lower than before; not only do we need more data to determine this, but in areas sampled by the Interagency Program, *Acartia* species are still abundant in spring and typically become uncommon only in summer. This may be because the community grazing rate of *P. amurensis* does not become a major factor in the dynamics of these populations until late spring and summer (Kimmerer and Orsi 1996).

Acartia spp. have been by far the most abundant taxon in the samples we have taken, even in samples taken in the Golden Gate near the end of a flood tide. This is somewhat surprising: neritic species (from the coastal ocean) were fairly common in previous sampling in San Francisco Bay (Ambler *et al* 1985) and Tomales Bay (Kimmerer 1993) but have not yet been common in our samples. Most of the *Acartia* were of the subgenus *Acartiura*, identified by Ambler *et al* (1985) as *A. clausi*, but in nearby Tomales Bay there were two species of this subgenus, *A. hudsonica* and *A. omorii* (Kimmerer 1993). Species of this subgenus are notoriously difficult to distinguish. The summer dominant (*A. californiensis*) has not yet appeared in our samples.

The second most common copepod genus was *Tortanus*, represented by the common introduced *T. dextrilobatus* (Orsi 1995) and the rarer, neritic *T. discaudatus*. Also common were the introduced *Pseudodiaptomus marinus* (*P. forbesi* is the summer numeric dominant just landward of the entrapment zone) and the large copepod *Epilabidocera longipedata*. We have identified several other common neritic species previously listed by Ambler *et al* (1985), although none has been common in our samples.

Several taxa common in the 1997 samples were not listed by Ambler *et al* (1985), presumably because that report focused on copepods and microzooplankton. These include the cladoceran *Podon polyphemoides* and the larvacean *Oikopleura dioica*. Both of these species are moderately abundant; *O. dioica* in particular could play an important role in bay food webs because larvaceans of this genus can grow very rapidly. Meroplanktonic taxa were dominated by barnacle nauplii.

Gelatinous zooplankton were represented by a few chaetognaths (arrow worms; genus *Sagitta*) and occasional medusae, but they do not appear to be as abundant as they can be in other estuaries. During sampling in April, we collected large numbers of worms identified as nemerteans, which will need to be confirmed by an expert on that group.

Distribution

Data so far do not allow much interpretation regarding patterns. The major influence on distribution appeared to be salinity and depth: *Acartia* species were less abundant and *T. dextrilobatus* more abundant at low salinity than at high salinity (Table 1). In the April cruise *Acartia* adults were significantly ($p < 0.05$, t test) less abundant in surface tows than in vertical tows, but not in May. Juvenile abundance was not different between the two sample types on either cruise. This contrasts somewhat with the results of Ambler *et al* (1985), who found adults to be more abundant below the surface and juveniles more abundant at the surface.

Table 1
ABUNDANCE RELATIONSHIPS OF *ACARTIA* spp. AND *TORTANUS DEXTRILOBATUS* TO SALINITY
Determined by robust regression on salinity over a range of 14.9-30.7 psu.

Species	Slope ± SE	P value
Acartia spp.	0.093 ± 0.016	<0.0001
Tortanus dextrilobatus	-0.091 ± 0.017	<0.0001

There was little consistent difference in abundance of common taxa among transects or between stations on transects except as explained by salinity and depth. This may reflect the generally vigorous circulation patterns in the estuary.

Next Steps

We will scale up to the Bay Study cruises in August or September after some additional work to identify species and to sample for larger organisms such as mysids. In addition, we will develop and test a pump system for sampling microzooplankton. We will also explore day/night differences in abundance to determine their importance in biasing results of day-only sampling.

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Status of Delta Smelt Culture Project

Joan Lindberg, Randy Mager, Brent Bridges, and Serge Doroshov

In recent years the Interagency Program has supported two research projects on breeding and culture of delta smelt aimed at creating a supply of this threatened species for research. This year we are combining efforts into a single project to capitalize on expertise and site-specific advantages. The work is being performed at two sites: the SWP fish facility near Tracy, and the Institute of Ecology at UC-Davis. The project is designed to take advantage of each site's strengths in rearing particular life stages. Most broodstock are spawned and the post-larvae reared to juveniles at the SWP site, where the use of delta water provides the advantages of natural temperature fluctuations and a supply of natural zooplankton for the post-larval stage. The eggs are incubated and the larvae reared to age 30 days after hatching at the UC-Davis site, where the clean well water and temperature-controlled recirculation system promotes success with these early developmental stages. Further, the well water allows the rearing, in monoculture, of unicellular algae and rotifers required for feeding the early larval stage of smelt.

Immature smelt were collected from the delta in the fall, and by January 1 the SWP site had 278 and UC-Davis had 220 future brood fish. These fish were reared in tanks and matured over the winter, with little mortality (7-8%). Brood fish at the SWP site were maintained in a flow-through system with delta water supply; the UC-Davis fish were maintained in recirculating systems, with controlled temperature and photoperiod.

Natural spawning in tanks began in late March as water temperatures rose above 14°C, peaked in April, and continued through May (Figure 1). Spawning success rate was significantly higher than our previous trial at the SWP site: 27,000 eggs were obtained compared to 5,000 in 1995 (Lindberg 1996). As previously observed, natural spawning occurred at night, and the adhesive eggs were removed from tanks to incubators in the morning. The collected embryos were usually at the morula stage. At the UC-Davis site, only few spawns occurred naturally in the tanks (about 2,000 eggs were collected). The majority of fertile eggs (4,500) at UC-Davis were obtained by stripping the brood fish and *in vitro* insemination.

In the beginning of June, the captive populations at both sites were surveyed for any remaining ripe females. Nine gravid females were stripped and their eggs fertilized *in vitro*, resulting in another 7,600 inseminated eggs. From both sites, 40,500 eggs were collected, yielding 18,000 developing embryos and 10,700 hatched larvae. Early in the season, fungal infestation accounted for 30% of the embryo losses; later, the prophylactic treatment with 250 ppm formaldehyde (1-hour bath) prevented further occurrence.

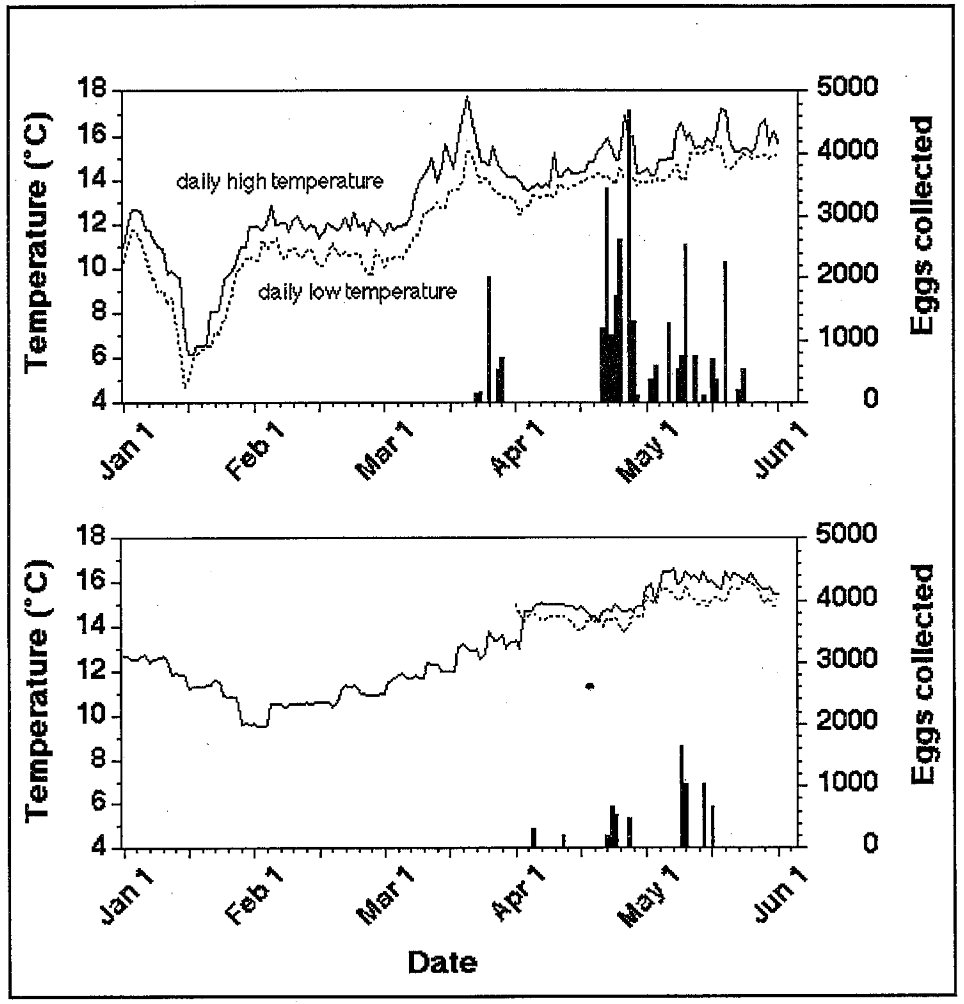

Figure 1
DAILY WATER TEMPERATURE AND DELTA SMELT EGGS COLLECTED DURING SPRING 1997
Temperatures are daily minimum and maximum at SWP site (top) and at 7 a.m. and 7 p.m. at UC-Davis site (bottom. The adhesiver eggs were collected from tanks, except for eggs stripped from fresh mortalities and fertilized in vitro at the UC-Davis site in May.

A total of 10,200 hatched larvae were transferred to 20-50 liter glass aquaria for rearing (a small percentage of larval mortalities occurred directly after hatching). The aquaria were maintained in a temperature-controlled water bath, with 80% of the water changed daily. Water salinity was maintained at 5 ppt (Instant Ocean salt). Larvae were fed rotifers (*Brachionus plicatilis*) raised in monoculture on cultured algae (*Nannochloropsis oculata*) and enriched in Selco media. Rotifers were introduced into the aquaria at a final concentration of 5-12 per milliliter. In addition, live concentrates of cultured algae were added to aquaria water in the morning and late afternoon to stimulate feeding. After 30 days of rearing, larvae were counted, sampled for length measurements, and transferred to the SWP site for further rearing. The survival rate from hatching to 30 days was 7-67% in the various aquaria, with a mean survival rate of 49%. Total length of the larvae varied between 7.5 and 13.5 mm, with larger larvae developing in the 50-liter aquaria and smaller larvae in the 20-liter aquaria.

Post-larval smelt (age about 30 days and length about 11 mm) are now being reared at the SWP site. Rearing this life stage is new to the SWP site, and procedures are being developed as the season progresses. Upon arrival at the SWP site, larvae are transferred to 120-liter flow-through circular tanks seeded with natural zooplankton and artemia nauplii. Zooplankton 240-400 microns in size are collected by sieving delta water. These prey consist primarily of juvenile stages of copepods and are fed to the larvae each morning. At periodic intervals, larval samples are preserved for later measurements and stomach content analysis; samples of the zooplankton population are also preserved. As the larvae develop, procedures at the SWP are modified to enhance growth and survival. For example, we find that a small spotlight (25 watt) directed on the surface of the water creates a dense zone of feeding activity. The post-larval smelt are visual hunters, and the light may help them locate prey. Larvae feed by assuming an "S-posture" and thrusting forward to capture prey. We are finding that weaning the post-larvae from artemia to zooplankton requires exclusive feeding on natural zooplankton 1-2 hours before adding cultured artemia. These and other changes in larval rearing procedures are in place for the new group of post-larvae recently received from UC-Davis and for the last group of fish due to arrive in mid-July.

In summary, the culture of delta smelt, as with many "new" species, is initially difficult but has proven to be technically feasible. The life cycle of delta smelt is characterized by adults living in brackish water and spawning in fresh water, and a by a prolonged larval stage returning to brackish water and feeding on microzooplankton. The high sensitivity of mature adults to stress and the prolonged larval stage requiring live food are two difficult challenges in delta smelt culture; these two stages are also likely to be the most sensitive life stages in the wild population.

Literature Cited

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Slide Show on Bay/Delta Geologic Evolution

Ken Lajoie will be presenting his slide show on the geologic evolution of the bay/delta estuary — 1 p.m. August 9, 1997, at the Corps of Engineers' Bay Model in Sausalito.

Anyone who missed Ken's presentation at the annual Asilomar workshop should take advantage of this opportunity to see a great slide show.

Ken has graciously consented to describe his findings in the January issue of the Newsletter.

Noteworthy for Managers

Randall Brown

This is the first in a series of quarterly columns that will describe some significant management activities in the Interagency Ecological Program, around the estuary, and in the watershed that directly or indirectly will shape the Program's future.

Spring Chinook Candidacy

On June 13, 1997, the California Fish and Game Commission advanced the Central Valley spring run of chinook salmon to candidacy. During the next 12 months, DFG staff will prepare a status report to be used by the Commission to determine if spring chinook should be listed pursuant to the California Endangered Species Act and, if listed, whether threatened or endangered.

During candidacy, spring chinook receive the same protection as a listed species. The Commission issued a special order allowing the incidental take of spring chinook under specified conditions. In the bay/delta, the Commission basically stipulated that incidental take of spring chinook juveniles at the CVP and SWP intakes is allowed provided the projects operate as agreed to in the 1994 Bay/Delta Accord and described in the 1995 SWRCB Water Quality Control Plan. The Commission did require a workshop in late August to provide them with more information on how flexibility in the Accord and Water Quality Control Plan will be used to help protect spring chinook.

Information about spring run migration and abundance will be essential in developing operational and other measures to protect and restore spring run. The Interagency Program's Central Valley Salmon project work team and its spring run and delta work groups will be developing the monitoring and special studies needed to provide this information. Last fall's Category III program approved $450,000 for the UC-Davis Bodega Marine Laboratory to determine if genetic techniques can be used to distinguish spring chinook from the other three Central Valley chinook races, and perhaps among individual stocks. The project, funded by Metropolitan Water District, will begin August 1, 1997. As part of its Feather River fish studies, DWR is funding a program to determine if the microchemistry of the salmon's otoliths (ear bones) will enable biologists to determine the stream origin of fish captured in the lower rivers, estuary, and the ocean. This study, by UC-Berkeley and Lawrence Livermore Laboratory researchers will begin around the middle of August. The spring run and delta groups are refining their proposed monitoring programs for this fall and spring.

NMFS Considerations

NMFS is expected to announce its decision on listing Central Valley steelhead by August 6, 1997. The announcement on the other Central Valley chinook races is expected in early 1998.

On a separate issue, NMFS will soon release a public review draft of the Winter Run Recovery Plan. Winter run escapements have been looking better in recent years, and the 1997 escapement is no exception. Initial run estimates are in the range of 450 to 780, which is coming off an estimated escapement of 189 in 1994, the lowest on record. The final estimate for 1997 will be available after August 1.

Central Valley Project Improvement Act

Several aspects of the federal act will affect the Interagency Program. Two key aspects are:

- Anadromous Fish Restoration Plan and Management of (b)(2) Water. On June 24, the Department of Interior released the draft AFRP and draft administrative proposals on the plan and use of the b2 water (the 800,000 acre-feet dedicated to fish and wildlife). After the release, Interior established three teams (fish, toolbox, and modeling) to develop a 5-year plan for implementing the AFRP, including management of the 800,000 acre-feet of CVP water. The 5-year plan is due this fall.

In the delta, the stakeholder-driven process will apparently use an adaptive management approach, much along the lines of the Vernalis (or San Joaquin) Adaptive Management Program. Under this approach, instead of simply proposing and enacting a protective or recovery measure and hoping for the best, the measures will involve testable hypotheses, data collection (monitoring and special studies), data analysis, and modifying (as necessary) the measure being tested. Interagency Program staff will be involved in all phases of the adaptive management.

- Comprehensive Assessment and Monitoring Program (CAMP).

In March 1997, FWS released the final implementation program report for CAMP. The CAMP is designed to help Interior assess the overall effectiveness of actions to restore anadromous fish and to determine the relative effectiveness of specific categories of measures. CAMP will fund monitoring and special studies, and Interagency Program staff and