Interagency Ecological Program for the Sacramento-San Joaquin Estuary

# Newsletter

364

Summer 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.

## Phytoplankton and Organic Carbon Sources for the Bay/Delta Food Web

*Alan Jassby, University of California, Davis*

Several years ago, I contributed an organic carbon budget to the San Francisco Estuary Project's Status and Trends Report on Aquatic Resources. The purpose of such a budget is to delineate the relative contributions of different energy sources for the food web. In subsequent years, with the collaboration of Jim Cloern and Tom Powell, I refined the budget and included a consideration of interannual variability and a comparison with other estuaries (Jassby *et al* 1993). An organic carbon budget is almost as tedious to read about as to construct, so I suspect that the latter publication has not figured prominently in the bedside literature of most Bay/Delta researchers. My suspicions are confirmed when I hear peculiar pronouncements about the trophic role (or lack of one) for phytoplankton, supposedly based on the organic carbon budget. I would like, then, to summarize the budget for San Francisco Bay.

The goal was to determine what could be said on the basis of collating and summarizing existing information.

New data that bear on the budget were presented at the recent AAAS symposium on San Francisco Bay (June 1994) by Elizabeth Canuel, Larry Schemel, and others; their results, which support the basic conclusions of the budget, will be available in the summary volume for the symposium.

### Organic Carbon Sources in North and South Bays

The budget considered only North Bay (from San Pablo Strait to Chipps Island) and South Bay (from the Bay Bridge to the southernmost extremity); sufficient data were simply not available elsewhere. Data for 1980 were used where possible, as that was the single year for which the most relevant data were available. The budget was comprehensive in the sense that all credible organic carbon sources were considered. Little, however, could be deduced about net transport at the seaward boundary of the bays, a process that could conceivably contribute significant amounts of organic carbon, particularly to North Bay via gravitational circulation. Moreover, almost all estimates were highly uncertain and errors of 100% in most of the terms would not be surprising. So although the budget is a "best guess", it is not necessarily a good one. That said, some useful deductions from the analysis are still possible.

Phytoplankton, benthic microalgae, river-borne organic loads, tidal marsh export, and point sources each contributed at least 5% of the total organic carbon supply to either North or South bay, or both. On the other hand, sea grasses, macroalgae, bacterial autotrophs, runoff, atmospheric deposition, spills, ground water, and biotic transport (fish migration) all appeared to be negligible sources of organic carbon.

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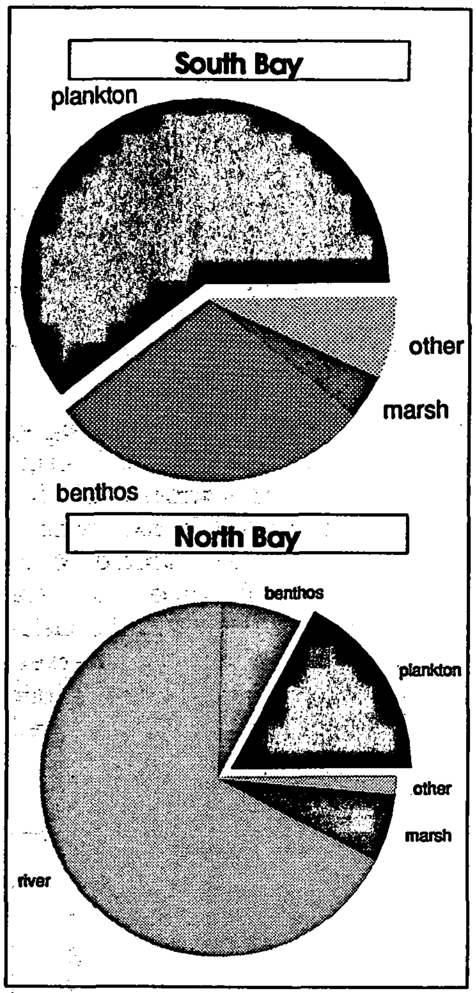
The figure below shows sources of organic carbon for 1980. For South Bay, phytoplankton production was dominant and constituted about 60% of the total. North Bay sources were dominated by the loading of organic carbon from the Sacramento and San Joaquin rivers, and autochthonous (local) phytoplankton production provided only about 20% of the total. The estimates of river-borne carbon were based on the work of Larry Schemel; he has recently re-estimated the riverine contributions for 1980 and they appear to be even higher than portrayed here.




**ORGANIC CARBON SOURCES IN SAN FRANCISCO BAY DURING 1980**
The area of each circle is proportional to the total supply of organic carbon. *Plankton*, phytoplankton production; *benthos*, benthic microalgal production; *river*, river-borne organic carbon load; *marsh*, imports from tidal marsh; *other*, mostly point sources and runoff.

The availability of this river-borne organic matter, both dissolved and particulate forms, to the North Bay's food web is unknown. In other words, some of the material may be metabolically inert compared to phytoplankton or benthic microalgae and incapable of being incorporated into the food web. Much of the particulate fraction appears to be phytoplankton and phytoplankton-derived detritus from upstream. Most of this phytoplankton-associated organic matter was produced in the delta and is probably not very old, in which case it might be comparable to autochthonous phytoplankton production in terms of availability. (Liz Canuel's work on biochemical markers confirms that upstream phytoplankton are an important component of the organic carbon load, which also includes terrigeneous and other materials.) But $BOD_5$ measurements in the Sacramento River over many years correspond on average to only about 10% of the total organic carbon concentration, which suggests that most of the organic matter is not readily usable. The availability of organic matter imported from tidal marsh and other sources is probably less than that of microalgal production as well, although in these cases we have even less basis on which to make a correction.

The timing of the river-borne load is also an issue, as it is so highly seasonal compared to other sources. The seasonality of the influx may not be in phase with the seasonal needs of higher organisms. Furthermore, the pulses of organic matter occur when residence time in North Bay is low; much of the dissolved material may simply pass through North Bay. So there is clearly a potential for phytoplankton to play a much larger trophic role than portrayed by Figure 1.

The budget exhibits variability from one year to the next. Although data are not sufficient to construct completely independent budgets for separate years, it is instructive to compare the interannual variability in certain components of the budget. We examined, in particular, the amount of phytoplankton-associated organic matter entering Suisun Bay from the delta compared to the amount of phytoplankton produced within Suisun Bay. Together, these constitute the total supply of phytoplankton-derived particles for Suisun Bay. During 1975-1989, the percentage attributable to river loading ranged from 20 to 90%; the dominant source, therefore, could change from year to year.

## Food Limitation

What are the practical implications of this budget and of phytoplankton variability? One basic assumption motivating work on these subjects in the estuary has been that this variability propagates through the food web and ultimately affects organisms such as fish that are of more immediate concern to people. One of the clearest indications that variability at higher trophic levels is driven by variability at the base of the food web was provided by an experimental study of the bivalve *Macoma balthica* (Thompson and Nichols 1988). Growth was not strongly affected by either salinity or temperature; rather, differences in growth rates and tissue weights at various sites in the bay could be attributed most strongly to differences in chlorophyll *a* levels. Food-limited growth has also been reported for the bivalve *Corbicula fluminea* located upstream in the tidal freshwater portion of the estuary (Foe and Knight 1985).

Limitation of the pelagic food chain by phytoplankton availability is less well established. Zooplankton gut contents certainly illustrate the dominance of phytoplankton as a food source (Kost and Knight 1975), but there is almost no experimental evidence that low ambient phytoplankton concentrations control growth rates. Recent declines in the planktonic copepod *Eurytemora affinis* are due to direct consumption by clams rather than by competition between zooplankton and clams for phytoplankton (Kimmerer *et al* 1994). Although positive statistical associations between chlorophyll levels and zooplankton abundance can be shown, both are affected by salinity distributions, and the correlations could be an artifact. Recent evidence, however, does suggest food limitation for *Neomysis* (Kimmerer, pers comm) The significance of food limitation for the pelagic primary consumers remains an important issue for this estuary and needs to be resolved further.

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## Sacramento Splittail Work Continues at UC-Davis


*Howard C. Bailey, University of California, Davis*


Adult splittail were collected last fall and maintained in floating net pens in Suisun Marsh. In April, about 30 adults were transferred to UC-Davis, where they were held in circular outdoor tanks continuously supplied with well water. Spawning was induced by intra-muscular injection of carp pituitary extract. The fish were hand-stripped, but spawning also occurred in the tanks. Fertilization was verified microscopically. Eggs were incubated under flow-through conditions using a variety of techniques, including McDonald jars, spawning mats, dishes, and beakers. Fungal infection killed all the eggs from the first spawning within 72 hours. For the second spawning, treatments to increase embryo survival emphasized reducing egg density during incubation and increasing water flow around the embryos. We also evaluated the effectiveness of disinfection with daily Iodophor treatments. Of all procedures tried, the Iodophor treatments were the most effective at producing viable offspring.

At 18.5°C, the embryos hatched in 3-5 days. At 15.5°C, hatching took 7 days. At 18.5°C, the larvae were poorly developed, and averaged 5.97 mm total length at hatch. This increased to 6.50 mm at 1 day, 6.90 mm at 2 days, 7.77 mm at 4 days, 9.30 mm at 9 days, and 10.67 mm at 15 days post-hatch. After 39 days, the larvae averaged 16.17 mm TL.

Larvae from embryos incubated in clumps hatched sooner than those separated prior to incubation. Newly hatched larvae were demersal and poorly developed. Larvae initially had no eye pigment, and they had no mouth at 48 hours post-hatch. By 96 hours, the mouth was formed and the swim bladder was dilated. Swim bladders inflated at 5-7 days post-hatch, and swim-up was completed at 7 days. Feeding began 5 days post-hatch, with rotifers (*Brachionus plicatilis*), and the larvae were clearly feeding on rotifers by day 7. Beginning 8 days post-hatch, the diet was supplemented with *Artemia* nauplii, and all fish were consuming *Artemia* by day 10. At 13 days, the larvae were introduced to artificial diet, and are now being maintained on a mixture of *Artemia* nauplii and artificial diet. Survival of the larvae has been greater than 95% through 58 days post-hatch.

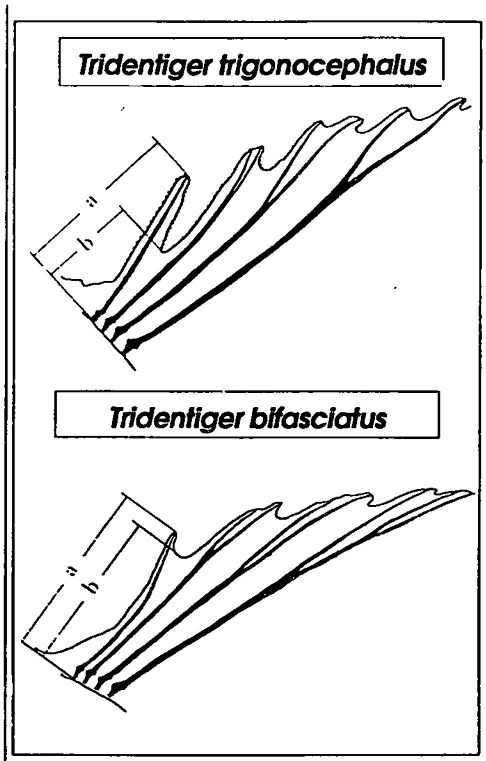

The following people have contributed to the success of this effort. Erik Hallen of the Aquaculture and Fisheries Program assisted with the spawning, embryo incubation, and rearing the larvae. Dr. Sergei Doroshov and his assistant Kevin Kroll also provided helpful suggestions. Dr. Bill Cox, formerly of Dr. Hendrick's laboratory and now with the Pathology Unit at DFG-Rancho Cordova helped identify ways to deal with the fungal problem. Tom Hampson of the Fisheries Foundation cared for the adults while they were confined at Suisun Marsh.

# A Third Asian Goby Found in the Sacramento-San Joaquin Estuary

*Scott Matern, University of California at Davis*

The chameleon goby, *Tridentiger trigonocephalus*, an Asian invader to California (probably via ballast water), became established in South Bay in the late 1950s or early 1960s (Ruth 1964; Brittan *et al* 1970). In the San Francisco area, it was first collected in June 1962 (California Academy of Sciences specimen CAS 27011). The University of California, Davis, has sampled in Suisun Marsh monthly since 1979, and first collected chameleon gobies, assumed to be *T. trigonocephalus*, in 1985. By 1989, this was the second most abundant species in the Suisun Marsh trawls (Meng *et al*, in press).

Akihito and Sakamoto (1989) differentiate between *T. trigonocephalus* and *T. bifasciatus*. *T. trigonocephalus* is tolerant of sea water but cannot live in completely fresh water; *T. bifasciatus* cannot withstand sea water and has spawned in fresh water in my laboratory. *T. bifasciatus* can be distinguished most easily by its uppermost pectoral fin ray, which is attached to the other rays; in *T. trigonocephalus* this ray is free.




**UPPER PART OF PECTORAL FIN RAYS**

a. Length of uppermost pectoral fin ray.
b. Distance from base of fin rays to deepest edge of concave part of membrane between uppermost and second pectoral fin rays.

Source: Akihito and Sakamoto (1989).

Based on these and other diagnostic characteristics, specimens from the first introduction as well as those taken recently from South Bay have been identified as *T. trigonocephalus*. We have identified our Suisun Marsh specimens as *T. bifasciatus*. I believe this is the first observation of *T. bifasciatus* outside its native range in Asia. However, "chameleon" gobies found in fresh or mildly saline water in Southern California and Australia (Haaker 1979, Hoese 1973, Friese 1973) are likely *T. bifasciatus* as well.

I am documenting the introduction and distribution of *T. bifasciatus* and would appreciate copies of any distributional data or specimens of this species. Please contact me at UC-Davis, Dept. of Wildlife and Fisheries Biology, Davis, CA 95616 (email: samatern@ucdavis.edu; fax: 916/752-4154).

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## Laboratory Breeding System for Delta Smelt

*Serge Doroshov, University of California, Davis*

In April-June, four colonies of wild-caught delta smelt were raised in separate recirculation systems with sterilized water, controlled temperature, and photoperiod. Health and gonadal development were monitored by regular sampling in collaboration with Dr. Hendrick's laboratory. No *Mycobacterium* disease was observed. Based on histological observations, most fish were sexually mature by mid-April.

Three colonies were examined for ovulatory females and milting males, using mild anesthesia and gentle abdominal pressure. Preovulatory females were microinjected with LHRH-A to stimulate ovulation. The eggs were stripped and artificially inseminated. Less mature fish were returned to the rearing tanks. One tank colony was left intact. All tanks were observed daily for the presence of eggs. Adhesive eggs were gently scraped from the tank bottom, counted, and incubated in flow-through jars. Larvae were stocked in 12-liter tanks with water flow and in 7-liter glass aquaria with daily water renewal. Salinity was 3-10 ppt, pH was 7.8-8.3, dissolved oxygen was at saturation, and temperature was 13-16°C. Continuous cultures of *Chlorella vulgaris* and *Brachionus plicatilis* were established, and density of rotifers was maintained at 3-12/mL.

Production of eggs and larvae through mid-June is summarized in the accompanying table. Number of spawnings and total egg production were high, but the overall yield of viable embryos (21%) and larvae (16%) was modest. Most of the stripped egg batches and about half the natural spawnings were not used for incubation because of low fertility. The proportion of viable embryos in the 28 incubated batches averaged 30-40% and ranged 15-75%. Hatchability was high (73-95%), and newly emerged larvae did not exhibit significant abnormalities. In rearing trials during April and May, larvae did not survive beyond 3 weeks post-hatch. Major problems were inadequate density of rotifers in the rearing tanks and difficulty maintaining water quality. The live food production system has been improved, and we can now maintain a stable supply of food organisms. Trials with age 2-3 week larvae and newly hatched embryos are continuing.

Major successes this year have been rearing mature broodstocks, managing *Mycobacterium* disease, developing spawning and egg incubation techniques, and elucidating the required density of food organisms for larvae. Egg quality and fertility can be improved by reduction of broodstock rearing density, supplemental feeding, and timely separation of ripe fish in dedicated spawning tanks. Developing a larval rearing system will require substantial effort, since this culture is labor-intensive. Delta smelt larvae need a high density of food organisms (10-12/mL, 150-250 µm particle size) in the water column for at least 4 weeks of exogenous feeding. Optimal environmental parameters for larval development and growth are not yet known. To develop more efficient culture systems, we should focus on larval feeding and optimization of the physical and chemical environment in rearing containers.

**Summary of Delta Smelt Spawning in the Laboratory Culture System**
Preliminary data for April-June 1994

| Parameters | Method of Egg Production: Stripping and Artificial Insemination | Method of Egg Production: Natural Spawning in Rearing Tanks |
|---|---|---|
| Spawning Period | April 13-May 2 | April 21-June 17 |
| Total Egg Batches | 27* | 58** |
| Total Eggs | 30,000 | 55,000 |
| Viable Embryos | 3,000 | 15,000 |
| Hatched Larvae | 2,500 | 11,000 |
| Fertilization Success*** $x \pm$ sd (n) | 40 ± 17 (7) | 36 ± 11 (21) |
| Hatching Success**** $x \pm$ sd (n) | 95 ± 3 (6) | 73 ± 24 (17) |

* Number of stripped females, x=1,100 eggs per fish.
** Number of daily spawnings in four tanks (range 300-4,000 eggs per spawning).
*** Percentage of normal embryos at 6 days after fertilization in incubated batches.
**** Percentage of fertilization success.

## Corrected Tables

The article, "Estimating Winter Run Survival with Late-Fall Run Fish", that appeared on pages 8 and 9 of the Spring 1994 Interagency *Newsletter* contained two tables that need to be corrected. In Table 1, the numbers for estimated survival of Georgiana Slough releases are incorrect. In Table 2, export rates for releases in December 1993 were misprinted. Results and conclusions printed in the article are based on the correct information and do not require revision.

For your convenience, the corrected tables are printed here.

**Table 2**
**Water Temperature at Time of Release, Mean Export Rate, and QWEST Rate from Release to Peak Recovery at Chipps Island for Experiments with Coded Wire Tagged Fall and Late-Fall Chinook Salmon Smolts, April 6, 1992, through December 19, 1993**

| Sacramento River at Ryde | | | | Georgiana Slough | | | |
|---|---|---|---|---|---|---|---|
| Date of: Release / Recovery | Temp. (°F) | Exports (cfs) | QWEST (cfs) | Date of: Release / Recovery | Temp. (°F) | Exports (cfs) | QWEST (cfs) |
| 04/06/92 04/15/92 | 64 | 3073 | 53 | 04/06/92 04/20/92 | 64 | 2425 | 499 |
| 04/14/92 04/21/92 | 63 | 1097 | 1410 | 04/14/92 04/20/92 | 64 | 1093 | 1449 |
| 04/27/92 05/02/92 | 67 | 1578 | 729 | 04/27/92 05/04/92 | 67 | 1883 | 749 |
| 04/14/93 05/06/93 | 58 | 3696 | 3214 | 04/14/93 05/12/93 | 58 | 3246 | 3493 |
| 05/10/93 05/14/93 | 59 | 1497 | 4161 | 05/10/93 05/22/93 | 65 | 1883 | 749 |
| 12/02/93 12/12/93 | 57 | 10316 | 72 | 12/02/93 12/19/93 | 57 | 10646 | 509 |

**Table 1**
**Release Data, Estimated Survival, Number Counted at SWP and CVP Facilities, and Survival Ratio for Experiments with Tagged Fall Run and Late-Fall Run Chinook Salmon Smolts, April 6, 1992, through December 2, 1993**

| | | Sacramento River at Ryde Releases | | | | Georgiana Slough Releases | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Release Date | Race | Water Temp. (°F) | Mean Fork Length (mm) | Estimated Survival | Estimated Salvage CVP/SWP | Water Temp. (°F) | Mean Fork Length (mm) | Estimated Survival | Estimated Salvage CVP/SWP | Ryde: Georgiana Survival Ratio |
| 04/06/92 | Fall | 64 | 77 | 1.36 | 0 / 34 | 64 | 74 | 0.41 | 10 / 4 | 3.30 |
| 04/14/92 | Fall | 63 | 82 | 2.15 | 0 / 0 | 64 | 81 | 0.71 | 12 / 8 | 3.00 |
| 04/27/92 | Fall | 67 | 81 | 1.67 | 0 / 0 | 67 | 83 | 0.20 | 1 / 4 | 8.30 |
| 04/14/93 | Fall | 58 | 61 | 0.41 | 0 / 0 | 58 | 63 | 0.13 | 0 / 24 | 3.15 |
| 05/10/93 | Fall | 59 | 75 | 0.86 | 0 / 0 | 65 | 75 | 0.29 | 15 / 36 | 2.96 |
| 12/02/93 | Late-Fall | 57 | 129 | 1.62 | 0 / 9 | 57 | 119 | 0.21 | 93 /149 | 7.71 |

## New Science Advisory Group for Interagency Program

*Larry Smith, USGS*

The recent revision of the Interagency Program emphasized the need for the program to be more responsive to management needs. To help ensure that the Interagency Program focuses on the right scientific questions relative to management issues, the coordinators have selected a panel of scientists to provide a periodic, unbiased, external review of the technical program. Members of the group will serve 3- to 5-year terms, with overlap to ensure continuity.

The Science Advisory Group will soon begin a review of the program to become familiar with:

- Resource management issues of the delta and bay.
- Scientific findings relevant to these issues.
- Technical elements of the Interagency Program and the findings being sought.

Given this information, the group will recommend specific technical elements. The group will meet at least annually. During the 3-day meetings, Interagency managers will brief the group on the status of water issues, and Interagency scientists will present findings of project work teams. The advisory group will incorporate findings of the work teams into the larger context and recommend revisions. Within 2 weeks of the annual meeting, the group will provide an assessment of the Interagency Program. Between meetings, the group will review the annual report and other reports for relevancy to management issues.

The charge of the Science Advisory Group is broader than for other advisory groups, which have focused on specific program elements or on how to approach specific investigations. This group does not replace or supersede the other groups. Both kinds of technical advice are essential.

Sam Luoma, a senior scientist with the USGS-Menlo Park, has been selected as chair. Sam has been working on San Francisco Bay issues since 1977. His principal research interests deal with effects of contaminants. He has participated in many technical discussions about bay monitoring programs over the last 2 decades and has served in a number of technical advisory capacities locally and internationally.

Sam and the management team have nominated the other group members based on their expertise in an essential discipline, understanding of estuarine processes, experience with interdisciplinary studies, and lack of previous association with the Interagency Program. Nominees represent a balance between scientists with a long interest in San Francisco Bay, who will bring knowledge of local issues to the group, and scientists less familiar with San Francisco Bay issues, who will bring insight from experience in other systems. Nominees, yet to be confirmed by the coordinators, are:

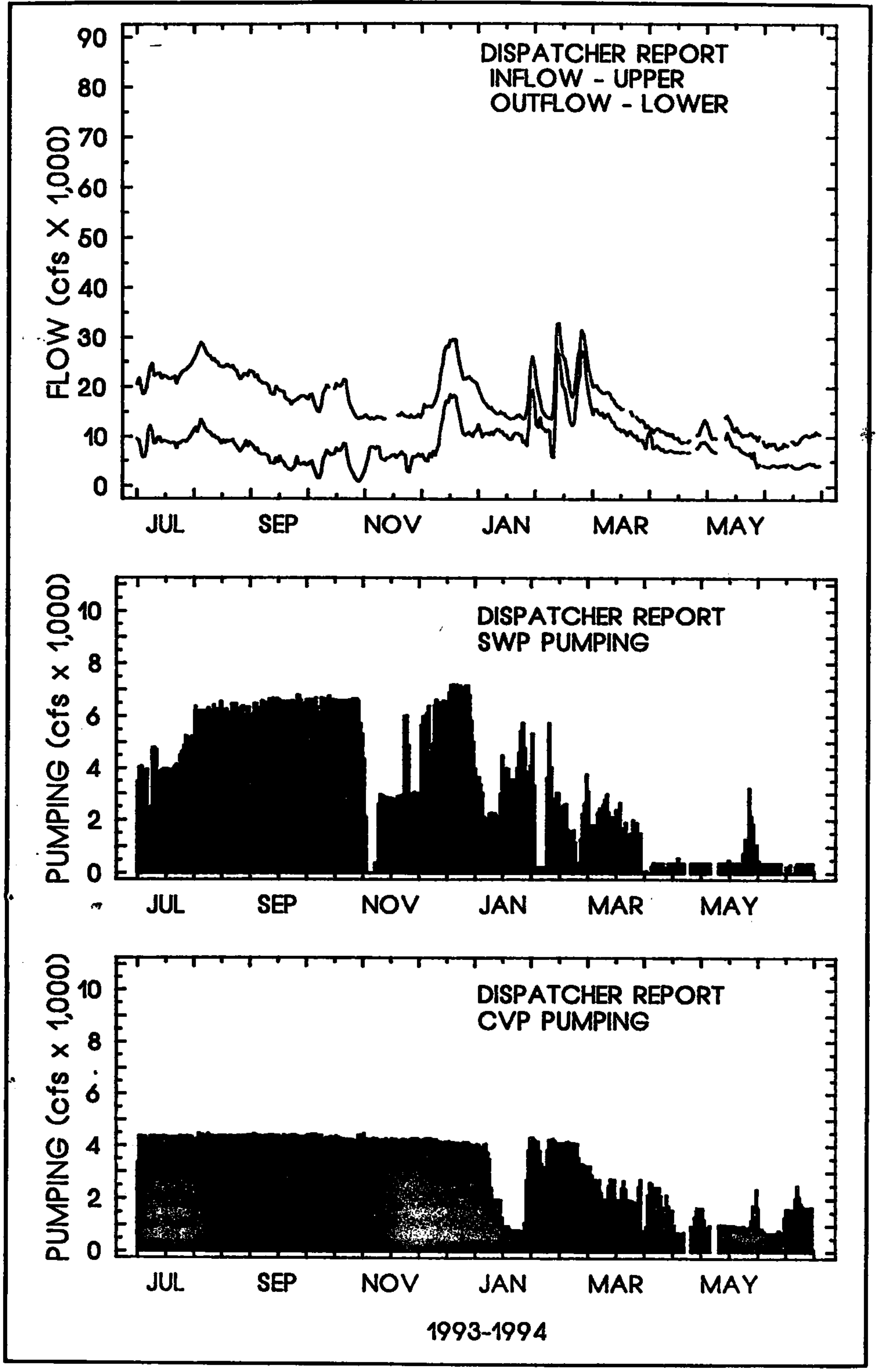
- James Cloern, ecologist with USGS. Jim's principal interests are phytoplankton ecology, modeling, and linkages between ecology and physical processes. Jim has developed some of the important ideas that guide our understanding of the San Francisco Bay ecosystem.
- Alan Jassby, ecologist with the Division of Environmental Science at UC-Davis. Alan has unique expertise working with large data sets from aquatic ecosystems. He has worked extensively with data from Sierra Nevada lakes and in recent years has contributed to our understanding of linkages between streamflows and the ecology of San Francisco Bay.

*Continued on page 12.*

## Delta Flows

*Sheila Greene, DWR*

From April through June, 1994, delta inflow averaged 10,000 cfs and ranged from 7,500 to 14,000 cfs. Except in late May, SWP pumping was low, an average of 450 cfs, to capture reservoir releases made for water temperature control. CVP pumping averaged 1,350 cfs.



# Progress Report: Environmental Factors Affecting Reproduction and Recruitment of Pacific Herring in the San Francisco Estuary

*Gary N. Cherr and Murali C. Pillai, University of California, Davis, Bodega Marine Laboratory*

This progress report is for a study that began in December 1993 with financial support provided by DFG. Results summarized are preliminary. As new data are analyzed, they will be included and discussed in a final report.

## Background

Based on field surveys by DFG, the herring *(Clupea pallasi)* biomass in the San Francisco estuary has declined dramatically (Spratt 1992), and 1992 biomass estimates were the lowest ever reported. This decline could be related to increases in salinity (due to drought and increased freshwater exports) and temperature (due to El Niño conditions) in the estuary, where herring spawning and early life stages occur. This hypothesis is supported by studies suggesting Pacific herring require optimal salinity (~16 ppt) and temperature for successful reproduction and recruitment (Alderdice and Hourston 1985).

Objectives of our present study are to:

- Determine optimal salinity and temperature for successful fertilization and development (through hatching) in the laboratory.
- Study development and hatching under field conditions in the San Francisco estuary, including embryo transplant experiments.

## Results

We studied the effects of altered salinity on fertilization and embryonic development in *C. pallasi* from the estuary. Before collecting data, we performed a series of experiments to standardize experimental conditions, such as gamete density (sperm/egg ratio), gamete incubation time, *etc.* Based on these trial experiments, we established ideal conditions for optimal fertilization and development in this species. Details will be included in the final report.

Experiments on salinity effects on fertilization success included inseminating eggs in media of different salinities (8, 12, 16, 20, 24, 28, 32 ppt) and assessing successful fertilization as shown by the presence of elevated chorions and formation of perivitelline spaces. Figure 1 shows data from five experiments using five females collected on five days of spawning. As predicted, the optimal salinity range for successful fertilization appears to be 16-20 ppt, although this may vary depending on the individual male and female and on sperm concentrations. These data are consistent with other studies of sperm physiology and fertilization for this species (Yanagimachi 1953, 1957; Yanagimachi *et al* 1992; Pillai *et al* 1993). We are continuing to analyze the data to determine statistical significance between experiments and treatment conditions.

To determine salinity effect on embryonic development, we inseminated eggs at 16 ppt, transferred them to media of different salinities (8, 12, 16, 20, 24, 28, 32 ppt), and cultured them under optimal conditions through hatching. We found optimal salinity for successful hatching to be 16-20 ppt, and hatching rates were low above 28 ppt (Figure 2). Many spawning regions in the estuary were higher than 28 ppt during the recent drought (DFG 1992; Trujillo *et al* 1992). Again, further statistical analyses of the data are in progress.

We also conducted a series of laboratory experiments to determine combined effects of salinity and temperature on fertilization and embryonic development through hatching. Protocol for these experiments included fertilizing eggs under optimal salinity and temperature conditions and transferring them to different salinities and temperatures. Embryos were then cultured through development and hatching. At higher salinities, hatching rates appear to be better if temperatures are lower (*eg,* 12°C) (Figure 3). Likewise, hatching rates were better at lower salinities if the temperature of the medium and incubation conditions were higher (*eg,* 15°C). The data must be analyzed further before conclusions are possible.

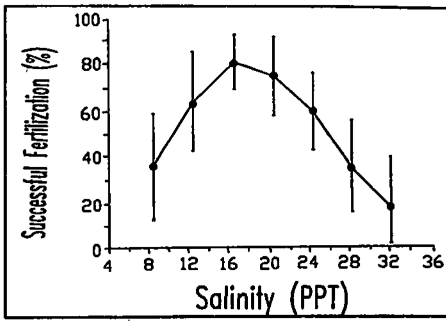



**Figure 1**
**EFFECTS OF SALINITY ON FERTILIZATION**
(n=5)

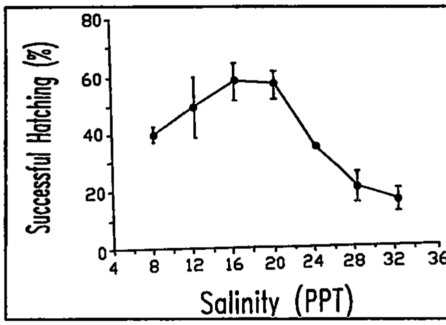



**Figure 2**
**EFFECTS OF SALINITY ON HATCHING**
(n=3)

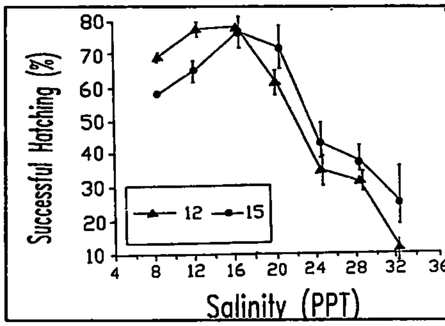



**Figure 3**
**COMBINED EFFECTS OF SALINITY AND TEMPERATURE ON HATCHING**

## Field Experiments on Embryonic Development and Hatching

The field component of the project was initiated after the laboratory studies on fertilization and development were well underway. DFG biologists D. Watters and K. Oda collected samples of fertilized eggs and early embryos from Richardson Bay and Potrero Point (South Bay) and took them to the Bodega laboratory for culture. For outplant experiments, samples were taken to the NMFS laboratory in Tiburon and secured in the water column at eight depths. Site salinity was recorded at time of initial collection, transplanting, and final collection.

The data are still being analyzed, but it appears that herring embryos can develop successfully in the chambers we used for transplant experiments. Embryo samples were also preserved for future analysis of contaminants and for histological examination of cytogenetic effects.

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# Recent Publications

The 1992 Annual Report for the Interagency Program (January 1994) is now available, as are the following Interagency Technical Reports (listed by number).

35 Observations of Early Life Stages of Delta Smelt, *Hypomesus transpacificus*, in the Sacramento-San Joaquin Estuary in 1991, With a Review of Its Ecological Status in 1988 to 1990 (JCS Wang and RL Brown. November 1993)

36 Proceedings of the Tenth Annual Pacific Climate (PACLIM) Workshop (KT Redmond and VL Tharp. March 1994)

37 Delta Agricultural Diversion Evaluation, 1992 Pilot Study (S Spaar. May 1994)

38 Long-Term Trends in Benthos Abundance and Persistence in the Upper Sacramento-San Joaquin Estuary, Summary Report: 1980-1990 (Z Hymanson, D Mayer, J Steinbeck. May 1994)

39 Seasonality and Quality of Eggs Produced by Female Striped Bass *(Morone saxatilis)* in the Sacramento and San Joaquin Rivers (JD Arnold and T Heyne. April 1994)

Single copies of these reports may be obtained without charge from the California Department of Water Resources, P.O. Box 942836, Sacramento, CA 94236-0001.

## Delta Smelt Update

*Leo Winternitz, DWR*

Hydrological conditions during spring and summer of water year 1993, classified under Decision 1485 as above normal, greatly contributed to the sixth highest adult abundance index on record (Figure 1). As of March 1994, adults were still well distributed throughout Suisun, Grizzly, and Honker bays; Cache Slough; and the lower Sacramento and San Joaquin rivers. Will this result in a high or moderate adult abundance index during water year 1994, which is classified as critically dry? Signs look promising.

DFG summer tow-net surveys through July 3 place the 1994 juvenile abundance index at 13.0 (Figure 2). This is higher than the mean (12.42) for all dry and critical years since 1959, but lower than the mean of 14.89 for all the wetter years. The prognosis? Things are not all that bad, considering the current water year type. Delta smelt distribution is beginning to take on the aspects of distribution during the recent dry years. Although about 20% of the fish are distributed from the confluence to Suisun Bay, the rest were in the lower San Joaquin and Sacramento rivers, and most (64%) were in the lower Sacramento (Table 1). Some believe this pattern places the fish at risk of extinction due to lower productivity in delta channels and inhospitable delta conditions including export and agricultural pumping. However, this same pattern during the recent drought still enabled the population to rebound in 1993.

Geographical location of the fish may affect survival of delta smelt between summer and fall. If most of the fish congregate in the Sacramento and San Joaquin rivers, then this year's fall index likely will be low. The fall index is calculated in part by a volume-weighted function dependent on the presence of fish in at a sampling site. For example, given an equal density of fish in Suisun Bay and the lower Sacramento River, the calculated abundance index will be higher for Suisun Bay than for the Sacramento River because of the greater volume of water in Suisun Bay.

Delta smelt salvage at the Skinner and Tracy fish facilities is greatest during late May, June, and early July. Timing of peak salvage was the same in 1994, with one important exception—total combined export pumping was very low. Average monthly total export in May was 1,980 cfs; June averaged 1,649 cfs; and during the first week of July, the average was close to 2,000 cfs. Even with these low exports, delta smelt salvage shot up to thousands of fish per day in late May and averaged about 500/day through June 15. Salvage dropped to below 50/day through the latter part of June and into the first week of July.

To determine if salvage may have reflected a large resident population in Clifton Court Forebay, kodiak trawling, purse seining, and beach seining were conducted in the forebay on June 27. Of about 30 sample sets, three delta smelt were collected. Though the kodiak trawl efforts were not "'clean" due to shallow depths and numerous snags, it

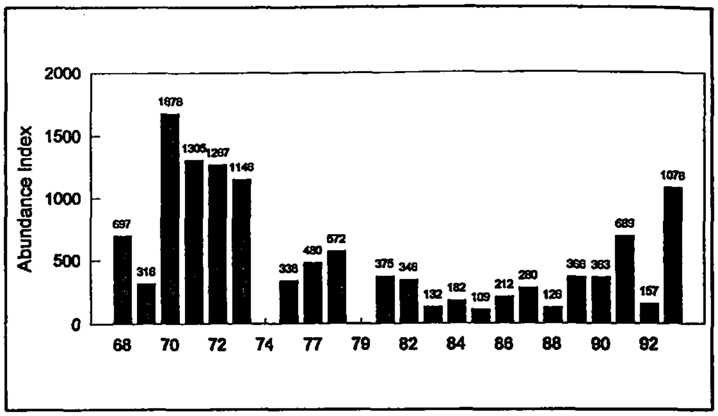


**Figure 1**
**FALL MIDWATER TRAWL ABUNDANCE INDEX**

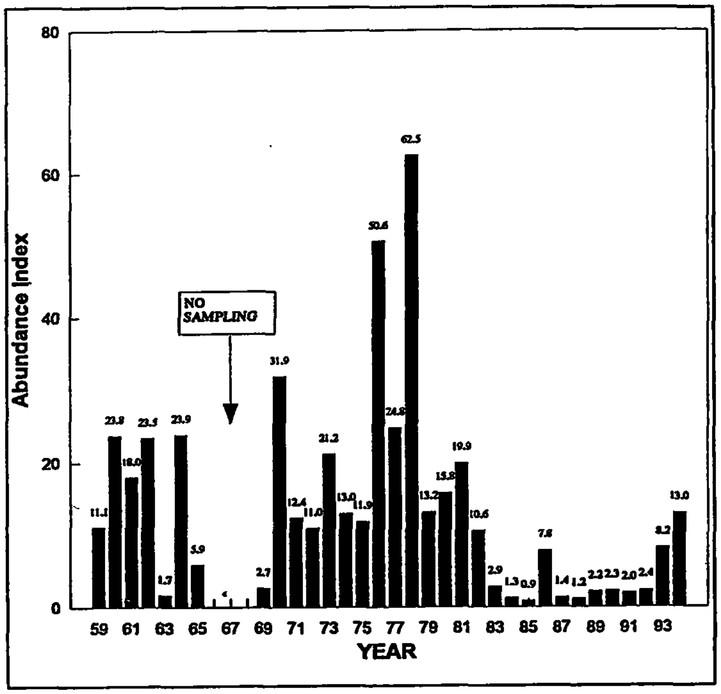


**Figure 2**
**SUMMER TOW-NET ABUNDANCE INDEX**

**Table 1**
**1994 SUMMER TOW-NET DATA**

| | Catch | Percent |
|---|---|---|
| Montezuma Slough | 0 | 0 |
| Suisun Bay to Honker Bay | 34 | 12 |
| Chipps Island to Confluence | 20 | 7 |
| Lower Sacramento River | 184 | 64 |
| Lower San Joaquin River | 51 | 18 |
| San Joaquin River | 0 | 0 |
| Southern Delta | 0 | 0 |
| Total Catch | 289 | |

does not appear that a large population of delta smelt were in the forebay during this period. This sampling should be repeated if numbers of salvaged fish consistently increase to the hundreds.

To evaluate the relationship between delta smelt distribution and salvage at the pumps, kodiak trawls were used. Results from the Georgiana Slough Acoustic Study showed that the kodiak trawl was highly efficient for catching a variety of juvenile fish. To compare the relative efficiencies of the tow-net and kodiak trawl, side-by-side comparison trawls were conducted over 6 days. So far, the kodiak trawl appears to have a lower detection limit; that is, it consistently caught fish in areas where the tow-net did not. Further analytical and sampling work is needed to determine whether the kodiak trawl is more efficient than the tow-net on a catch-per-unit-effort basis.

To provide information on the relationship between delta smelt distribution and SWP/CVP export rates, a study is underway to intensively monitor two sites (914 and 915) on Old and Middle rivers under low and moderate pumping rates. The study is scheduled for completion by July 20. To detect changes in density and total numbers of delta smelt caught in response to a base condition of low export rates (2,000 cfs combined pumping) and to moderate export rates (6,000 cfs combined pumping for 10 days), 24 kodiak trawls were conducted daily. In addition, two broader geographical surveys will be conducted throughout the Delta and Suisun Bay. Diurnal sampling will be included in all the trawling. The four null hypotheses being tested through this study are:

- There is no significant increase in the relative abundance in Old and Middle rivers associated with increased exports.
- There is no significant correlation between relative abundance of juvenile delta smelt in the Old and Middle rivers and density of delta smelt in salvage operations.
- There is no significant relationship between export rates and distribution of delta smelt in the southern and central delta and Suisun Bay.
- Density of young-of-the year delta smelt is not significantly different between shallow water habitat and deep water channels.

In a study such as this, conclusive results depend on disproving the null hypothesis. Negative results (no statistically significant findings) do not either prove or disprove the null hypothesis. However, even inconclusive results provide information from which management decisions can be made.

### Effect of Fish and Wildlife Service Reasonable and Prudent Alternatives

The delta smelt summer tow-net index is moderate (Figure 2), but delta smelt did not migrate west until June, after outflows dropped to about 4,000 cfs and San Joaquin River flows dropped to about 1,000 cfs. Outflows had averaged over 12,000 cfs in March and over 7,000 cfs in April and May. FWS required these flows to transport larval and juvenile smelt west of the delta. San Joaquin River flows during this period averaged over 2,000 cfs. The Reasonable and Prudent Alternatives did not succeed in transporting many delta smelt to the confluence or Suisun Bay area. Delta smelt appeared to move west after outflow levels dropped. However, the RPA and take provisions in conjunction with NMFS requirements for winter run may have led to better survival of larval and juvenile smelt. This is probably one reason delta smelt salvage was so high this year given the low pumping rates. Whether these actions result in an increased adult abundance index and adequate adult distribution remains to be seen.

## New Biologist at DFG Bay/Delta Division

Marty Gingras, a fishery biologist, recently joined the Fish Facilities Unit at DFG-Stockton. Marty spent several years as a contractor for DFG's Marine Resources Division in Monterey, through the Pacific States Marine Fisheries Commission. He received his BS in biology from UC-Santa Cruz and has amassed considerable fisheries experience as a research assistant at UC-Santa Barbara and as a fisheries technicial at DFG.

Before working at the Marine Resources Division, Marty owned and operated a fishing vessel and sailboat repair business, which he sold in 1993.

Marty will play a pivotal role in developing the Bay/Delta Division's hydroacoustics fisheries sampling program. This will supplement existing sampling efforts at many water project facilities and will provide invaluable information about fish entrainment, recruitment, and movement patterns.

- Stephen Monismith, professor in the Department of Civil Engineering at Stanford University. Collaborating with USGS investigators, Stephen and his students have made fundamental contributions to our understanding of the hydrodynamics of San Francisco Bay at a variety of scales and have applied hydrodynamic models to issues of broad interest.
- Carole McIvor, ecologist at the University of Arizona and Arizona Cooperative Fish and Wildlife Unit. Carole's PhD is from the University of Virginia, where she studied the ecology of tidal marshes. She has not worked directly in San Francisco Bay, but her expertise in marsh fishes and their ecology will bring important insights to bay/delta issues.
- Edward Houde, fisheries ecologist at the Chesapeake Biological Laboratory of the University of Maryland. Ed is experienced with many of the important fisheries in the bay and delta, including striped bass, food sources, and life histories. His insights from the east coast will be valuable in interpreting local issues.
- James Quinn, professor in the Division of Environmental Science at UC-Davis. Jim is a conservation biologist with interests in assessing extinction risks in different species and in designing monitoring programs. His experience with conservation issues will be a valuable addition to the group.

The Science Advisory Group will meet this fall to develop an initial understanding of the issues and program. Requests for briefings from managers and scientists can be expected as the agenda develops. Later, panel members will attend the annual program conference and then review the program and develop recommendations.


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Interagency Ecological Program for the Sacramento-San Joaquin Estuary

# *Newsletter*

A Cooperative Effort of:

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