Interagency Ecological Studies Program for the Sacramento-San Joaquin Estuary

NEWSLETTER

Winter 1994

Readers are encouraged to submit brief articles or ideas for articles. Correspondence, including requests for changes in the mailing list, should be addressed to Randy Brown, California Department of Water Resources, 3251 S Street, Sacramento, CA 95816-7017.

EDITOR'S NOTE: The following article was submitted by Dr. Bruce Herbold of the U.S. Environmental Protection Agency. The author describes the data and rationale he used to arrive at estuarine habitat standards to protect delta smelt. Written comments on this or other articles in the *Newsletter* are welcome and will be presented, along with the author's responses, in the spring edition. -R. Brown and P. Herrgesell

Habitat Requirements of Delta Smelt

Bruce Herbold, USEPA

One of the greatest difficulties in devising protection for the threatened delta smelt has been to determine exactly what is threatening them. In their recent Biological Assessment, DWR and USBR pointed out the lack of a significant relationship between delta smelt abundance and a wide array of variables. The absence of a simple linear relationship with any of the environmental factors associated with flow results from delta smelt's apparent low abundance in years of either very low or very high flow conditions (Moyle *et al* 1992; Moyle and Herbold 1989.) The following analysis focuses on the habitat requirements of young delta smelt as low salinity water in or near shallow habitat (Moyle *et al* 1992). The question is: "Does the occurrence and duration of suitable habitat during the spawning and nursery period in spring relate to subsequent delta smelt adult fall abundance?"

Delta smelt are found in greatest abundance at salinities near 2 ppt (3.0 mS/cm). During the recent drought almost the entire population was found near Emmaton (Figure 1), where bottom salinity stayed near 2 ppt almost year-round. By contrast, in 1993 about half the population remained in Suisun Bay throughout the summer, although the region of 2 ppt retreated upstream. This is consistent with the pattern in earlier years when dispersal of delta smelt was greater following wetter springs (Sweetnam and Stevens 1993).

When delta smelt are in Suisun Bay, they are found in greatest abundance at stations in the shallows (Moyle *et al* 1992). It is unclear whether this greater capture rate reflects a habitat preference of smelt or greater efficiency of the sampling gear.

Methods

The quantity of shallow, low-salinity habitat available each year was estimated by calculating the number of days between February 1 and June 30 when salinities of 2 ppt were in Suisun Bay. The numbers of days were calculated based on

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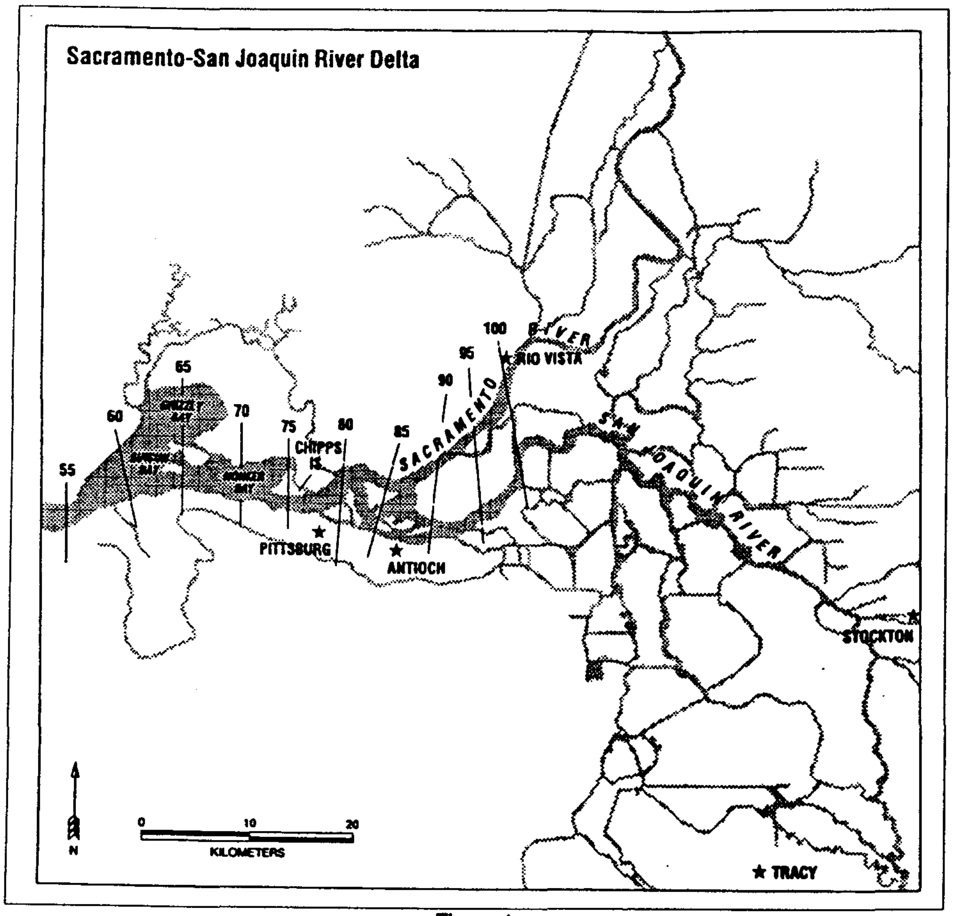

Figure 1
SACRAMENTO-SAN JOAQUIN DELTA

outflow (QOUT from the DAYFLOW data set) and the X2 equation described in Kimmerer and Monismith (1993); *ie,*

$$X2_t=10.16+0.945*X2_{(t-1)}-1.487*Log_{10}(QOUT)_t$$

These calculated values have been shown to accurately reflect measured salinities in and near Suisun Bay (Kimmerer and Monismith 1993). The calculated values provide a continuous data set, unlike the salinity data, which contain many gaps and do not include data for all stations in all years. For 1993, a preliminary estimate of the Delta Outflow Index was obtained from DWR. Springtime conditions in each year from 1967 to 1993 were compared with subsequent abundance of delta smelt as measured by DFG's fall midwater trawl survey (excluding 1974 and 1979, which were not sampled). Data used in this analysis are available from the author.

Results and Discussion

The correlation between the number of days from February through June when mean daily salinities of 2 ppt were in Suisun Bay and the abundance of adult delta smelt in the fall is significant at the 0.05 level ($r=0.496$).

Figure 2 is a scatter plot of the data, with each point labeled by year. The driest year on record (1977) and the wettest year on record (1983) both provided no days of 2 ppt in Suisun Bay and resulted in low abundances of delta smelt. Total delta outflows were similar in 1986 and 1993, but the single large storm in 1986 did not provide as much habitat, or as many delta smelt, as the more prolonged precipitation of 1993. The early 1970s yielded successive years of very high delta smelt abundance despite producing as few as 60 days of 2 ppt in Suisun Bay.

To identify which areas in Suisun Bay contributed most to the overall relationship, I calculated a separate correlation for each 5-km reach of the delta smelt historical range (San Pablo Bay to Rio Vista). The number of days when 2 ppt was in each 5-km reach was correlated with the subsequent abundance of delta smelt. The resulting Pearson correlation coefficients are shown in Figure 3, labeled by a shore location near the upstream end of each reach. The correlation for the reach from Roe Island to Middle Ground is significant at the 0.01 level. It is the only significant

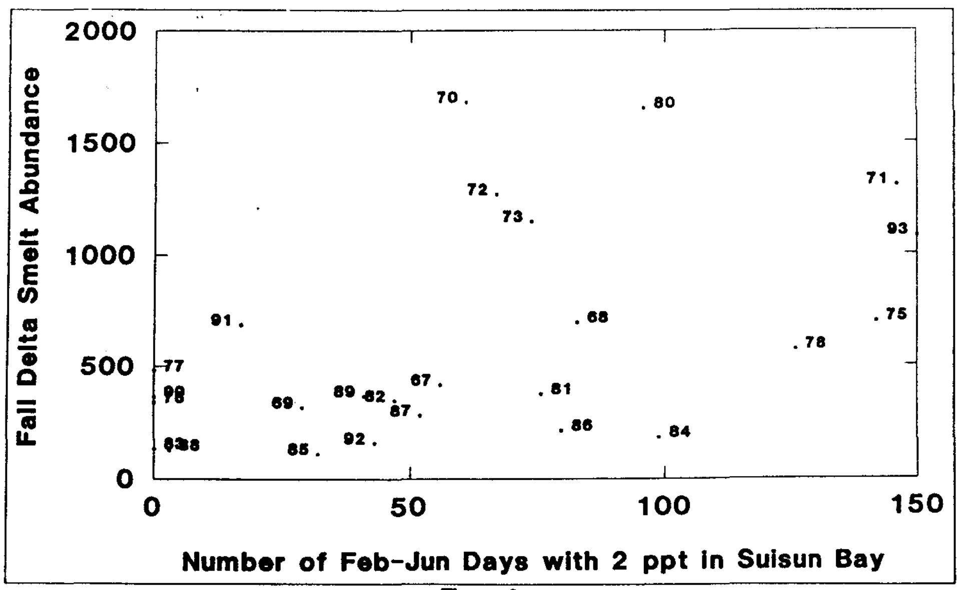

Figure 2
SPRING HABITAT EFFECTS ON DELTA SMELT RECRUITMENT

value (r=0.558). Note that all values downstream of Carquinez Bridge or upstream of Chipps Island are negative, while all sites in Suisun Bay are positive.

To try to pinpoint the months of greatest sensitivity in this relationship, I calculated a separate correlation for each month of the year. The number of days when 2 ppt was in Suisun Bay for each month of the water year preceding the fall midwater trawl was correlated with the subsequent abundance of delta smelt. The Pearson correlation coefficients for each month are displayed in Figure 4. Correlations from October through May are high but only the peak in April represents significance at the 0.05 level (r=0.486).

However, within a year, the autocorrelations in time and space reduce the reliability of any analysis that compares parts of years or small geographic areas.

Conclusions

The resurgence of delta smelt in 1993 to the highest abundance in 13 years, after a 12-year period of record low abundance, suggests stock/recruitment relationships play a small role in determining the fall abundance of delta smelt. However, spring of 1993 provided more of the habitat this species appears to require than any other year on record. The recent high abundance of delta smelt is consistent with the pattern in earlier years when springtime conditions in Suisun Bay correlate well with fall abundance.

There is some evidence that a large part of this relationship rests on the number of days in April when salinities of 2 ppt are between Middle Ground and Roe Island. However, for 1993, larval smelt were reported as early as February and as late as June, so nursery habitat may be needed throughout the 5-month period.

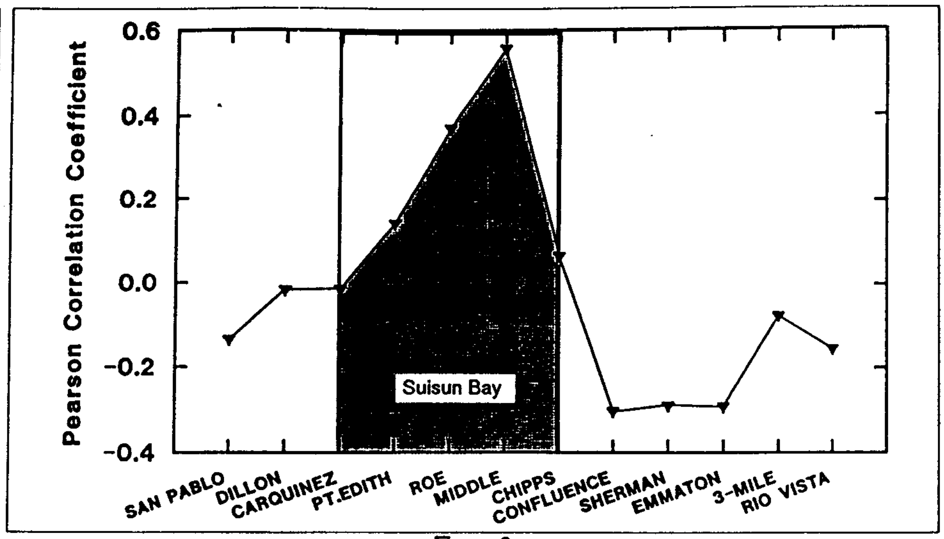

Figure 3
CORRELATIONS WITH 5-KM REACHES

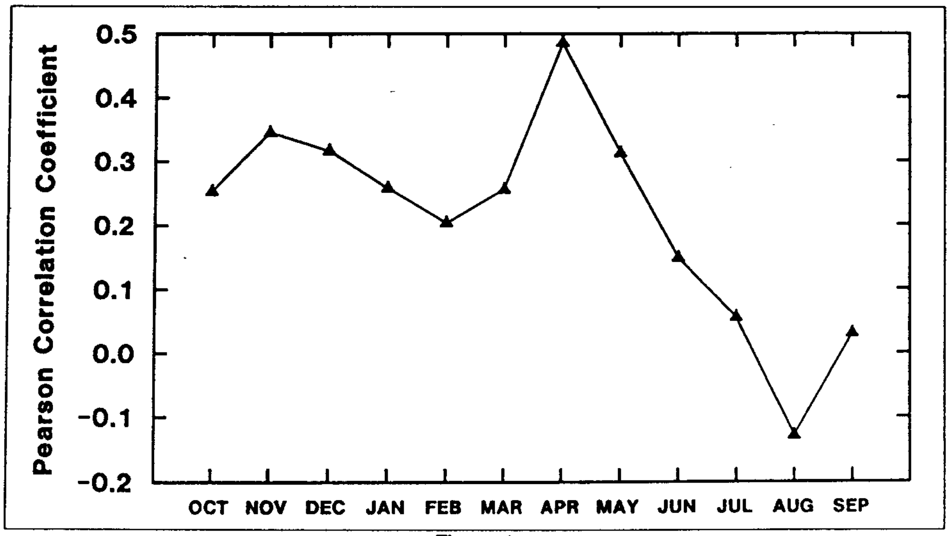

Figure 4
CORRELATIONS IN EACH MONTH

The higher captures of delta smelt near waters of 2 ppt and in shallow habitats (when waters of 2 ppt are near shallow habitats) strongly suggest habitat selection by delta smelt. The tie between the amount of this habitat and fall abundance of delta smelt argues that availability of suitable habitat limits the abundance of this species. In the absence of a significant stock/recruitment relationship or tie to any other environmental variable, availability of nursery habitat seems to be the primary limiting factor to abundance of adult delta smelt.

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Potamocorbula Amurensis Survey

Peggy Lehman, DWR, and Wayne Fields, Hydrozoology

Introduction of the Asian clam *Potamocorbula amurensis* (Mollusca Corbulidae) in the San Francisco Bay/Delta estuary in 1986 has been of great concern because of its high grazing rate (Hollibaugh and Werner 1991) and an associated decrease in chlorophyll biomass and production rate in Suisun Bay (Alpine and Cloern 1992). Suisun Bay is of concern because it often serves as a nursery for many estuarine species. Clam larvae were probably introduced from ship ballast water (Carlton *et al* 1990), and adult clams were first detected in 1986. During the 1987-1992 drought, the clam spread throughout much of the estuary and was common in the Suisun Bay region (Lehman 1994, in press).

To determine the extent of *P. amurensis* and the influence of freshwater flow on its distribution, two surveys were conducted. The first was in late August and early September 1990 (Hymanson 1991), a critically dry year; the second was in late August and September 1993, the first subsequent wet year.

The following summary describes some of the initial findings for 1993 and makes some comparisons with the 1990 survey. A more comprehensive description and analysis of the data are in progress.

Methods

Single benthic samples were collected from about 190 stations throughout the bay and delta using a Ponar dredge (0.052 m^2). Sampling stations were 2 km apart in the shoals and 1.5 km apart in the channels (any region narrower than 2 km). In addition, stations in the channels were alternately sampled near the bank and the center of the channel. For each station, density and size distribution of *P. amurensis* and substrate type were determined. Regional divisions of the data were based on natural geography. Hymanson (1991) described the methods in detail.

Results

Distribution of *P. amurensis* was similar during 1990 and 1993. During 1990, clams were almost always found from the southern end of San Pablo Bay eastward into the delta. For the Sacramento River, clams were found upstream to just below Horseshoe Bend (station 145). For the San Joaquin River, clams were found as far upstream as Jersey Point (station 172). During 1993, upstream distribution increased slightly. Clams were found about 1.5 km farther upstream in the Sacramento River on the other side of Horseshoe Bend (station 146), and in the San Joaquin River 1.5 km farther upstream from Jersey Point (station 173).

In 1993, most *P. amurensis* were found in San Pablo Bay. Densities up to 43,000 clams/m^2 were measured at station 19, in the southern end of the bay (Figure 1). Maximum density at each station was at least four times lower in the northern end of San Pablo Bay, where densities reached only 9,578 clams/m^2. Densities near 9,578 clams/m^2 were also measured in Suisun Marsh. In Suisun Bay, densities were comparatively low; maximum density for a single station was 4,981 clams/m^2 in Grizzly Bay and 1,245 clams/m^2 in Honker Bay. Few were found upstream of Honker Bay. Maximum density measured for one station was 2,644 clams/m^2 at Chipps Island. Densities remained below 2,107 clams/m^2 in the Sacramento and San Joaquin rivers.

There were large differences between years in the number of *P. amurensis* in each Ponar sample for most regions. For San Pablo Bay, the number of clams increased by a factor of 9, from 3,033 in 1990 to 27,936 in 1993 (Figure 2). For Suisun Bay and Suisun Marsh, the number of clams decreased by a factor of 3 to 5 in 1993. Numbers of clams sampled in the delta region remained stable.

Changes in numbers of clams sampled were accompanied by differences in size distribution. For San Pablo Bay, most *P. amurensis* in 1990 were 14 mm long or less, and most of these were 12-14 mm long (Figure 2). By 1993, most of the

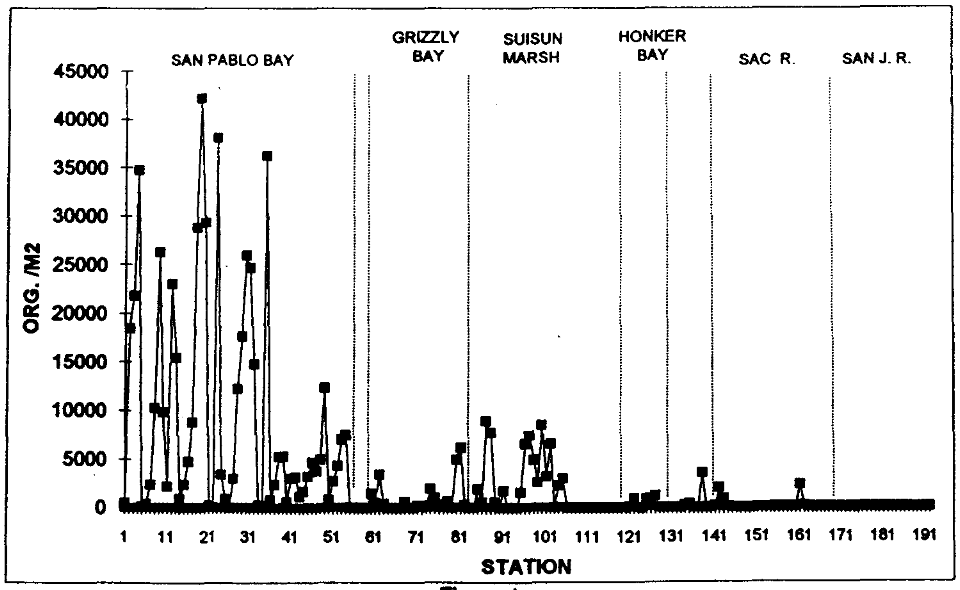

Figure 1
CLAM ABUNDANCE IN 1993

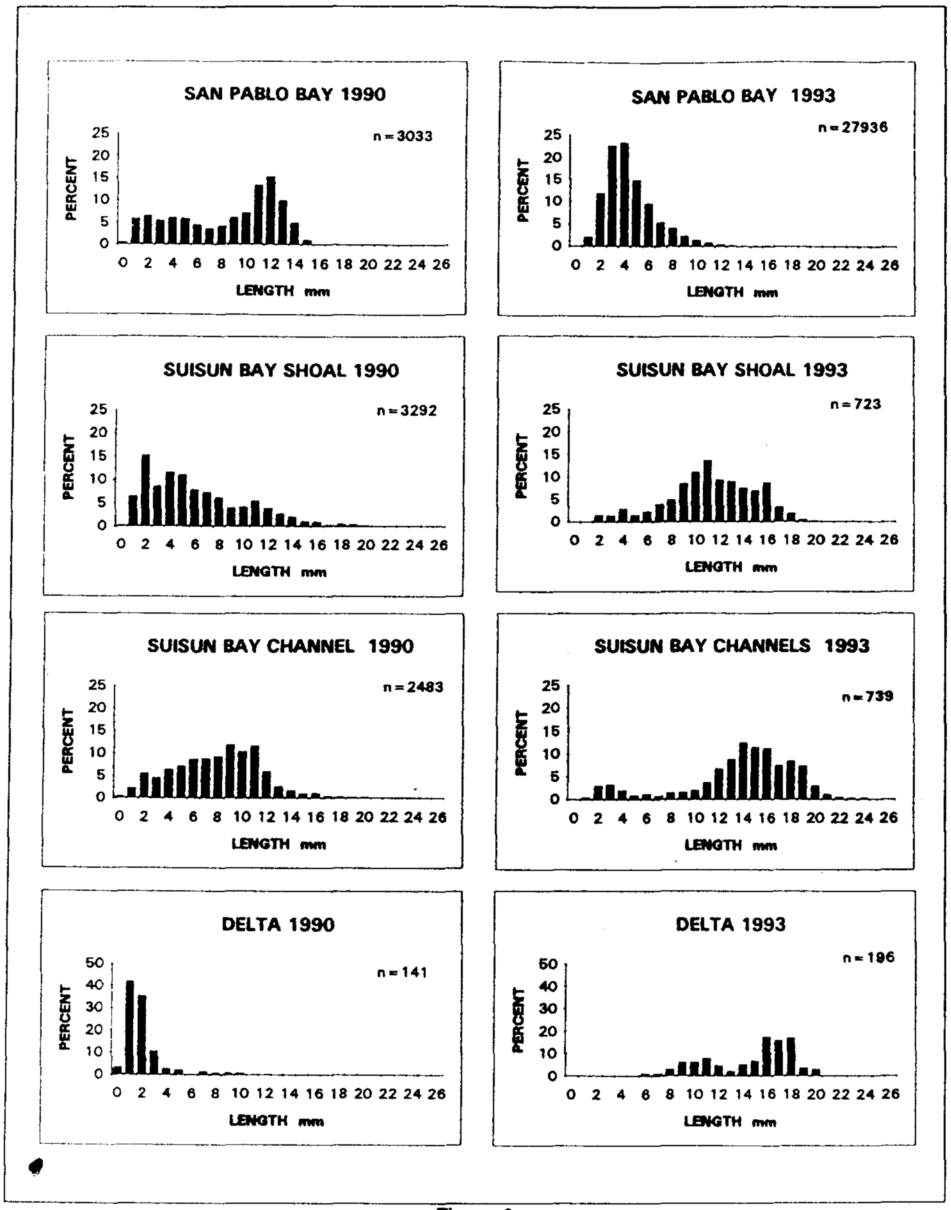

Figure 2
CLAM SIZES, 1990 AND 1993

clams were less than 10 mm long and most of these were 2-5 mm long. For the rest of the estuary, clam size was larger in 1993 than in 1990 (Figure 2). In 1990, most of the clams were less than 13.5 mm for Suisun Bay shoal and channel stations and less than 7 mm for Suisun Marsh and the delta. By 1993, clams were usually larger than 8 mm throughout the bay, marsh, and delta, and maximum density occurred between 11 mm and 16 mm.

Summary

P. amurensis were slightly farther upstream in 1993 than in 1990. Clam densities in 1993 were higher in San Pablo Bay, lower in Suisun Bay and Suisun Marsh, and similar in the delta than in 1990. Size distribution shifted from clams less than 13 mm in 1990 to clams greater than 10 mm in 1993, except for San Pablo Bay. For San Pablo Bay, the population shifted to small clams about 2-5 mm long.

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1993 Georgiana Slough Acoustic Behavioral Barrier Evaluation

Charles H. Hanson, Hanson Environmental, Inc.

Juvenile Chinook salmon emigrating from the upper Sacramento River and its tributaries are susceptible to diversion into the central delta at the Delta Cross Channel, Georgiana Slough, and Threemile Slough. Studies using fall-run salmon smolts have demonstrated substantially higher mortality rates for those fish passing into the interior delta. The increased mortality rates reflect, in part, increased susceptibility to predation, delays in migration, exposure to increased water temperatures, and increased susceptibility to entrainment losses at the SWP and CVP and a large number of other water diversions in the delta. Juvenile winter-run Chinook losses as a result of entrainment at the SWP and CVP diversions are regulated by incidental take provisions of the Endangered Species Act. The allowable level of incidental take has been established as 1% of the estimated number of winter-run smolts entering the delta. If effective in deterring a portion of juvenile Chinook salmon from entering the interior delta through Georgiana Slough, use of an acoustic (underwater sound) behavioral barrier could contribute to an increase in survival of all races of salmon during emigration. The successful guidance of winter-run Chinook from entering Georgiana Slough would also contribute to a reduction in their susceptibility to entrainment losses at the SWP and CVP diversions and, therefore, a reduction in incidental take as a result of water diversion operations.

Proposals have been considered to physically block passage of juvenile salmon into Georgiana Slough by installing a rock barrier or other structures. Concern has been expressed, however, that a physical barrier in Georgiana Slough may adversely affect water quality, alter the natural flow of water from the Sacramento River through interior delta channels, impede upstream migration of adult fish, and obstruct recreational boating. An alternative approach would be a behavioral barrier designed to utilize the avoidance response of juvenile salmon to reduce diversion into Georgiana Slough without adversely affecting hydrology, flood protection, water quality, or navigation.

Behavioral barriers have had variable success in reducing losses of fish at water diversions. Factors contributing to the variable results include differential response to a stimulus between species and life stages of fish, environmental conditions such as streamflow and turbidity, and diversion hydraulics.

In several recent applications where a behavioral barrier was targeted on the avoidance response of a specific species, a substantial increase in effectiveness was demonstrated. However, additional consideration and scientific evaluation need to be given to evaluating the guidance efficiency of behavioral barriers and also the potential for increased susceptibility to predation losses, sublethal physiological effects, potential delays or blockage in adult upstream migration, and other factors that influence the overall biological benefit associated with behavioral barrier operations.

The San Luis and Delta-Mendota Water Authority, in cooperation with the State Water Contractors, DWR, and USBR, initiated a research project in 1993 to test the effectiveness of an underwater acoustic repulsion system (barrier) in deflecting fall-run Chinook salmon smolts from entering Georgiana Slough at its confluence with the Sacramento River (Figure 1). The acoustic array used species-specific sound frequencies targeted to Chinook salmon smolts. The studies were coordinated through the Interagency Program's Fish Facilities Committee.

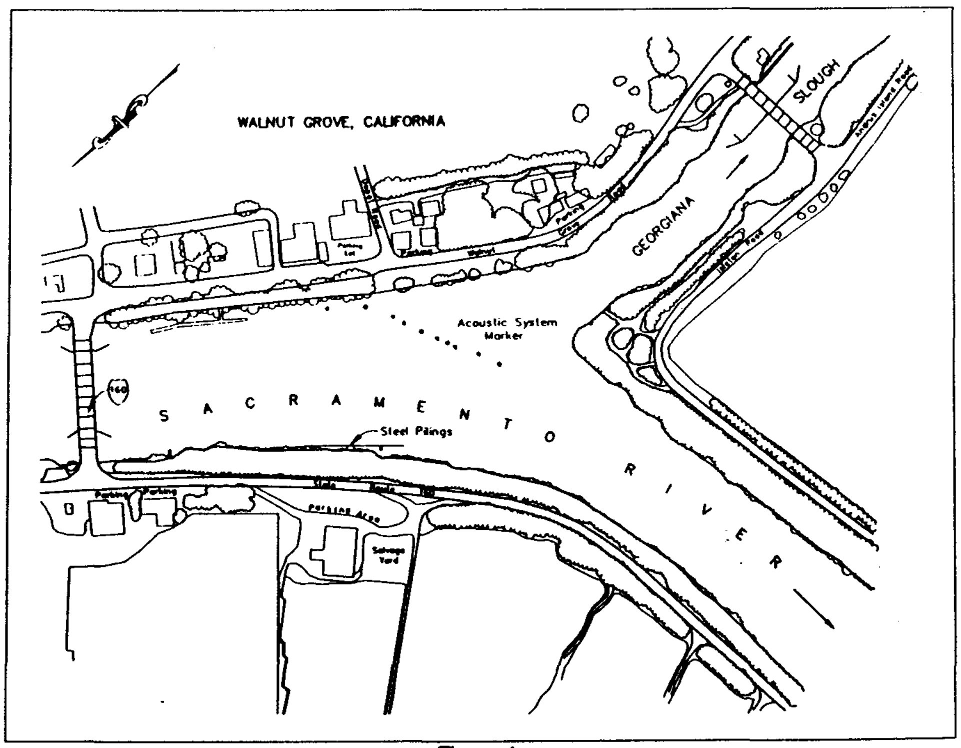


Figure 1
LOCATION AND CONFIGURATION OF ACOUSTIC BARRIER IN THE SACRAMENTO RIVER UPSTREAM OF GEORGIANA SLOUGH DURING FINAL WEEK OF PHASE I FIELD TEST
(Based on aerial photographs taken June 11, 1993)

Objectives of the 1993 field investigation were:

- Install and operate an acoustic array upstream of Georgiana Slough on the Sacramento River.
- Document the effectiveness of the acoustic barrier in reducing the numbers of juvenile fall-run Chinook salmon smolts entering Georgiana Slough.

To evaluate the effectiveness of the acoustic barrier, we determined changes in the ratio of juvenile fall-run Chinook salmon captured in Georgiana Slough and the Sacramento River during periods when the acoustic barrier was on and during periods when it was off.

Results of fish collections, performed using a Kodiak trawl, were reported as a catch-per-unit-effort to account for variation in sampling effort. A total of 610 Kodiak trawls were completed in Georgiana Slough and the Sacramento River between May 6 and June 10 for use in evaluating effectiveness of the acoustic barrier. Juvenile Chinook salmon comprised 95% (5,163 salmon) of the total number of fish collected (5,460 fish).

Results of the first complete weekly testing cycle (May 10-14) showed a greater relative number (ratio) of juvenile Chinook salmon entering Georgiana Slough when the acoustic barrier was on compared to catches when the acoustic barrier was off, resulting in a negative index of guidance efficiency (Figure 2). We hypothesized that the angle and location of the acoustic barrier were too close to the entrance to Georgiana Slough given the channel hydraulics, resulting in insufficient reaction time and distance for juvenile Chinook salmon to respond to the barrier and overcome velocities of water entering the slough. Based on this hypothesis, the configuration of the acoustic barrier was modified in an attempt to guide juvenile Chinook salmon toward the mid-channel area of the Sacramento River a sufficient distance upstream of the confluence with Georgiana Slough to allow guidance and passage downstream. The barrier was subsequently modified each week based on results of the biological evaluation. Results of the evaluation (Figure 2) show a pattern of increasing guidance efficiency during each weekly testing sequence. The final two testing sequences (June 1 and 4, June 7 and 10) had an estimated index of guidance efficiency above 50%.

The 1993 field test results were encouraging but did not provide the necessary degree of replication to support rigorous statistical analysis, calculation of absolute guidance efficiency that can be used with confidence to represent a range of environmental conditions, or detailed analyses on changes in the distribution pattern of juvenile Chinook salmon in response to acoustic barrier operations. Therefore, additional investigations have been designed for 1994 to provide more comprehensive documentation on environmental conditions such as velocity, flow rates, and acoustic signal mapping and more replication to allow statistical testing for differences in juvenile Chinook salmon catch-per-unit-effort in Georgiana Slough and the Sacramento River as a function of acoustic barrier operations. The 1994 research program includes a number of independent measures of acoustic barrier efficiency to help evaluate barrier performance given the relatively high degree of variability in Kodiak trawl catch-per-unit-effort observed during the 1993 studies. In addition, the 1994 studies will document changes in the horizontal and vertical distribution of juvenile Chinook salmon in response to acoustic barrier operations, using both trawling and hydroacoustic monitoring and coded-wire tag mark/recapture studies to estimate survival rates for juvenile Chinook salmon during periods when the acoustic barrier is on and periods when it is off. Although each of these alternative approaches has inherent strengths and weaknesses for use in evaluating acoustic barrier performance, collective results of the 1994 tests should provide a sufficient basis for evaluating guidance efficiency of the acoustic barrier for juvenile Chinook salmon smolts.

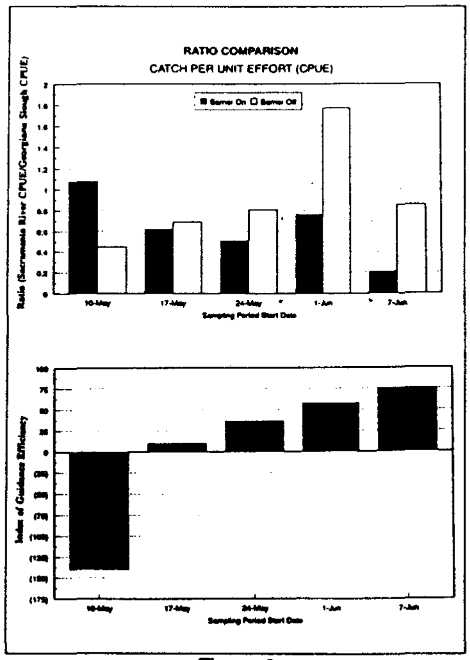


Figure 2
RATIO ESTIMATES AND
INDEX OF GUIDANCE EFFICIENCY
OF THE ACOUSTIC BARRIER

(Based on Chinook salmon catch per 1,000 m^3 sampled in Kodiak trawls in the Sacramento River and Georgiana Slough.)

The 1994 studies will also consider, through various field and laboratory experiments, effects of the acoustic signal on hatching success and survival of larval and juvenile fish, increased susceptibility to predation, and potential changes in resident fish populations in response to acoustic barrier operations. Radio tagging and hydroacoustic surveys are also proposed to evaluate the potential for blockage or delays in adult upstream migration of adult striped bass and fall-run Chinook salmon as a direct result of acoustic barrier operations.

Development of Striped Bass IBM Nears Completion

Jim Cowan, University of South Alabama & Kenny Rose, Oak Ridge National Laboratory

In a thoughtful contribution to the Autumn 1993 edition of the *Interagency Newsletter*, Wim Kimmerer identified several information needs relative to forthcoming management decisions about the delta. Specifically, he suggested that "new conceptual models and population models for the estuary that can be coupled with the developing hydrodynamic models"... (were needed) to try to predict what has and will happen there to many bay/delta fishes. For the last 3 years, researchers at the Oak Ridge National Laboratory, in collaboration with scientists from the DFG Bay-Delta Fishery Project, DWR, Interagency Program, and the academic community have been developing an IBM *(individual-based model)* of the striped bass population in the delta. The model has been developed as part of a larger project designed to study compensatory mechanisms *(COMPMECH)* in fish population dynamics. The Sacramento-San Joaquin River striped bass population is one of four populations under investigation by COMPMECH, whose larger goal is to make interpopulation comparisons of striped bass life history across environmental gradients indicative of its range. With the incorporation of new data and fine tuning based on results of a recent workshop, a first version of a full-life-cycle California IBM soon will be completed and will provide a powerful tool for decision-makers charged with sorting out the complex environmental consequences of the "mismatch in time and place between water supply and demand" in the delta. The following paragraphs briefly describe the IBM approach and our plans to use the model to address some issues we and our collaborators deem most important.

IBMs are receiving increasing attention as a means of understanding population dynamics of fishes (for more information, see papers from an IBM symposium published in Volume 122, Number 3 in *Transactions of the American Fisheries Society*). Models of fish populations dynamics, if process oriented, can enhance our ecological insights about how populations function within their environment. Because growth and mortality in fishes is related and because fishes have highly plastic and variable growth rates within classes or cohorts, the mechanisms governing survival and recruitment (and ultimately evolution) operate at the level of the individual. When individuals differ substantially, the results we see at the population level may be derived from a small minority of atypical individuals. Thus, models based on the average individual are likely to provide little insight into the factors that affect recruitment variability and often are misleading.

In this light, the California model begins with spawning by individual females and simulates the growth and mortality of the newly spawned striped bass as they develop through the egg, yolk-sac larval, feeding larval, juvenile, and adult life history stages. The young-of-the-year model represents these dynamics daily in multiple, well-mixed compartments that represent different regions within the estuary (*eg,* upper Sacramento River, lower Sacramento River, lower San Joaquin River, Suisun Bay). Environmental conditions considered in each compartment are daily water temperature, fraction of the 24-hour day with daylight, and the densities of zooplankton and benthic prey types.

For the egg and yolk-sac stages, each female's spawn of eggs is followed as an entity (cohort); a random sample of individuals is followed for the feeding larval and juvenile stages. Total length, weight, age *(d)*, life stage, and other attributes are chronicled for each individual. Egg and yolk-sac larval development and mortality rates are expressed as a function of daily temperature. Upon initiation of first feeding, initial weight and length of feeding larvae in each female cohort are determined from egg weight. Feeding larvae develop into juveniles when their length exceeds 20 mm.

When larvae begin to feed, they are followed day-by-day through growth and mortality processes. Larvae are sampled from each cohort in proportion to that cohort's contribution to the total number of surviving first-feeding larvae. Daily growth of each individual beginning at first feeding is calculated via a bioenergetics relationship. A major departure from other bioenergetics approaches, however, the proportion *(p)* of maximum consumption realized by an individual on a given day here is determined from stochastic prey encounters with multiple zooplankton prey groups for feeding larvae and multiple benthic prey groups for juveniles.

Mortality of feeding larvae and juveniles depends on weight and length. Weight-dependent mortality is considered to be due to starvation. Length-dependent mortality is estimated from field data and, therefore, includes predation and other losses. Probability of dying (P_d) is evaluated daily for individuals: $P_d - (1-e^{-M})$, for which $M = 0.003 + 0.295 * e^{-0.075*L}$. (We are attempting to define a separate mortality curve for each compartment.) If the generated random number from a uniform distribution between 0 and 1 is less than P_d, the individual is assumed to die. Thus, growth rate (size) is directly tied to mortality rate in simulations.

After the first year of life, IBM output on numbers and mean length of age-1 survivors combined from all compartments of the YOY module are used as input to a matrix projection adult model. Age-specific growth and mortality schedules are used to project the numbers and mean size of individuals in each age class. An age-specific maturity schedule then is used to determine the number and size distribution of spawners as input to the YOY module for the next year. This is repeated on an annual time-step for multiple years.

We have developed the California IBM based on our understanding of resource problems specific to the California striped bass population and its recent decline in abundance. We plan to use the model to evaluate several scenarios that describe the relative importance of factors believed to have contributed to the striped bass decline. Possible factors include:

- Differences in prey fields and temperature regimes in the different regions of the delta in high versus average versus low flow years,
- Changes in numbers and sizes of spawning females, and
- Changes in life-stage-specific mortality rates due to a variety of causes.

The model will be used to predict the effects of these factors on:

- Development, growth, and survival rates during early life stages (when recruitment success is determined), and
- Long-term (multi-generational) numbers of age-1 survivors and spawning females.

Our first simulations will attempt to address the following types of questions:

① How do different flow regimes affect the distribution of eggs, larvae, and juveniles in the delta and how do differences in distribution affect survival rates to age 1?

We will collaborate with hydrodynamics modelers at DWR to realistically distribute individuals within in the system in high versus low flow years. We also are analyzing DFG and Interagency Program Food Chain Committee field data on prey distributions and temperature, partitioned by salinity and flow, to better define environmental conditions in the model.

② Are striped bass food-limited in this system and have changes in prey species composition, distribution, and abundance contributed to the decline in striped bass since the mid-1970s?

③ Have changes in adult population demographics (*eg*, numbers, sizes, mortality rates, *etc*) contributed to the decline in striped bass since the mid-1970s?

④ Have changes in mortality rates of eggs, yolk-sac larvae, feeding larvae, or juveniles contributed to the decline in striped bass since the mid-1970s? If so, what life stage has been affected and what is the probable cause of the change?

Factors such as entrainment and toxics have been implicated in the delta, and each is likely to affect a different life-history stage. The type of stress of interest determines how it is implemented in the IBM. To determine the relative importance of such stresses, some fraction of individuals in a particular life stage, during a specific time, and/or in a certain size range or nutritional condition will be removed based on appropriate empirical data from the simulated population in one or more of the four regions of the delta. In this way, comparison of the relative changes in survivorship to age 1 act as a sensitivity analysis of the population to the defined stresses.

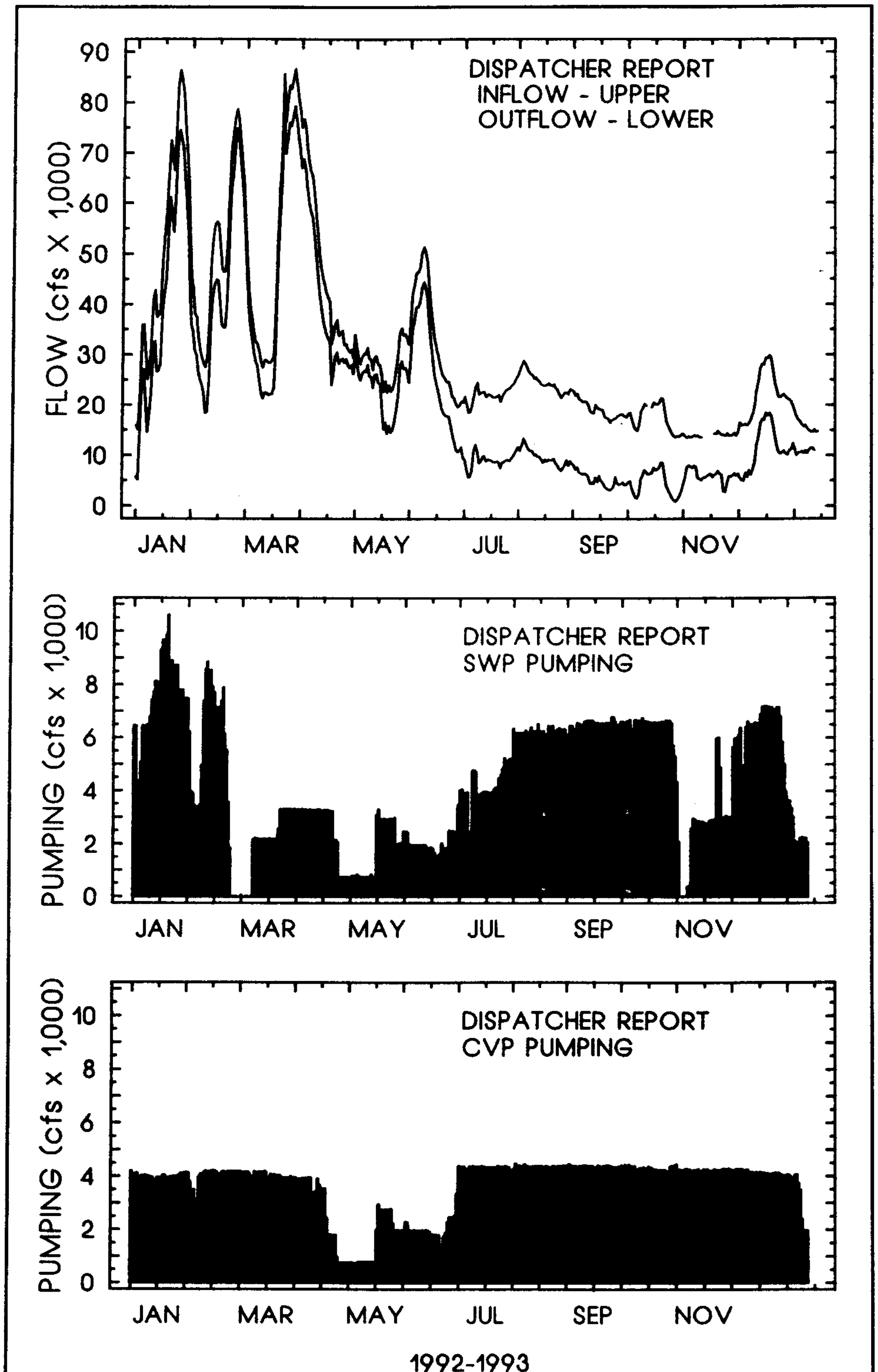
One of the most powerful aspects of the striped bass IBM is that it also can be used to compare the importance of these factors applied singly or in combination. For example, we may wish ask: "How do the effects of changes in size of female spawners and reduced spawning biomass compare to the effects of increased larval mortality in reducing survival to age 1?" or: "Are the effects of increased larval mortality due to diversions and reduced edible zooplankton additive?" We have used this type of approach in a similar IBM configured to specifications of the Potomac River in Maryland, with good success (see *Transactions of the American Fisheries Society*, Volume 122, Number 3).

Obviously, the above questions do not address all possible scenarios and ultimately may not include the most important combination of recruitment factors. More specific analyses will depend on those who know the delta best; success in model application to delta striped bass depends greatly on your input and advice. As COMPMECH moves on toward its larger goals, we will focus more on interpopulation comparisons (California, Hudson River, Santee-Cooper, Chesapeake Bay). Thus, we urge the research and management community in California to work with our principal collaborators (DFG and DWR) to thoroughly apply what we believe to be a powerful tool for understanding the recruitment dynamics of an important fishery resource in its changing environment.

Delta Flows

Sheila Greene, DWR

Combined export pumping was high during October 1993, at 10,750 cfs. SWP pumping was halted during the first week of November while the new fish facility control system was installed. Otherwise, SWP pumping was about 2,900 cfs during November to comply with the QWEST standards, except during a Clifton Court Forebay predation study. Increased delta inflow permitted pumping to be increased in December without violating QWEST standards. In early January 1994, SWP pumping was decreased again to avoid "taking" winter-run Chinook salmon and because San Luis Reservoir was filled.



Noteworthy —

☞With Perry Herrgesell's promotion to division chief, the Interagency Program will be selecting a new program manager. The position will remain in the DFG Stockton office. The selection committee will include representatives from other agencies in the program.

☞Modifications and maintenance work on the *San Carlos* have been mostly completed, and the vessel and crew have been conducting training cruises to become familiar with the new gear. DWR and USBR are also modifying the *Scrutiny* and the *Compliance* (formerly the *Rantz*) to expand the capability of these vessels to conduct biological as well as water quality sampling. New computer systems are being installed to help automate data acquisition.

☞Program staff are planning for this spring's extensive field study of Suisun Bay. Major study participants include USGS, DFG, DWR, USBR, and several consultants. USACE may be contributing partial funding to this study. The study will focus on developing an understanding of the physics, chemistry, and biology in this area of the estuary. Contact Larry Smith (916/978-4648, Ext. 395) or Leo Winternitz (916/445-7203) for details.

☞A workshop on X2 will be held in Palo Alto on February 15 and 16. Contact Stephen Monismith at 415/723-4764 for more information.

Bay Fisheries Data Report

Chuck Armor, DFG

The Delta Outflow/San Francisco Bay Study has completed a draft report that describes the basic life histories and summarizes 19801992 abundance, distribution, salinity, and temperature data for 28 species of fish, 4 species of shrimp, and Dungeness crabs. The report is being reviewed and will be published either as part of DFG's Fishery Bulletin series or as an Interagency Technical Report.

Preparation of this document has been an ongoing effort interrupted by water right hearings, staff changes, and other demands for staff time, such as analysis used for endangered species review. The final document will be over 400 pages and is the first comprehensive review of San Francisco Bay fisheries data to include the recent drought years. Included are a compilation of the catch and percent catch by gear type and year for all species of fish, shrimp, and Cancer crabs; the Secchi disk data; and the surface and bottom salinity and temperature data collected by the study. For fish and crabs, information is presented for young-of-the-year and where possible 1+ (one year and older) individuals. For shrimp, information was broken down by mature and immature individuals as well as by sex and egg maturity stage. Data that were not analyzed for this report but that will be included in future efforts include larval fish catch and length frequency and larval shrimp and crab data.

Preparation of this report has helped focus staff biologists on what we know and what we don't know. It has also provided fresh insights into the biology of the species included and mechanisms that may control their abundance and distribution in the estuary. During the preparation, many questions arose about various species, and these will questions will provide the basis for future investigations and publications.

This report is a departure from past reports prepared by the study in that it concentrates on basic biology and data summarization rather than on the effects of outflow.

Annual Workshop

The Interagency Program annual workshop will be held March 2-4 at the Asilomar Conference Center in Pacific Grove. The agenda, presented on the following pages, reflects the myriad of issues facing us as the Interagency Program is being revised to cope with these issues. It should be a stimulating meeting. These people have more information:

Chuck Armor, DFG *209/948-7800*
Jim Arthur, USBR......................... *916/978-4923*
Marty Kjelson, USFWS..................... *209/946-6400*
Pete Smith, USGS................ *916/978-4648 (Ext 373)*
Jim Sutton, SWRCB *916/657-2190*
Leo Winternitz, DWR *916/445-7203*

AGENDA

INTERAGENCY ECOLOGICAL STUDIES PROGRAM ANNUAL WORKSHOP
March 2-4, 1994 Asilomar Conference Center

March 2 — Wednesday

1:00 Arrive and Assemble — DO NOT check in!

1:30 Welcome and Announcements . . . . Jim Arthur, USBR

INTERAGENCY ECOLOGICAL STUDIES PROGRAM REPORTS

1:40 The Revised Interagency Ecological Study Program:
- Overview of the Revised Program
- Staff Level Management Team
- Project Work Teams
- Science Advisory Group
- Management Advisory Group . . . . Perry Herrgesell, DFG

PROJECT UPDATES . . . . Chair: Pete Smith, USGS

2:20 Georgiana Slough Acoustic Barrier . . . . Chuck Hanson, Hanson Environmental Inc.

2:45 Status of the Suisun Marsh Wildlife Program . . . . . . Steve Cordes, DFG and Brenda Grewell, DWR

3:10 Estuarine Food Chain Conceptual Models . . . . Wim Kimmerer, BioSystems Analysis Inc.

3:45 CHECK IN — Pick Up Keys to Rooms

6:00 Dinner — Served Only Until 7:00 PM

7:00 Social Activity and Guest Speaker:
Exotic Species in the SF Bay Estuary . . . . Jim Carlton/Andy Cohen *(Tentative)*

8:30 Adjourn

March 3 — Thursday

7:30 Breakfast

8:15 Announcements . . . . Chuck Armor, DFG

ENDANGERED SPECIES . . . . Chair: Marty Kjelson, USFWS

8:25 1992/93 Winter Run Field Survey Results . . . . Mark Pierce, USFWS

8:50 Winter Run Recovery Team Activities: . . . . Jim Smith, USFWS
- What has the team been doing?
- What constitutes recovery?
- What actions are needed to recover?

9:15 1992/93 Delta Smelt Field Survey Results . . . . Dale Sweetnam, DFG

9:40 Delta Smelt Biological Opinion . . . . Cay Goude, USFWS

10:05 Break

10:30 Delta Native Fishes Recovery Team Activities: . . . . Peter Moyle, UCD
- What has the team been doing?
- What constitutes recovery?
- What actions are needed to recover?

10:55 Sacramento Splittail Field Survey Results. . . . . Randy Baxter, DFG/ Lesa Meng, USFWS

CVP IMPROVEMENT ACT . . . . Chair: Jim Arthur, USBR

11:20 Overview with Emphasis on the Bay/Delta Estuary . . . . Jim McKevitt/Roger Guinee, USFWS

11:45 The Doubling Plan — How Will It Be Done? . . . . Terry Mills, DFG

12:10	Lunch	
1:00	Free Time	
5:00	Social Hour — Drinks and Snacks	
6:00	Dinner	

EVENING SESSION:
THE EPA STANDARDS .... Chair: Leo Winternitz, DWR

7:00	Policy Behind the Estuarine Standards: - Why they were developed? - How they will be implemented? - How long they will be in effect? - What is their relationship to BDOC? - Results of the Public Hearing	Patrick Wright, USEPA
7:20	Biological Basis for X2 and EPA Standards	Bruce Herbold, USEPA
7:45	The Hydrodynamic Element — New Insights/New Questions	Jon Burau, USGS
8:10	The California Urban Water Agencies Biological Team — New Perspectives?/New Solutions?	Jud Monroe/Randy Bailey, CUWA
8:35	The State Response — How Will the State Make New Standards Work?	Jerry Johns
8:55	Questions and Discussions	All
9:30	Adjourn	

March 4 — Friday

TECHNICAL SESSIONS .... Chair: Chuck Armor, DFG

8:15	New National Marine Fisheries Service Screening Policy and New Screen Technologies — Modular Inclined Screens	Darryl Hayes/Ted Frink, DWR
8:40	Results of the 1993 Clifton Court Forebay Predation Study	Jennifer Bull/Mike Healy, DFG
9:05	Response of Sturgeon, Bass and Other Fish to 1993 Hydrologic Conditions	Lee Miller/Dave Kohlhorst, DFG
9:30	Break	
9:55	Response of *Potamocorbula* (Asian Clam) to 1993 Hydrologic Conditions	Peggy Lehman, DWR

OUTSIDE TOPICS .... Chair: Jim Sutton, SWRCB

10:20	Suspended Solids Concentrations in Central San Francisco Bay During the 1993 Winter Runoff	Dave Schoellhamer, USGS
10:45	Delta Wetlands Project	Jordan Lang, Jones & Stokes
11:10	Check Out of Rooms	
12:00	Lunch	
1:00	End of Workshop	

A POSTER SESSION will be held concurrently with the Workshop.
Please review the contributions during breaks or during other times.
(A list of posters is on the next page).

NOTE: Unless otherwise indicated, speakers will be allotted 25 minutes.
Presentations should be 15 minutes and there should be 10 minutes left for questions.

TIME LIMITS WILL BE STRICTLY ENFORCED
Timer: Jim (The Enforcer) Sutton

INITIAL LIST OF POSTERS

- Twitchell Island Pheasant Hunt
- Surf Perch
- Pacific Herring
- Geographical Information System
- Agricultural Diversion Study
- What Is A Winter Run?
- Egg and Larval Automatic Sampling
- Data Acquisition for the New Compliance Monitoring Program
- Striped Bass Spawning on the Sacramento River
- Fishery Improvements at Red Bluff
- Delta SOS

Interagency Ecological Studies Program
NEWSLETTER
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Sacramento, CA 95816-7017

Interagency Ecological Studies Program for the Sacramento-San Joaquin Estuary

NEWSLETTER

A Cooperative Effort of:

California Department of Water Resources
State Water Resources Control Board
U.S. Bureau of Reclamation
U.S. Army Corps of Engineers
California Department of Fish and Game
U.S. Fish and Wildlife Service
U.S. Geological Survey
U.S. Environmental Protection Agency

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