98	24252	9	0.18		10	0.07				
	Total		17	0.17		19	0.07				0.18
Feather	Lighthouse Marina	21288	34	0.78	0.15a	71	0.56				
	4/27/98	22821	27	0.56		73	0.54				
	Total	44109	61	0.68		144	0.55				0.67
Feather	Jersey Point	15270	15	0.48							
	4/28/98	15928	26	0.80							
	Total	31198	41	0.64							0.71
Feather	Mossdale	21712	15	0.34		11	0.10			372	
	05/06/98	21712	6	0.13		4	0.03			252	
	Total	43424	21	0.24		15	0.07			624	
a Mossdale to Lighthouse Marina ratio.											

Recovery efforts

Midwater trawling at Chipps Island was conducted during daylight hours for approximately 400 minutes per day (doubling historical effort), seven days per week, from 16 April through 30 May, and continued at approximately 200 minutes per day until 13 June. Past trawling at Jersey Point had identified that peak catches occurred around dawn and dusk, so these periods were sampled at Chipps Island each day.

In addition to the recovery effort at Chipps Island, kodiak trawling was performed at Jersey Point, where the channel width is much narrower and thus a larger percentage of the channel can be sampled. From 15 April through 15 May, trawling here was conducted throughout the day and into the night; after 16 May this effort was scaled back. This effort was begun in 1997 as a pilot study in an attempt to increase raw recovery numbers (which had been very low through much of the 1990s), and to obtain additional independent estimates of survival.

Recoveries also were made at the Central Valley Project (CVP) and State Water Project (SWP) salvage facilities.

A third set of independent survival estimates will be obtained in future years from recoveries made in the ocean fishery.

Survival indices

The survival index for a given release group between the release site to Chipps Island is calculated by dividing the number of tags recovered in the midwater trawl at Chipps Island from each particular tag group by the number released, multiplied by the fraction of time and channel width sampled at Chipps Island. Indices to Jersey Point are calculated similarly to those for Chipps Island using the appropriate expansions for fraction of time and channel width sampled.

Net pen mortality studies

Survival indices in the south delta had been very low through much of the 1990s. Net pen mortality studies were begun in 1997 to address the possibility of any immediate or short term mortality associated with the stressors of trucking and handling or the potential effects of temperature shock on the experimental fish contributing to this phenomenon. Continuing in 1998, immediately following each release, 25 fish was taken at random and weighed, measured, and evaluated for vigor and mortality. These fish also were examined with regard to several criteria to determine their general health and to look for signs of disease. Approximately 200 additional fish were then noted for vigor and mortality, and placed in a live pen on site and left for 48 hours. After the holding period, another subsample of 25 fish were evaluated as above for general condition and health. The remainder of the fish were weighed, measured, and again noted for vigor and mortality.

Absolute survival

The releases at Jersey Point and at the mouth of the Mokelumne River (Lighthouse Marina) serve as downstream controls for the recovery efforts at Chipps Island and Jersey Point, respectively. Using the ratio of the survival indices of the upstream group relative to the downstream group provides a way to estimate absolute survival between the upstream and downstream location. This method is used to allow comparisons of Chipps Island indices among years, eliminating changes in efficiency from year to year due to different environmental conditions. This ratio also provides a way to make more valid comparisons of survival using recovery information from both Jersey Point and Chipps Island.

Results and Discussion

SURVIVAL INDICES

All recovery numbers reported at this time are preliminary and indices may change slightly based on the results of the quality control process of verifying tag codes.

Chipps Island recoveries/First release set

Survival indices to Chipps Island for all three of the releases using Merced River stock were among the highest indices ever seen in the south delta for similar releases. Mossdale had an index of 0.56, Dos Reis, 0.60, and Jersey Point, 1.84 (see Table 1). Counter to previous results in most past years without a barrier, the similarity of Mossdale and Dos Reis indices unexpectedly suggests that there was very little loss associated with the Old River diversion. This could suggest either two things: that during the high flows in 1998, (1) not many fish from the Mossdale release group were diverted into Old River or (2) the fish that were diverted into Old River had a higher rate of survival to Chipps Island than in past years. Both hypotheses could be true as a smaller percentage of water and presumably fish are diverted into upper Old River during high flows. In addition, in past reports we have shown that survival through the delta is improved as flows increase.

Chipps Island recoveries/Second release set

The second set of releases used Feather River stock and yielded overall much lower survival indices to Chipps Island: 0.10 for Mossdale, 0.17 for Dos Reis, and 0.64 for Jersey Point. Conditions changed somewhat, but were still very favorable. However, there is a more likely explanation for the lower overall indices than a slight change in hydrological conditions in the delta. The Feather River Hatchery experienced a severe outbreak of Infectious Hematopoietic Necrosis disease (IHN) and many of the early fish that were used for these release groups died over a period of several weeks at the hatchery. Thus, it is not valid to directly compare the survival indices of the two sets of releases. However, within this Feather River release set, different information was obtained regarding the extent of loss associated with Old River. Here, the difference in survival between the Mossdale and Dos Reis releases reflects the more typical, greater loss associated with Upper Old River seen in past experiments. The poorer condition of the fish used in this second release set may have not only decreased their overall survival, but had a larger negative impact on the survival of those fish migrating through upper Old River, thereby increasing the difference.

Jersey Point recoveries/First release set

The Jersey Point recoveries from the first set releases reveal an overall lower survival trend than do the corresponding Chipps Island recoveries, as the Mossdale index was 0.17 and the Dos Reis index was 0.33. This demonstrates a 50% loss from Mossdale to Dos Reis, which is directly counter to the survival trend seen in the Chipps Island recoveries for the first set of releases.

Jersey Point recoveries/Second release set

The second set of releases revealed an even lower set of survival indices, with the Mossdale index at 0.06, and the Dos Reis index at 0.07. These indices are virtually identical and indicate no significant loss from Mossdale to Dos Reis. This is also counter to the result obtained for the second set of releases at Chipps Island. The release at Lighthouse Marina yielded an index of 0.55.

Survival indices to Jersey Point should be much higher than those to Chipps Island, given that the Jersey Point recovery site is farther upstream and mortality over this distance should be less. However, there may be several explanations for the opposite being observed. Perhaps the expansion factor for the Jersey Point trawl could be improved or the efficiency of the Kodiak trawl for fish of this size range is lower than at Chipps Island. It also is likely that sampling at Jersey Point during night hours, when catches have been shown to be lower, potentially depresses the indices relative to Chipps Island. All of these factors could decrease the survival indices at Jersey Point relative to those at Chipps Island, but should not effect the trends between groups if the biases were consistent for all release groups.

More difficult to explain is the difference in trends observed between the Mossdale and Dos Reis groups between the Chipps

Island and Jersey Point recovery locations. The trends are not consistent for the first or second set of releases. Part of this difference may be due to sampling variability.

Of interest is that for the first Mossdale release and for upstream tributary releases, raw recoveries were higher at Chipps Island than at Jersey Point (Tables 1 and 2). The cross sectional area of the channel sampled is much greater at Jersey Point, as was the percentage of time sampled making a higher number of raw recoveries at Jersey Point than Chipps Island more likely for all groups. It is uncertain why fewer of the first Mossdale group and tributary groups were recovered at Jersey Point. An examination of the recovery distributions at both locations, with the exception of only a couple of fish from the tributary releases, eliminates the possibility that some fish may have passed by Chipps Island after the Jersey Point trawl was discontinued. Perhaps the fish migrating through upper Old River bypassed the Jersey Point recovery location by way of either Dutch Slough (see Figure 1) and/or through successful salvage operations. In this latter event, fish collected at the salvage facilities are trucked and released at locations downstream of the Jersey trawl site, but are available for capture at Chipps Island. In 1998, however, total percent salvaged at the facilities for the first Mossdale group was so low (discussed below), it is doubtful that this mechanism explains the disparity in recovery numbers. More fish from the tributary groups were observed in salvage and potentially this could help explain the discrepancy in recovery numbers between the two locations for those groups (see Table 2). Other possible explanations could include movement of the fish from the San Joaquin River into the Sacramento River by way of Threemile Slough on certain tides, but this mechanism should have had a similar impact on recoveries of all groups released upstream of Jersey Point, which was not seen.

Table 2 Chipps Island and Jersey Point coded wire-tagged chinook salmon recovery summary for releases made in the tributaries of the San Joaquin river, survival indices, and expanded SWP and CVP salvage numbers

			Chipps Island		**Jersey Point**		**Expanded Recoveries**	
Source Hatchery	**Release Site and Date**	**Number Released**	**Number Recovered**	**Survival Index**	**Number Recovered**	**Survival Index**	**SWP**	**CVP**
Merced	Upper Merced	27973	15	0.26	4	0.02	4	276
	4/12/98	35800	25	0.34	10	0.05	4	212
		36289	24	0.32	11	0.05		364
	Total	100062	64	0.31	25	0.04	8	852
Merced	Lower Merced	34805	22	0.31	9	0.05		524
	4/14/98	30857	17	0.27	9	0.05		280
		8447	2	0.12	1	0.02		76
	Total	74109	41	0.23	19	0.04		880
Merced	Upper Tuolomne	32787	28	0.42	26	0.14	6	284
	4/15/98	26633	5	0.09	4	0.03		280
		27404	19	0.36	8	0.05	6	312
		7209	2	0.13	0	0.00	22	84
	Total	94033	54	0.25	38	0.05	34	960
Merced	San Joaquin River below Tuolomne	25661	18	0.35	13	0.09		212
		21927	20	0.45	5	0.05		220
	Total	47588	38	0.40	18	0.07		432
Merced	Upper Merced	28248	8	0.16	10	0.07	6	228
	5/3/98	25482	6	0.11	3	0.02		180
		25220	5	0.10	3	0.02	30	192
		24934	10	0.20	5	0.04	18	240
	Total	103884	29	0.14	21	0.04	54	840
Merced	Lower Merced	49873	18	0.18	12	0.04	21	840
	5/5/98	25201	16	0.31	6	0.05	32	396
	Total	75074	34	0.24	18	0.04	53	1236

RECOVERIES AT THE CVP AND SWP SALVAGE FACILITIES

Recoveries of these releases (expanded for the fraction of time sampled) at the salvage facilities were relatively low compared to similar releases in previous years. Fish from the Mossdale releases did show up at the CVP for both the first set (n=48) and the second set of releases (n=192), but the percentages of total release salvaged were low, 0.06% and 0.5%, respectively. The expanded number salvaged does not include the losses associated with screen efficiency and predation losses at the facilities. Thus the estimates of loss would be greater than the expanded salvage reported here.

The last group released at Mossdale on 6 May had the greatest number of expanded recoveries (n=624), possibly because many of these fish may have remained in the system after the evaluation period, when total exports increased to 2,400-3,600 cfs. No fish from the Mossdale releases were seen at the SWP, nor were any fish from the Dos Reis or Jersey Point releases seen at either facility. Most likely, this is attributable to the combination of high flows and low exports, a condition where fish released below the head of Old River are not as likely to move into the southern delta and be susceptible to the pumps. In 1998, low exports and high San Joaquin River flows seemed to be effective at minimizing direct losses at the pumps.

NET PEN MORTALITY STUDIES

For the Merced River fish releases, water temperature differences between the truck and the river were small (2 to 3 °C) (Table 3). For both the Mossdale and Dos Reis groups, the fish were without exception in very good condition and very vigorous both immediately after release and after being held for 48 hours. Mortality was not observed among these releases after 48 hours. The exception was at Jersey Point where several fish appeared to be lethargic in the pen immediately after release and several more were found dead after 48 hours, resulting in a mortality rate of 1.6%.

Table 3 Summary of results of 1998 net pen mortality studies

			At Release			After 48 Hours			
Source Hatchery	**Release**	**Temperature Difference (°C)**	**Condition**	**Vigor**	**River Temperature (°C)**	**Condition**	**Vigor**	**Total Percent Mortalitya**	**Comments**
Merced	Mossdale 16 Apr	2	very good	vigorous	16	very good	vigorous	0	no signs of poor health
Merced	Dos Reis 17 Apr	3	very good	vigorous	16.5	very good	vigorous	0b	no signs of poor health
Merced	Jersey Pt. 20 Apr	2	very good	vigorous	17.8	very good	vigorous	1.6	two injuries, one bug eye and dark color
Feather	Mossdale 23 Apr	7	very good	vigorous	16c	very good	vigorous	7.2d	one fin hemorrhage, one cyst seen
Feather	Dos Reis 24 Apr	6	good	vigorous	18	good	vigorous	2	fish had bronze tint, some pale gills
Feather	Lighthouse 27 Apr	1.3	good	vigorous	16.5	good	vigorous	1	fish had bronze tint, some pale gills
Feather	Jersey Pt. 28 Apr	3.7	poor	some dead	19	good	vigorous	9.2	most fish bronze tint, many pale gills, some bug eyes and fin hemorrhage
Feather	Mossdale 6 May	7.2	good	1 dead	18	good	1 dead	6.5	most fish had bronze tint, few pale gills, one bug eye, one fin hemorrhage

a Total percent mortality is based on the total number of fish in the net pen after 48 hours.

b 172 fish present at the end of 48 hours.

c Estimated from temperature recorded at Mossdale trawl.
d 137 fish present after 48 hours (pen found damaged).

For the Feather River releases, truck and river water temperature differences were somewhat greater (1.3 to 7 °C). Probably more significant, however, was the health and condition of the fish. Signs of IHN were evident to varying extents in each of the release groups, most severely at Jersey Point. At release, the April 23 Mossdale group looked good and only a few minor signs of disease were apparent; however, the mortality rate for this group after 48 hours was high--7.2%. At Dos Reis, although fish were vigorous, they had a bronze tint rather than a bright silver color and many had paler gills. The final mortality rate here was only 2%. The condition of the fish released at Lighthouse Marina was similar, where the final mortality rate was only 1%. Finally, the fish released at Jersey Point appeared to be in the worst shape. Again they had a bronze tint and many had pale gills. Several fish were already dead upon release, fin hemorrhaging was seen and some eyes were visibly "bugged." After 48 hours, the mortality rate of this group was 9.2%.

ADJUSTED SURVIVAL INDICES

Assuming the mortality rate for fish actually released into the river is similar to that of the fish held in the net pens (although it may differ for various reasons, such as an increase in vulnerability to predation), we can consider that any percentage of the fish dying within the first two days after release (due to poor health and not environmental conditions) are not likely to survive long enough to be vulnerable to the recovery trawl. It is then appropriate to apply the observed mortality rate to the entire release, and calculate an adjusted survival index. In most cases in 1998, the change in the index due to this adjustment is negligible, but for the second Jersey Point release, the index changed from 0.64 to 0.71 (see Table 1). The index increases because as the effective release number is decreased, a larger portion of the release group is assumed to have survived to Chipps Island.

ABSOLUTE SURVIVAL ESTIMATES (RATIOS)

Absolute survival between an upstream and downstream location can be estimated using the ratios of the upstream to downstream survival indices to allow comparisons to past releases. The Mossdale to Jersey Point absolute survival estimate, based on Chipps Island recoveries, was 0.30 for the first set of releases (see Table 1). This compares favorably to absolute survival estimates generated in past years (Figure 2) and shows that survival from Mossdale to Jersey Point is related to flow at Vernalis. Future analyses will be conducted to determine if the 1998 data shed any light on how CVP and SWP exports affect survival through the delta.

For the second set of releases, the Mossdale to Jersey Point absolute survival estimate, based on Chipps Island recoveries, was 0.16, roughly half that of the first group. The environmental conditions did not change considerably from the first release set to the next, and the observed decrease in absolute survival may be more a result of the questionable health of the fish. However, adjusted indices based on the net pen studies changed the absolute survival estimate from Mossdale to Jersey Point only slightly (0.16 to 0.15), and does not sufficiently account for the large apparent decrease observed in survival from the first release set. Thus the decrease in survival for the second group of fish could be due to stock differences as noted in previous experiments and/or due to an underestimate of the mortality due to IHN infection.

Although there are many reasons for not directly comparing the survival estimates generated at Chipps Island to those generated at Jersey Point, the ratios of the survival indices of the upstream and downstream groups can be used to factor out differences between recovery locations. Unfortunately, due to a shortage of available fish from the MRFF, there was no control group for the first set of releases in 1998 for the Jersey Point trawl, and thus no absolute survival estimate can be generated. For the second set of releases a control group was released at the mouth of the Mokelumne River at Lighthouse Marina. The ratio of survival indices of the Mossdale group relative to the mouth of the Mokelumne group should allow for valid comparisons between Chipps Island and Jersey Point data. The absolute survival between Mossdale and Lighthouse Marina was 0.11 for recoveries at Jersey Point and 0.15 at Chipps Island. The two survival estimates are in fairly good agreement, indicating that although the relative survival indices to Jersey Point are somewhat low, the absolute estimates are close to that based on Chipps Island data.

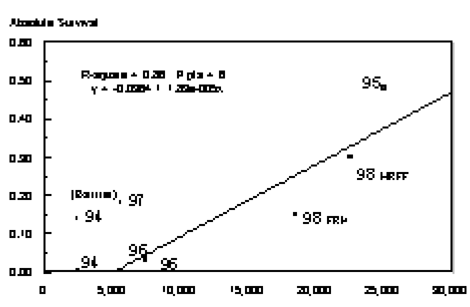


Figure 2 Absolute smolt survival between Mossdale and Jersey Point versus flow at Vernalis (cfs). Data obtained when the barrier was in place (circles) are not included in the regression. All releases were made using fish from the Feather River Hatchery with the exception of the 1998 MRFF data point as marked.

Summary

- In 1998, four independent observations indicated that CWT smolts released at Mossdale survived at the same or a lower rate than those released at Dos Reis when no HORB was operating.
- Very low numbers of CWT smolts were salvaged at the CVP, and none at the SWP, reflecting the low export rates and high San Joaquin River inflow. Total direct loss associated with the projects would be greater than the salvage values alone, but still reflect a low percentage of the total number released.
- The 48-hour mortality rate was very low for MRFF smolts but reasonably high for FRH groups (which expressed IHN disease), and was reflected in a lower in river survival estimate of Feather River fish. This may make the reliability of the data obtained from the Feather River set of CWT releases suspect.
- Absolute smolt survival estimates between Mossdale and Jersey Point using smolts from Merced River Fish Facility was 0.30, which was good, but not as high as might have been expected, given the favorable environmental conditions in the delta.
- The 1998 data helped to further define the direct relationship between Vernalis inflow and absolute smolt survival from Mossdale to Jersey Point without a HORB in place.
- Feather River smolts released were severely infected with IHN and absolute survival between Mossdale and the lower Mokelumne River was estimated at 0.11 at Jersey Point and 0.15 at Chipps Island, about half the rate of the first group using healthy fish from Merced River Fish Facility.
- The raw recovery numbers of smolts released upstream of upper Old River were not as high at Jersey Point as they were at Chipps Island, indicating some differential recovery bias may be occurring between tag groups at Jersey Point.
- Prospect Island Fish Sampling Results--Some Thoughts on Shallow Water Habitat Restoration

David Christophel (Beak Consultants), Gary Lawley (Clearwater Environmental Inc.), and Leo Winternitz (Department of Water Resources)

Prospect Island is located in Solano County in the northwestern part of the Sacramento-San Joaquin Delta. The island is bounded by the Sacramento River Deep Water Ship Channel to the west, the remnants of Little Holland Tract to the north, Miner Slough to the east, and the confluence of Miner Slough and the ship channel to the south. The objective of the Prospect Island Restoration Project is to restore aquatic ecosystem structure and processes to benefit fish and wildlife. Specifically, plans have been developed to create shallow water habitat that provides for suitable feeding, cover and resting habitat for delta smelt, splittail, other native resident fishes, anadromous fish, waterfowl and shorebirds. Partners in the restoration project are the US Army Corps of Engineers, the US Bureau of Reclamation, the US Fish and Wildlife Service, and the California Department of Water Resources.

In January 1997, prior to the initiation of habitat restoration work on Prospect Island, the Miner Slough levee breached at two locations. An internal cross-levee that separated the project site from flooded property owned by the Port of Sacramento also breached, allowing water from the Port property to mix with water at the project site. Prospect Island remained flooded until October 1998 when the levee breeches were repaired. The island was partially dewatered in preparation for construction of habitat project features scheduled for fall 1999. As required by the National Marine Fisheries Service and the US Fish and Wildlife Service, the project to dewater the island included a fish monitoring and fish recovery plan. Fish recovery (in other words, salvage of fish trapped on the island) was only to be implemented if any target species were collected in the monitoring efforts. Target species included chinook salmon (winter-run, fall-run, late-fall run, and spring-run), steelhead, delta smelt, and splittail.

Pumping to dewater Prospect Island began on 15 October. Clearwater Environmental Inc. (a contractor to US Army Corps of Engineers) and Beak Consultants (a subcontractor to Clearwater, Inc.) conducted random fish sampling over a three-week period commencing on 15 October. Sampling was conducted during the daylight hours and after dark (evening or predawn) using two beach seines, a 95 ft by 8 ft seine with -inch mesh, and a thirty-five-foot by four-foot seine with 3/16-inch mesh. Habitats sampled included the open water shallows (no emergent vegetation), emergent vegetation shallows, and deep-water channels with and without emergent vegetation. Although not tested, sampling efficiency was likely lower in the deep-water channels and areas with emergent vegetation.

Results

A total of 3,663 fish representing 25 species (6 native, 19 introduced) was collected between 15 October and 29 October (Table 1). No target species were collected on Prospect Island however, this was expected given the time of year of the sampling. Life stages collected ranged from young-of-the-year to adults. There appeared to be a marked difference in species and life stages captured between nighttime and daytime with more pelagic species and adults captured during night sampling. Most of the introduced species caught typically inhabit slow-moving, backwater-type habitat. The most numerous species collected were threadfin shad, inland silversides, American shad, striped bass, sunfish (various species), golden shiner, and common carp. Together, these species constituted about 93% of the total catch. Native species collected included the Sacramento blackfish, hardhead, hitch, Sacramento squawfish, sculpin, and tule perch. These species constituted less than 2% of the total catch.

Table 1 Species captured during sampling at Prospect Island

Common Name	**Scientific Name**	**Total Catch**
Threadfin shad	Dorosoma petenense	2116
Inland silversides	Menidia beryllina	325
American shad	Alosa sapidissima	226
Golden shiner	Notemigonus crysoleucas	234
Sunfish (includes green, redear, and bluegill)	Lepomis sp.	171
Striped bass	Morone saxatilis	184
Common carp	Cyprinus carpio	163
Bigscale logperch	Percina macrolepida	50
Crappie (black and white)	Pomoxis sp.	53
Sacramento blackfish	Orthodon microlepidotus	1
Bullhead	Ameiurus sp.	49
White catfish	Ictalurus catus	3
Channel catfish	Ictalurus punctatus	5
Yellowfin goby	Acanthogobius flavimanus	14
Hardhead	Mylopharodon conocephalus	1
Hitch	Lavinia exilicauda	9
Western mosquitofish	Gambusia affinis	7

Sacramento pikeminnow	Ptychocheilus grandis	13
Prickly sculpin	Cottus asper	4
Sacramento sucker	Catostomus occidentalis	3
Largemouth bass	Micropterus salmoides	12
Tule perch	Hysterocarpus traski	20
Grand Total		3663

Discussion

The three-week sampling effort at Prospect Island was designed to determine the presence of target fish species rather than to comprehensively evaluate the relative abundance and distribution of fish species. Despite the limited scope of the sampling effort we believe that the results reasonably reflect the species composition of the fish assemblage occupying Prospect Island at the time of sampling. The number of individual fish of each species contained in the catch, however, was likely strongly influenced by the selectivity and efficiency of the sampling gear and may not accurately characterize the relative abundance of the various species within the fish community at Prospect Island. The interpretation of results may also be complicated by the interchange between the fish assemblages occupying Prospect Island and the Port of Sacramento property that resulted when the cross levee that separates both properties breached. The extent to which this interaction may have influenced species interaction at Prospect Island is unknown. Nevertheless, the results suggest that non-native fish species will dominate shallow water habitats in the north delta in early fall when most of the migratory native fish are likely downstream. These results are generally consistent with the findings of the IEP Sacramento-San Joaquin Delta Breached Levee Wetland study in the central delta (Grimaldo and others 1998). This information is particularly interesting because a significant portion of the CALFED Program's restoration actions include restoration of shallow water habitat, primarily to benefit native species, which include those targeted in the Prospect Island sampling.

The apparent dominance of non-native fish at Prospect Island in the early fall does not necessarily imply that creation or restoration of shallow water habitat will not benefit native fish. However, it does suggest that the actual results of perennial shallow water habitat restoration in the delta may differ substantially from the expected benefits or results for native fish. The preliminary results of the IEP shallow water sampling study and the Prospect Island fish sampling emphasize the importance of monitoring restoration sites to confirm that project objectives are met and to provide the basis for modifying habitat management techniques to provide greater benefit to native fish species. These considerations are particularly important since a significant portion of the CALFED Program's restoration actions include restoration of shallow water habitat primarily to benefit native species, which include those targeted in the Prospect Island sampling.

References

Grimaldo L, B Harrell, R Miller, and Z Hymanson. 1998. Determining the Importance of Shallow Water Habitat in the Delta to Resident and Migratory Fishes: A New Challenge for IEP. IEP Newsletter 11(3):32-4.

- Errata

In the previous issue of the IEP Newsletter (fall 1998, Volume 11, Number 4, pages 38-42), Figure 1 in the article "Swimming Performance, Behavior, and Physiology of Delta Fishes in Complex Flows Near a Fish Screen: Biological Studies Using the Fish Treadmill" by C. Swanson, P.S. Young, and J.J. Cech, Jr., was incorrectly modified during reproduction. In that version of the figure, the directions of the approach, sweeping, and resultant flow vectors were reversed and thus presented a seriously inaccurate diagram of the fish treadmill and its operation. A correct version of the figure is presented below. For further questions regarding the fish treadmill design, operation, and biological studies or to arrange a visit to observe fish treadmill experiments, please contact Christina Swanson by telephone or e-mail. Telephone: (530) 752-8659; E-mail: cswanson@ucdavis.edu.

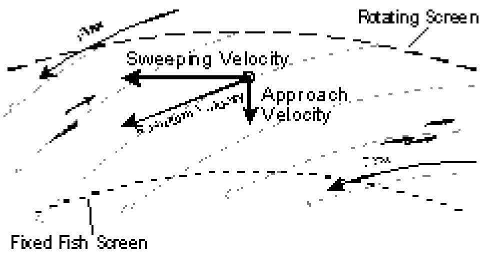


Figure 1 Top view diagram of the fish treadmill swimming channel. The outer rotating screen is at top, the inner fixed screen is at bottom. Arrows indicate the directions of the approach, sweeping, and resultant flow vectors.

Setting It Straight

Lauren Buffaloe, Department of Water Resources

Accuracy is fundamental in scientific writing. It is the policy of the editors of the IEP Newsletter to promptly acknowledge errors in the Errata section. Mistakes should be called to the attention of Lauren Buffaloe by calling (916) 227-1375.

We've Moved!

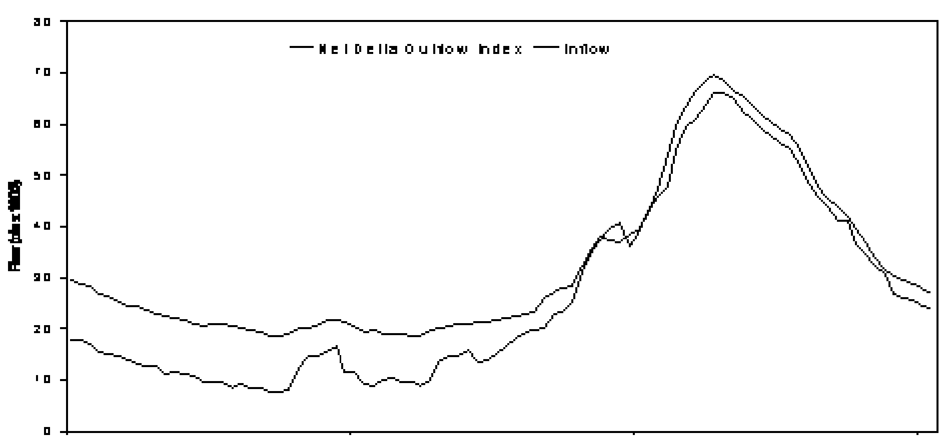
Sustainable Conservation

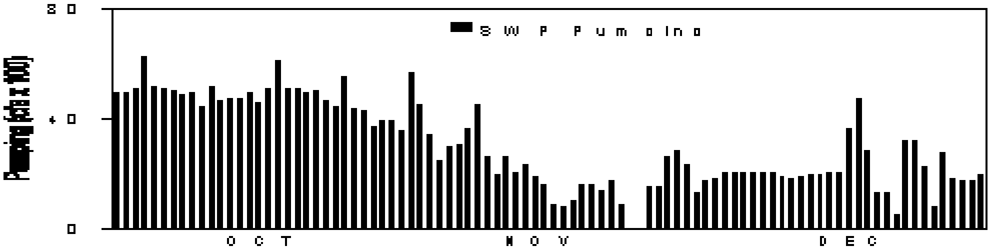
As of 15 March 1998, Sustainable Conservation's new offices are located at 109 Stevenson Street, 4th Floor, San Francisco, CA 94105. Telephone: (415) 977-0380; Fax: (415) 977-0381; E-mail: suscon@igc.org; Internet URL: http://www.suscon.org. Please make a note of these changes.

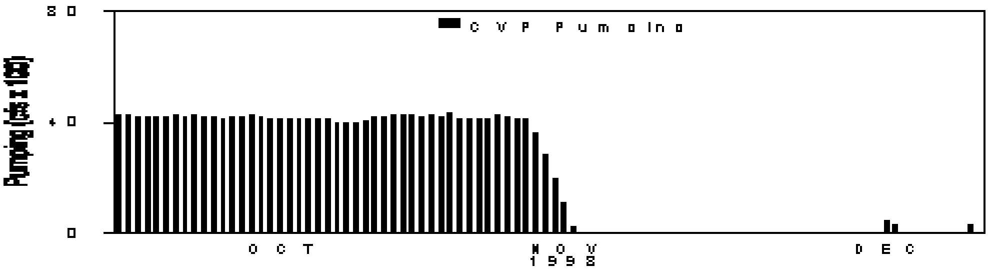
Delta Inflow/Outflow and Pumping

Dawn Friend, Department of Water Resources

Between 1 October and 31 December 1998, the average Net Delta Outflow was 26,546 cfs, with a peak outflow of 66,070 cfs occurring on 8 December 1998. This peak was the result of reservoir releases made for flood control purposes in response to significant precipitation over previous days. During the last half of the quarter, no CVP pumping took place in order to accommodate scheduled maintenance. Combined SWP and CVP pumping averaged about 5,100 cfs during this period. All data presented are considered preliminary by the source.







1. In our experience, hatchery chinook salmon juveniles typically have a blood glucose >90 mg/dL following stress.