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IEP NEWSLETTER

Interagency Ecological Program for the San Francisco Estuary

A Management Perspective

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The spring issue of the *IEP Newsletter* is traditionally devoted to an annual review of status and trends of key biological and physical conditions in the San Francisco Estuary, as reflected by long-term monitoring programs of the IEP and other entities. From the basic hydrology of the system, to unseen planktonic flora and fauna, to large sportsfish, ecological monitoring in the estuary provides fundamental baseline information that supports immediate, system-wide management efforts and develops focused scientific investigations. In this "status and trends" issue, readers should take note of the important selected observations and their implications for management activities.

Persistent Declines in the Abundance of Some Surfperch Species. Kathy Hieb's article on bay fishes (p. 15) includes information on the decline in abundance of some surfperch species. These observations from the IEP's San Francisco Bay-Outflow study were instrumental in the recent development and adoption of more restrictive angling regulations for surfperch.

The Role of Non-Native Species in the Estuary. Articles by Karen Gehrts (p. 7), Lee Mecum (p. 9), Kathy Hieb (p. 20), and Dennis Michniuk (p. 24) highlight the pervasive role of non-native species at all trophic levels in the estuary from both past and recent introductions. The dominance of non-natives and the frequency and unpredictability of new introductions should never be far from the minds of managers because of the strong implications non-native introductions have on efforts to restore native species and habitats in the system.

2001—A Dry Year. Callie Harrison (p. 4) reports on Delta hydrological conditions during 2001. The estuary and its users and managers have benefited from almost a decade of generally wet conditions. The dry conditions of 2001 stand as a reminder that the many challenges of drought conditions are never far away in California.

Continued Dramatic Declines in Ocean Salmon Harvest Rates. In a review of data and reports from the Pacific Marine Fisheries Council, Erin Chappell (p. 31) reports how natural conditions and more restrictive fishing regulations have led to reductions in the proportion of Central Valley salmon runs harvested by commercial and recreational fishing communities. It is thought that large harvest levels are at least partially responsible for past declines in Central Valley salmon stocks. High harvest levels may be particularly devastating to rare races of Central Valley salmon (winter run and spring run); thus, harvest reductions are thought to be important to the recovery of these races.

Delta Smelt and Juvenile Striped Bass Struggle to Recover. Kelley Souza and Marade Bryant (p. 21) report on the 2001 results from IEP's long running Townet and Fall Midwater Trawl surveys. Despite a long period of relatively good hydrological conditions and a dramatic recovery in adult abundance the annual production of juvenile striped bass has remained persistently low relative to historical levels. This observation, in combination with dramatic recent changes in the upper estuary's zooplankton community (see Mecum, p. 9) and inland silverside abundance (a predator of larval fish) suggests survival rates of striped bass early life stages may now be chronically depressed. Recent discussions among delta smelt biologists have pointed to these same food and predation changes as possible explanations for the relatively low and erratic recent production of juvenile delta smelt. These lower trophic level issues are important topics for future ecological research.

In contrast to juvenile striped bass abundance, estimated adult striped bass abundance (David Kohlhorst, p. 34) has increased dramatically in the past few years. (It should be noted that recent estimates have error bars due to low recovery rates for tagged adults.) There is no apparent explanation for the large numbers of adults despite continued low juvenile abundance.

IEP Quarterly Highlights

January–March 2002

Adult Telemetry Projects in the Delta Cross Channel

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The California Department of Fish and Game (DFG) continued to track sonic tagged white sturgeon released in San Pablo Bay in October of 2001. We monitor their movements with automated stations located throughout the interior Sacramento–San Joaquin Delta, Delta Cross Channel, lower San Joaquin River, Chain Island, and the Sacramento River at Hood. The station at Chain Island is the only one regularly detecting sturgeon. Surprisingly, we have not detected any tagged sturgeon migrating past Hood on the Sacramento River as of April 4, despite this being the time of their upstream spawning migration. Most of our sturgeon detections have been made by weekly boat tracking through the Delta and bays. To date, we have located 32 of the 40 tagged sturgeon ranging from San Pablo Bay to Cache Slough. DFG will continue tracking tagged sturgeon throughout spring 2002.

DFG will begin tagging adult striped bass with sonic transmitters in spring 2002 as part of ongoing Delta Cross Channel studies. We will monitor their movements from two tagging locations (lower Mokelumne River and Sacramento River near Decker Island) and track them in the interior Delta and the Delta Cross Channel. The tagging operations will occur during two phases of gate operations at the Delta Cross Channel: gates closed and gates operating tidally. Automated monitoring stations will detect sonic-tagged striped bass movements around the clock and we will supplement data collected by boat tracking.

2002 Salvaged Delta Smelt and Splittail Transportation and Release

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The current assessment of the transportation and release of salvaged delta smelt and splittail work encompasses several research topics, including:

1. the analysis of data collected during trucking and handling experiments carried out in 1999–2000;
2. an ongoing review of the extant literature to facilitate design of future experiments; and
3. the development and implementation—in cooperation with other state and federal agencies—of fish transport protocols at new fish protective facilities.

A series of transport and handling mortality experiments was conducted from March through June 1999 and April through July 2000 at the John E. Skinner Fish Protective Facility in Byron, Calif. During the experiments, juvenile splittail, American shad, delta smelt, and longfin smelt were used to test handling losses independently of transport losses. Treatment fish were placed into 300-gallon recovery tanks to observe mortality. Fish mortality counts were recorded immediately following the experiments, at 24 hours, and at 48 hours. The sample size for these experiments varied between 50 to 100 fish. Dissolved oxygen, temperature, and visibility were also recorded.

Preliminary data analysis has been completed, comparing handling versus trucking mortality, which was presented in a poster at the 2001 State of the Estuary Conference and the 2002 IEP Workshop at Asilomar. Delta smelt post-test mortalities for trucking experiments were as great as 100%, whereas chinook salmon mortalities for the same experiment type were only 5% (Table 1). The results of the handling tests show similar disparity between the two species with delta smelt mortalities at 97% and chinook salmon handling test mortalities at 13% (Table 1).

Table 1 Experimental trucking and handling mortalities for delta smelt and chinook salmon at the Skinner Fish Protective Facility in 2000

Species and treatment	*Live*	*Dead*	*Total*	*Percent mortality*
Delta smelt				
Trucking control	5	76	81	93.83%
Trucking experiment	0	55	55	100%
Handling control	2	160	162	98.77%
Handling experiment	6	221	227	97.36%
Chinook salmon				
Trucking control	239	25	264	9.47%
Trucking experiment	150	22	172	12.79%
Handling control	207	11	218	5.05%
Handling experiment	203	10	213	4.69%

Delta Smelt Culture Project Update

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This season broodfish at the Delta Smelt Culture Facility (DSCF) began spawning early (January 28, 2002) and 150,000 eggs have been collected so far. Egg production declined considerably since mid-March, but we anticipate another 30,000 to 50,000 eggs this year. The larval facility is in full production with individuals ranging from 5 to 18 mm long. The larvae are eating well and are experiencing better growth rates compared to last season.

This year, the DSCF has provided live specimens (eggs and larvae) to the California Department of Fish and Game Aquatic Toxicology Laboratory for testing exposure to herbicides. We anticipate a productive year and encourage those interested in obtaining delta smelt specimens to contact me by e-mail at the DSCF at braddbridges@mindspring.com.

Long-Term Monitoring Program Status and Trends

Delta Hydrology

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The dry hydrologic conditions of fall 2000 carried into the 2001 calendar year. Eventually, winter precipitation resulted in large runoff amounts from mid-February through mid-March. Outflow levels were low from April through the end of the year because of sparse precipitation during this period. During fall 2000, both the state and federal water projects had to adjust exports to comply with water quality standards. Poor water quality conditions were exacerbated by the closure of the Delta Cross Channel (DCC) gates for fish protection.

Net Delta Outflow

Figure 1 shows the calculated Net Delta Outflow Index (NDOI) and the 45-year (1956–2000) average net Delta outflow. Measurement of Delta Outflow by USGS was not available this year.

All outflow values are daily means. The 45-year average values were obtained from historical DAYFLOW data. The 2001 values were provided by DWR's Division of Operations and Maintenance (O&M). All Delta outflow values are based on the mass balance of flows into and exports out of the Delta.

Comparing the 2001 NDOI to the 45-year average net outflow shows that almost all of the year was well below average. In November 2001 several short storm events increased outflow above the 45-year average level.

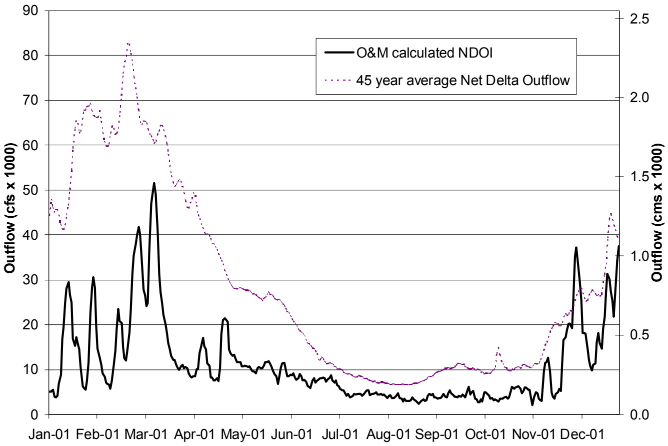

Figure 1 Calculated NDOI for January 1 through December 31, 2001 and 45-year average Net Delta Outflow

Inflows and Exports

Figure 2 shows Sacramento River and San Joaquin River mean daily flows and precipitation for year 2001. A series of storm events from January through March resulted in variably increasing flow in both rivers. The maximum mean daily flow for the Sacramento and San Joaquin rivers peaked at about 46,000 and 5,700 cfs (1,310 and 160 m^3s^{-1}), respectively, in early March. Flows rapidly decreased beginning mid-March and remained relatively low through late November. Flow increased during November and December on the Sacramento River due to a series of storm events beginning in the end of October.

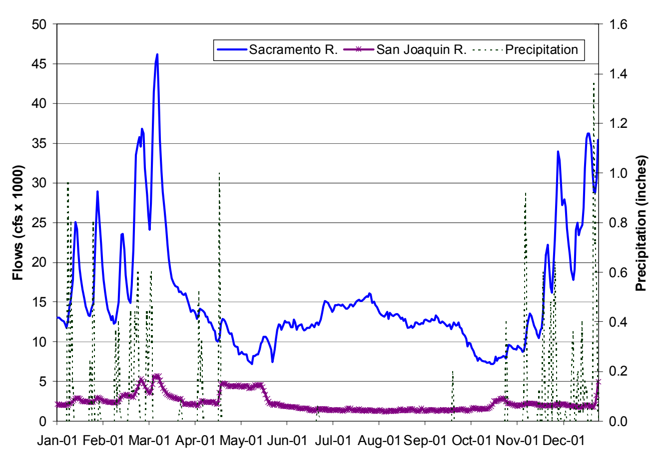

Figure 2 Mean daily Sacramento River and San Joaquin River flows for January 1 through December 31, 2001

Figure 3 shows the State Water Project (SWP) and Central Valley Project (CVP) mean daily export rates for 2001. The mean daily exports at Banks Pumping Plant (SWP) averaged about 3,000 cfs (90 m^3s^{-1}) over the year with peak pumping at about 8,000 cfs (230 m^3s^{-1}) on March 12, 2001. CVP exports at Tracy Pumping Plant averaged about 3,000 cfs over the year, with peak pumping slightly greater than 4,000 cfs (120 m^3s^{-1}) on September 13, 2001.

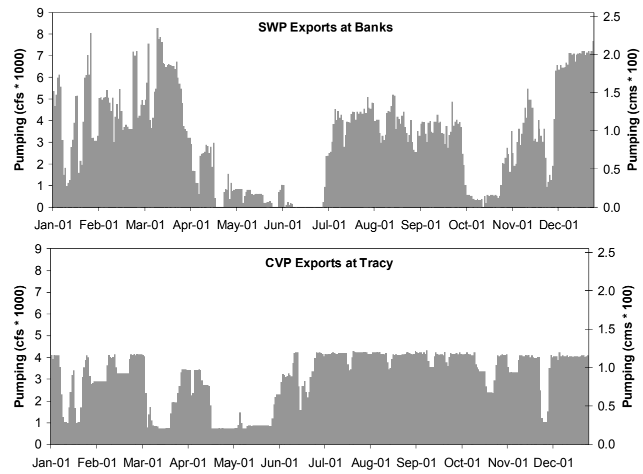

Figure 3 SWP and CVP mean daily export rates for January 1 through December 31, 2001

As shown in Figure 3, SWP export reductions occurred in mid-January due to water quality concerns. Both SWP and CVP decreased exports intermittently from January through June due to concerns for migrating salmon or delta smelt. From mid-April to mid-May, both projects reduced pumping in support of the Vernalis Adaptive Management Plan. In June and early July, repairs to the California Aqueduct forced a curtailment of exports from the Banks Pumping Plant. The CVP exported on behalf of SWP from mid to late June. From July through September, both water projects adjusted pumping as needed to meet either water quality or flow standards. The large reductions in pumping at both projects in mid-October and mid-December were also due to water quality and outflow concerns.

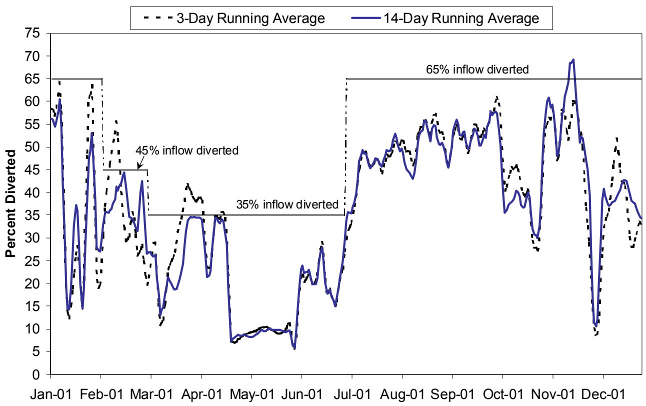

Figure 4 Percent Delta inflow diverted by SWP and CVP for January 1 through December 31, 2001

Figure 4 shows the percent of Delta inflow that was diverted by the SWP and CVP during calendar year 2001. Three-day and 14-day running averages are shown, along with the maximum allowable percent diversion for different times of the year. From February through June, the diversions are limited to 35% of Delta inflow. However, the standard for February is 45%, following a dry January, which occurred in 2001. For the rest of the year, diversions are limited to 65% of Delta inflow. Throughout the year, the percent diverted complies with the maximum allowed criteria. The percent diverted standard was relaxed in early November by the fishery agencies to gain water for the Environmental Water Account.

Annual Totals

Figure 5 compares the 45-year record for total annual Delta outflow and total annual exports (SWP + CVP). The 2001 totals were calculated from DWR O&M data and the historical totals were calculated from the DAYFLOW data set. The annual Delta Outflow Index for 2001 was somewhat lower than for 2000 and the lowest since 1994. 2001 Delta Outflow represents the eleventh lowest in the last 45 years. The annual exports were just above the average of the last 45 years.

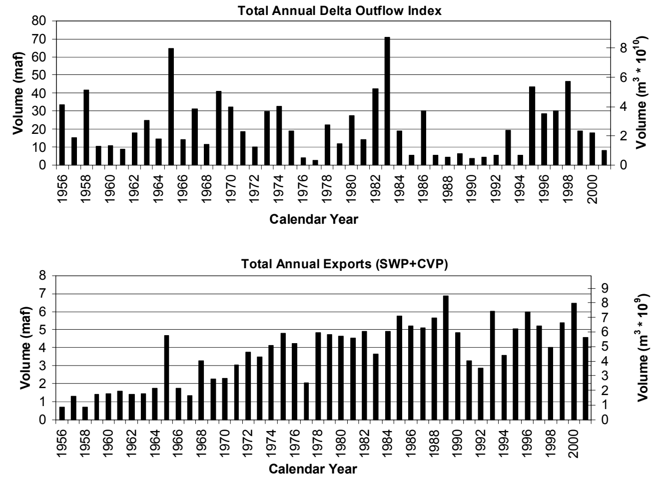

Figure 5 Total annual Delta outflow and annual exports for calendar years 1956–2001

Water Supply Forecast for 2002

Based on DWR's Bulletin 120, dated March 1, 2002, water supply is forecasted to be "below normal" for the Sacramento River region and "dry" for the San Joaquin region. Figure 6 shows water supply as a percent of average for the Sacramento and San Joaquin hydrologic regions.

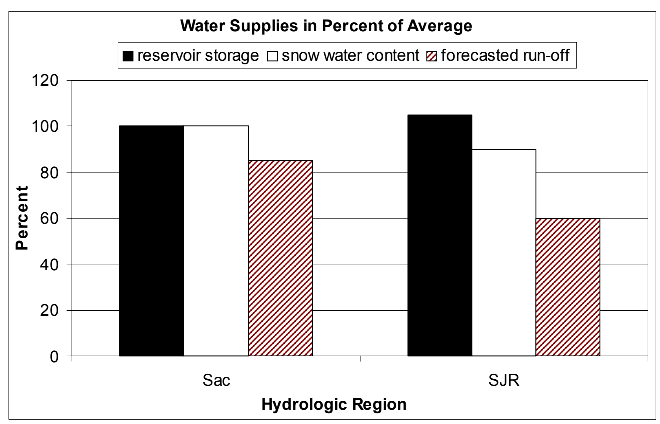

Figure 6 Water supplies in percent of average for the Sacramento (Sac) and San Joaquin (SJR) hydrologic regions for 2002

Statewide reservoir storage increased at a pace slightly ahead of normal during the month and is near average. Reservoir storage this year is approximately the same as it was last year at this time. Lake Oroville storage as of February 28, 2002, was 2.12 maf (2.62 x 10^9 m^3) compared to about 1.84 maf (2.27 x 10^9 m^3) last year.

Snow water content increased to 95% of average for this date compared to 85% last year. The snowpack is about 80% of the April 1 average, which is the date of maximum accumulation.

The water year forecasts have been lowered to about 80% of average statewide, but are still greater than the 50% actual runoff last year.

Phytoplankton and Benthos Abundance and Distribution in the Upper San Francisco Estuary in 2001

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Introduction

The status and trends of environmental water quality, phytoplankton, zooplankton, and benthos are all monitored through the IEP's Environmental Monitoring Program (EMP). The EMP is mandated by the State Water Resources Control Board Water Right Decision 1641, which permits the water management and export activities of the SWP and CVP. Staff from the Department of Water Resources, U.S. Bureau of Reclamation, Department of Fish and Game, and the U.S. Geological Survey completes all activities associated with the EMP. Monitoring involves the collection of discrete samples each month at established stations, as well as continuous monitoring of water quality conditions at seven shore-based stations (Figure 1).

More information about the EMP, including initial findings from a programmatic review now underway can be found at http://www.iep.water.ca.gov/emp.

In this article I summarize results from 2001 monitoring of phytoplankton and macro-benthic organisms. Results from 2001 *Neomysis* and zooplankton monitoring follow in a separate article (see Mecum, p 9). 2001 environmental water quality results are not presented in this issue of the *IEP Newsletter*.

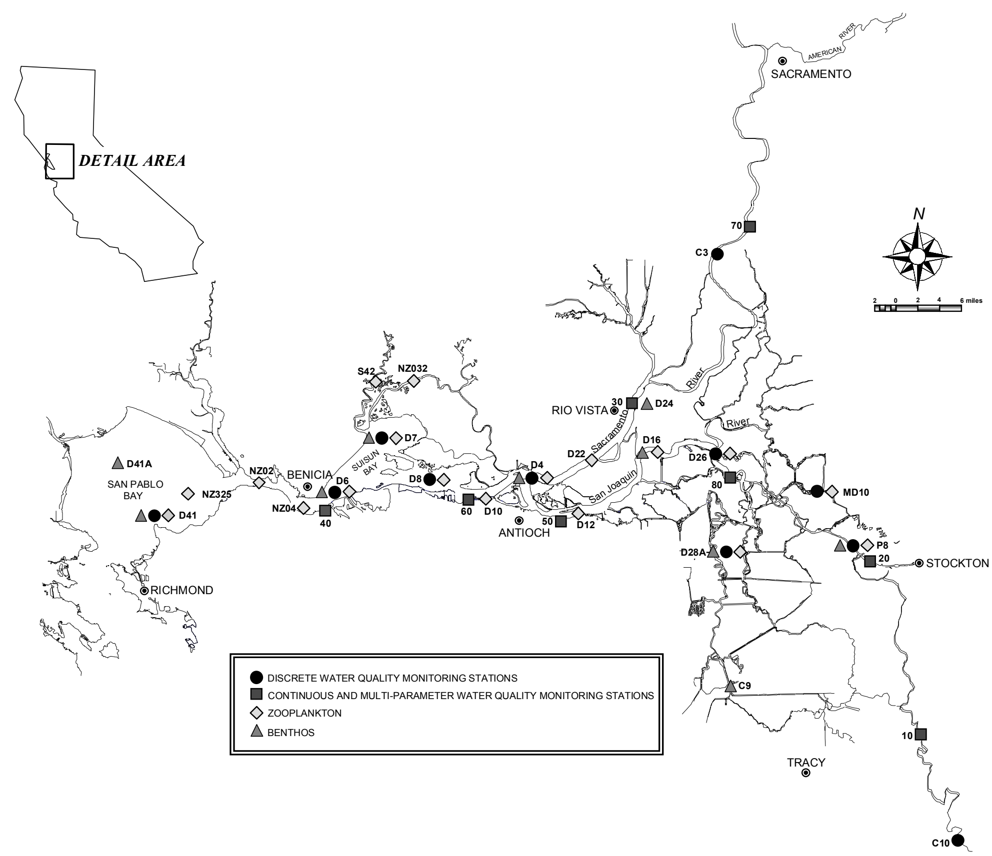

Figure 1 IEP Environmental Monitoring Program sampling sites in the San Francisco Estuary

Chlorophyll *a* and Phytoplankton Monitoring

Monthly monitoring of chlorophyll *a* and phytoplankton is conducted as part of IEP's Environmental Monitoring Program. Chlorophyll *a* samples were collected by DWR staff for extraction at 15 stations; phytoplankton samples were collected for identification and enumeration at 11 stations. Chlorophyll *a* was filtered from samples using a fiber glass filter with a diameter 47-mm and 1.0-mm pore size at a pressure of ten inches of mercury. Chlorophyll *a* extractions were completed at Bryte Laboratory according to *Standard Methods for the Examination of Water and Wastewater, 20th ed*. Phytoplankton identification and enumeration was performed at Bryte Laboratory using the Utermohl inverted microscope method.

Chlorophyll *a* is an estimate of phytoplankton biomass, and percent chlorophyll *a* concentration is used as an indicator of actively increasing phytoplankton biomass. The percentage of chlorophyll *a* increases during the initial stages of a phytoplankton bloom when cell division is exponential; it decreases during the decline phase of the bloom when pigment breakdown products increase. Percent chlorophyll *a* concentration is computed as the ratio of chlorophyll *a* concentration to chlorophyll *a* plus pheophytin concentration multiplied by 100%. The percent chlorophyll *a* concentrations in the spring and early summer of 2001 were well above 60% at most monitoring sites. The relatively high percentage of chlorophyll *a* indicates that plankton were increasing throughout the San Francisco Estuary during this period.

Chlorophyll *a* concentrations for 2001 were below 25 µg/L for all regions, except the South Delta. Concentrations commonly ranged between 0.5 µg/L and 15.0 µg/L throughout the estuary. The maximum concentration for most stations was reached during the spring, followed by a smaller peak in late summer or early fall. A maximum chlorophyll *a* concentration of 62.4 µg/L was reached during July in the South Delta at Vernalis. This value was greater than the 46.0 µg/L value recorded in September 2000 and occurred when water temperatures were high and freshwater inflows were low. Chlorophyll *a* maximum for the North Delta, East Delta, lower Sacramento River, and lower San Joaquin River regions occurred during May and April. The maximum for the Central Delta, South Delta, and Suisun Bay regions occurred during June and July. The San Pablo Bay region was unique with a maximum biomass increase during March.

Phytoplankton species composition changes seasonally due to many variables. The major factors include nutrient input and depletion, changes in inflows and salinity intrusion, and changes in light penetration, temperature, and other water quality parameters. Diatoms dominate the spring chlorophyll *a* maximum, and flagellates dominate the summer maximum in the North Delta, lower Sacramento River, lower San Joaquin River, Central Delta, South Delta, and the East Delta.

Unidentified flagellates, *Aulacosira granulata*, *Thalassiosira eccentrica*, and *Cyclotella* spp. were the most common species in the mid-Delta and South Delta regions. Unidentified flagellates and *Cyclotella* spp. were the most common species in the Suisun and San Pablo region west of the Delta.

Benthic Biota Monitoring

The benthic monitoring component of IEP's Environmental Monitoring Program (EMP) documents changes in the composition, abundance, density, and distribution of the benthic biota within the estuary.

Benthic biota are relatively long-lived, and can respond to changes in physical factors, such as freshwater inflows, salinity, and substrate composition. Therefore, benthic community data can provide an indication of physical changes occurring within the estuary. Because operation of the State Water Project and Central Valley Project can affect the flow characteristics of the Delta, and subsequently influence the density and distribution of benthic biota, benthic monitoring is an important component of the EMP. The benthic monitoring data are also used to detect and document the presence of newly introduced species within the estuary.

Benthic monitoring is conducted at ten sampling sites distributed throughout the major habitat types within the estuary (Figure 1). DWR staff collect four bottom grab samples and one sediment sample monthly at all sites. The grab samples are analyzed in the laboratory—all organisms collected are enumerated and identified to genus (and to species when possible). The field method for the collection of benthic macroinvertebrates is summarized in *Standard Methods for the Examination of Water and Wastewater, 20th ed*.

As a result of the environmentally diverse sampling regime, ten new organisms were added to the our benthic species list in 2001. The list of new species and the locations where they were collected are as follows.

San Pablo Bay:
Saline to brackish water sites west of the Delta (Sites D41A and D41)

- The nematode *Unid. Nematode species B* was first found in July and then again in September.[1]
- The platyhelminthes *Unid. Triclad species E* was first identified in November.[1]
- The arthropods *Heptacarpus pictus* and *Paranthura elegans* were first found in July and September, respectively.
- The molluscs *Onchidoris bilamellata* and *Ostrea lurida* were both first identified in May.
- The annelid *Paleanotus bellis* was found in April, while the annelids *Scolelepis species B* and *Dorvillea rudolphi* were found in July.

Grizzly Bay:
A saline to brackish water site west of the Delta (Site D7)

- The mollusc *Cooperella sudiaphana* was first identified in November.

Of the 152 species of benthic macrofauna collected in 2001, ten species represented approximately 89% of all organisms collected. These ten species include: (1) the amphipods *Corophium stimpsoni*, *Corophium spinicorne*, *Corophium alienense*, *Corophium acherusicum*, *Ampelisca abdita*, and *Gammarus daiberi*; (2) the aquatic oligocheates *Varichaetadrilus angustipenis* and *Limnodrilus hoffmeisteri*; and, (3) the Asian clams *Potamocorbula amurensis*, and *Corbicula fluminea*.

Of the ten dominant species, *Ampelisca abdita* and *Potamocorbula amurensis* represent macrofauna that inhabit a more saline environment and were found in San Pablo Bay (D41), Suisun Bay (D6), and Grizzly Bay (D7). *Corophium stimpsoni* and *C. spinicorne* tolerate a wider range of salinity—they were collected in saline western sites (D4, D6, and D7), as well as brackish to freshwater eastern sites, such as the San Joaquin River at Twitchell Island (D16) and the Sacramento River above Point Sacramento (D4). The remaining six species are predominantly freshwater species and were collected at sites east of Suisun Bay.

1. Taxonomic work continues on the unidentified nematode and platyhelminthes.

Neomysis and Zooplankton Monitoring

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Since its introduction in 1994, *Limnoithona tetraspina* has been the most abundant copepod in the Delta (Figure 1). Its congener *L. sinensis* has not been caught since early 1994. Spring 2001 abundance of *L. tetraspina* was at its lowest level since 1998 (4,277 m^{-3}), while summer abundance was the greatest of record (18,748 m^{-3}). Fall abundance declined from 22,882 to 20,943 m^{-3}. This is the second consecutive decline in fall abundance.

Abundance of *Pseudodiaptomus forbesi* in 2001 (first detected in 1987) declined from 2000 levels in spring, summer, and fall (Figure 2). At 55.4 m^{-3}, spring abundance was greater than in 1999 when the lowest level (12 m^{-3}) to date was observed. The summer and fall levels (542 and 292 m^{-3}, respectively) were the lowest measured since its introduction. Summer abundance had been fairly stable from 1994. The fall decline is part of a trend that became visible only with the addition of the 2001 data point. *Eurytemora affinis* spring abundance has been fluctuating around 250 m^{-3} since 1989. Although *E. affinis* spring abundance was down from last year, it appears to be within the range that has been normal for the last several years (Figure 2). In summer and fall *E. affinis* abundance likewise showed no change for 2001, remaining at very low levels.

Acartiella (first detected in 1993) occurs at only the more saline stations sampled by the *Neomysis*/Zooplankton Project, a component of IEP's Environmental Monitoring Program. The project began counting *Acartiella* in 1994. Spring abundance is generally low, typically below 10 m^{-3} (Figure 3). Abundance increases through the summer and is greatest in the fall. All three seasons have followed the same general abundance trend since 1994. *Acartiella* abundance was greatest in 1996, then declined until 1999, and has been increasing since then. *Acartia* (a native species) also occurs at only the more saline stations sampled by the *Neomysis*/Zooplankton Project. *Acartia* spring abundance increased (169 m^{-3} to 312 m^{-3}) for the second year (Figure 3). Summer abundance increased from 2000 but was lower than in 1999 while fall abundance has been declining since 1999.

Sinocalanus doerrii (first detected in 1978) spring abundance has been relatively stable at around 200 m^{-3} since 1996 (Figure 4). Summer abundance for the last three years has been somewhat greater (about 200 m^{-3}) than during the 1994–1998 period, which had a mean of approximately 61 m^{-3}. Fall abundance has been very low (usually less than 10 m^{-3}) but stable since 1990. *Diaptomus* (a native) spring abundance has been low throughout the history of the *Neomysis*/Zooplankton Project (Figure 4). Summer abundance ranged between 100 and 450 m^{-3} until 1979. Since then summer abundance has been below 15 m^{-3} for all but two years. The greatest fall abundance, 269 m^{-3}, was observed in 1972, the first year the project counted copepods. Fall abundance declined until 1981 when it stabilized at less than 3 m^{-3}.

The low abundance levels of *Cyclops* (a native) seen since 1989 (93 m^{-3} for spring, 28 m^{-3} for summer, and 4 m^{-3} for fall) did not change appreciably for any season in 2001 (Figure 5).

Spring cladoceran abundance has been fairly stable at around 600 m^{-3} since 1993 (Figure 6). Summer abundance, which had been increasing the last two years, dropped to 703 m^{-3}, which was nearer the levels observed from 1994 to 1998. Fall 2001 abundance remained at the same low level observed in 2000 (approximately 81 and 79 m^{-3} respectively).

Synchaeta bicornis (a native) spring abundance gradually declined in an oscillating fashion from 1973 through 1986 (Figure 7). Except for an anomalous 14,561 m^{-3} peak in 1990, its spring abundance has been relatively low since 1986 (0 to 803 m^{-3}). A similar pattern of summer decline lasted until 1989 when it stabilized around 10,000 m^{-3}. Fall abundance cycled more gradually from 1972 through 1986. From 1987 until 2001 it has been below 10,000 m^{-3}, but generally greater than the spring abundance. The abundance of all rotifers except *Synchaeta bicornis* has been declining since the project began counting them in 1972 (Figure 8). In general, spring abundance is greater than in summer or fall. The abundance figures for 2001 are 20,008, 7,975, and 12,932 m^{-3} respectively.

Acanthomysis bowmani (first detected in 1993) abundance in 2001 was lower in all three seasons than 2000 (Figure 9). Summer abundance, approximately 14 m^{-3}, was within the normal range but spring and fall abundance appear to have been in decline (from approximately 21 to 5 m^{-3} for spring and approximately 14 to 9 m^{-3} for fall) since 1998. *Neomysis mercedis* abundance has been low for spring and summer since 1987, and for fall since 1983 (Figure 9). For 2001, the abundance figures for spring, summer, and fall were 0.149, 0.037, and 0 m^{-3} respectively. All of these figures were lower than for 2000.

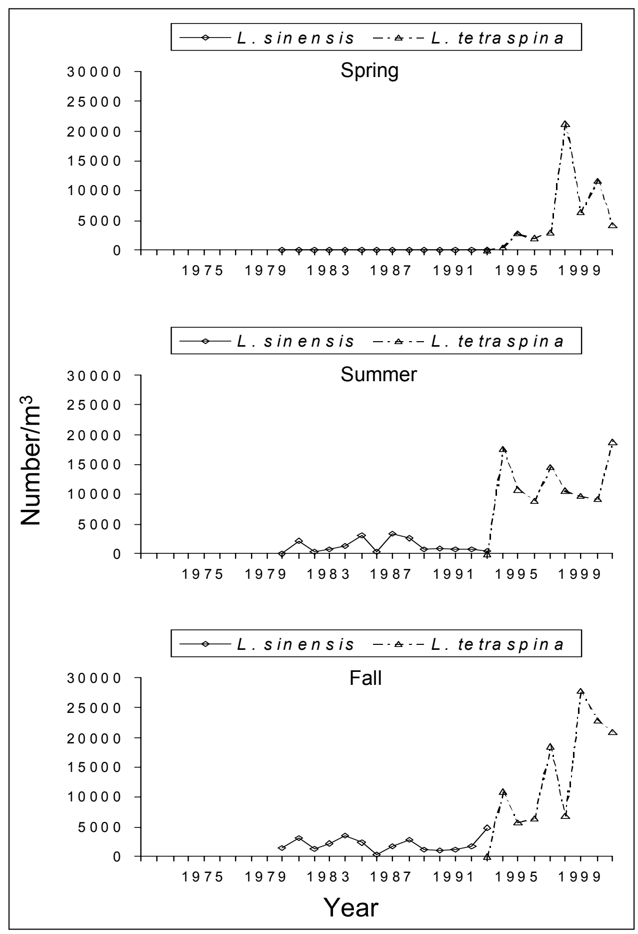

Figure 1 Mean abundance of *Limnoithona sinensis* and *L. tetraspina* in spring, summer, and fall, 1980–2001

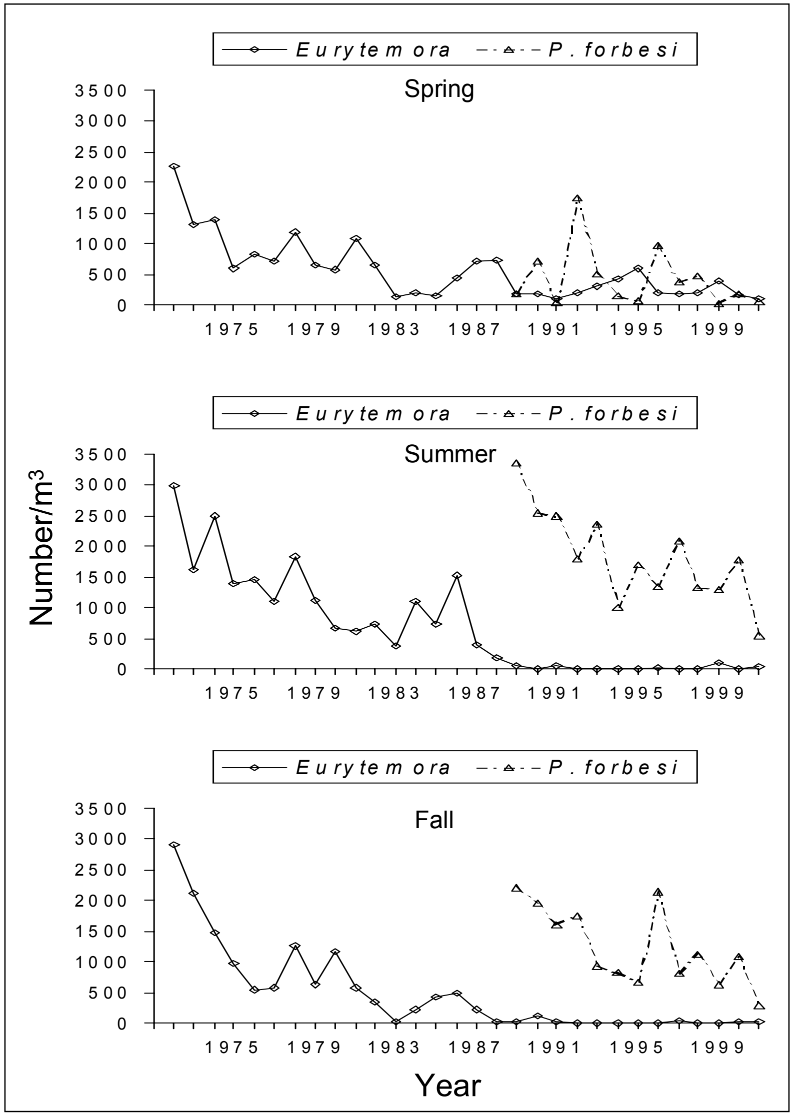

Figure 2 Mean abundance of *Eurytemora affinis* and *Pseudodiaptomus forbesi* in spring, summer, and fall, 1972–2001

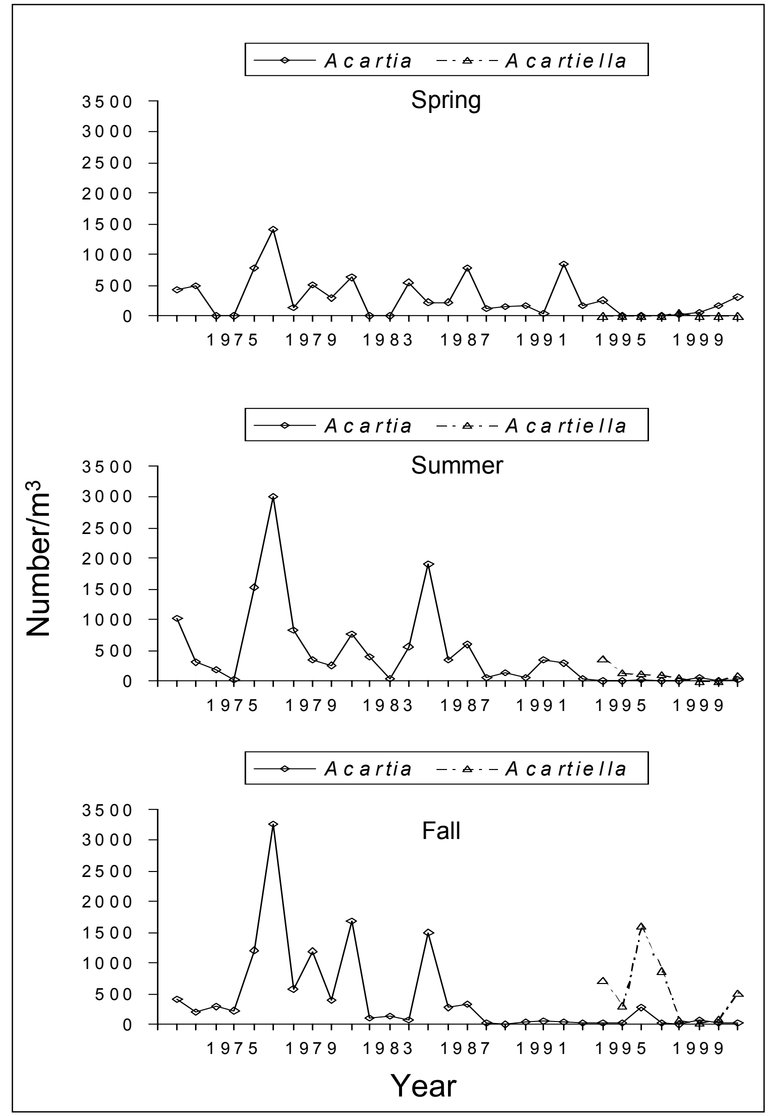

Figure 3 Mean abundance of *Acartia* spp. and *Acartiella sinensis* in spring, summer, and fall, 1972–2001

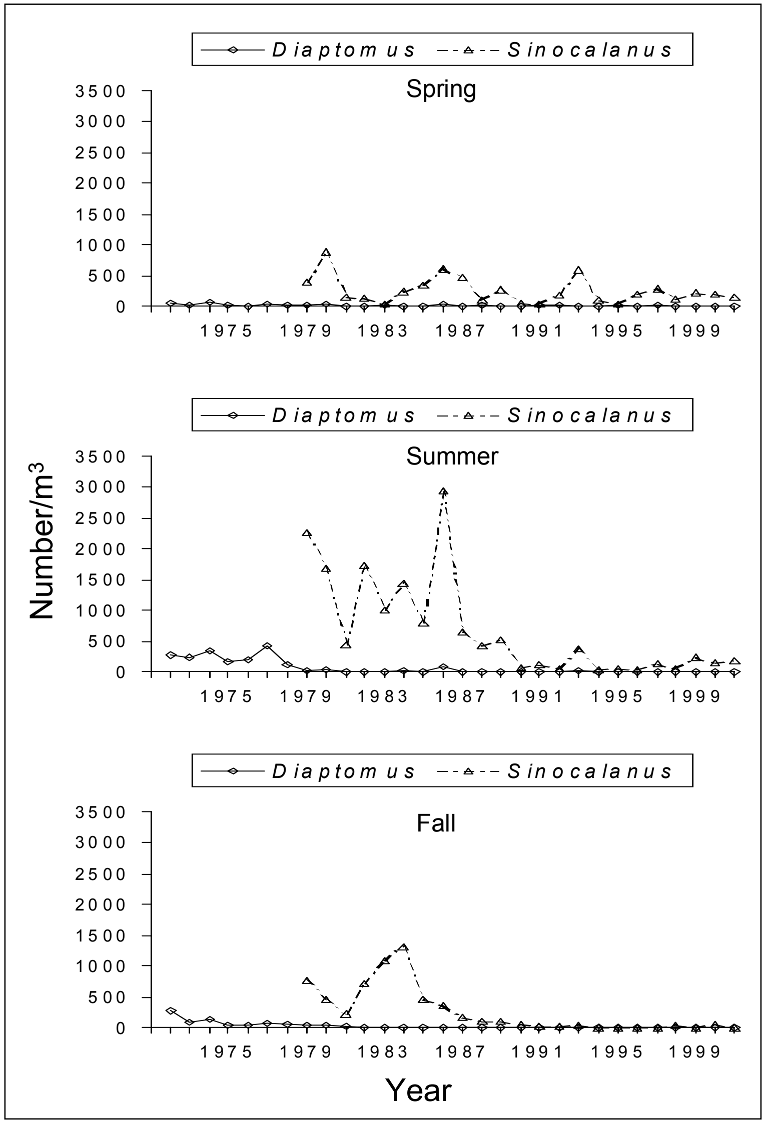

Figure 4 Mean abundance of *Diaptomus* spp. and *Sinocalanus doerrii* in spring, summer, and fall, 1972–2001

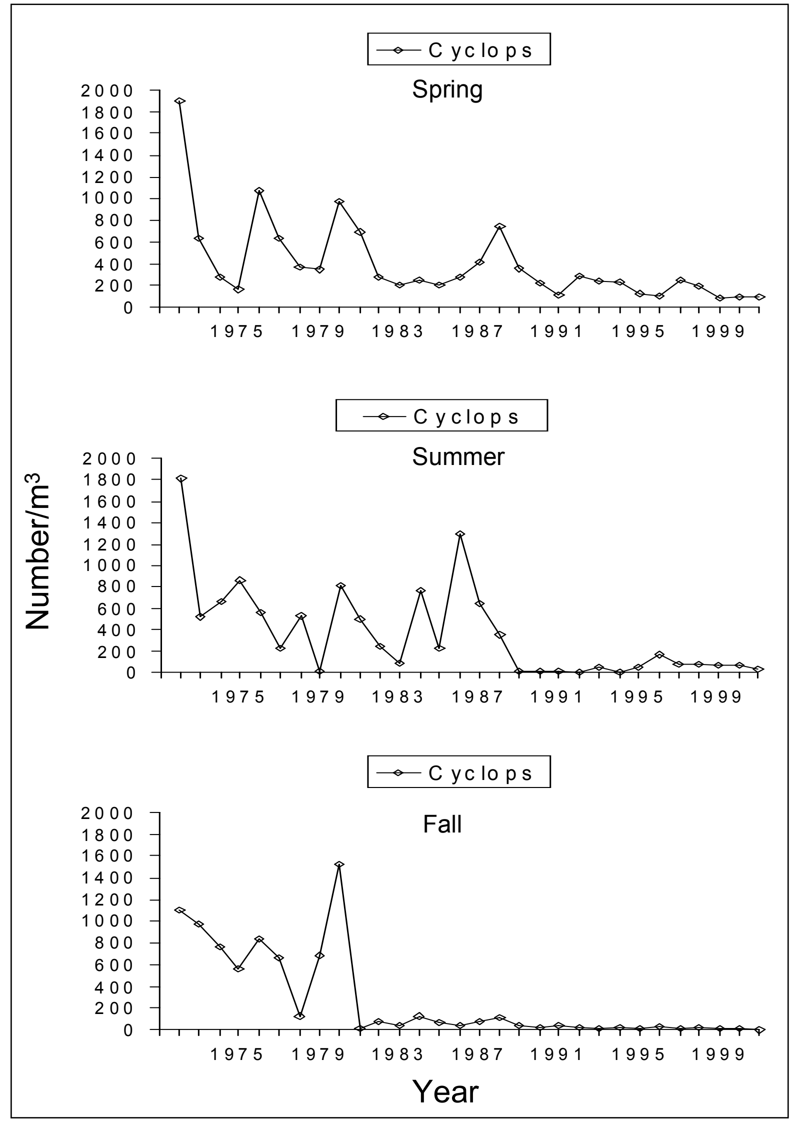

Figure 5 Mean abundance of *Cyclops* spp. in spring, summer, and fall, 1972–2001

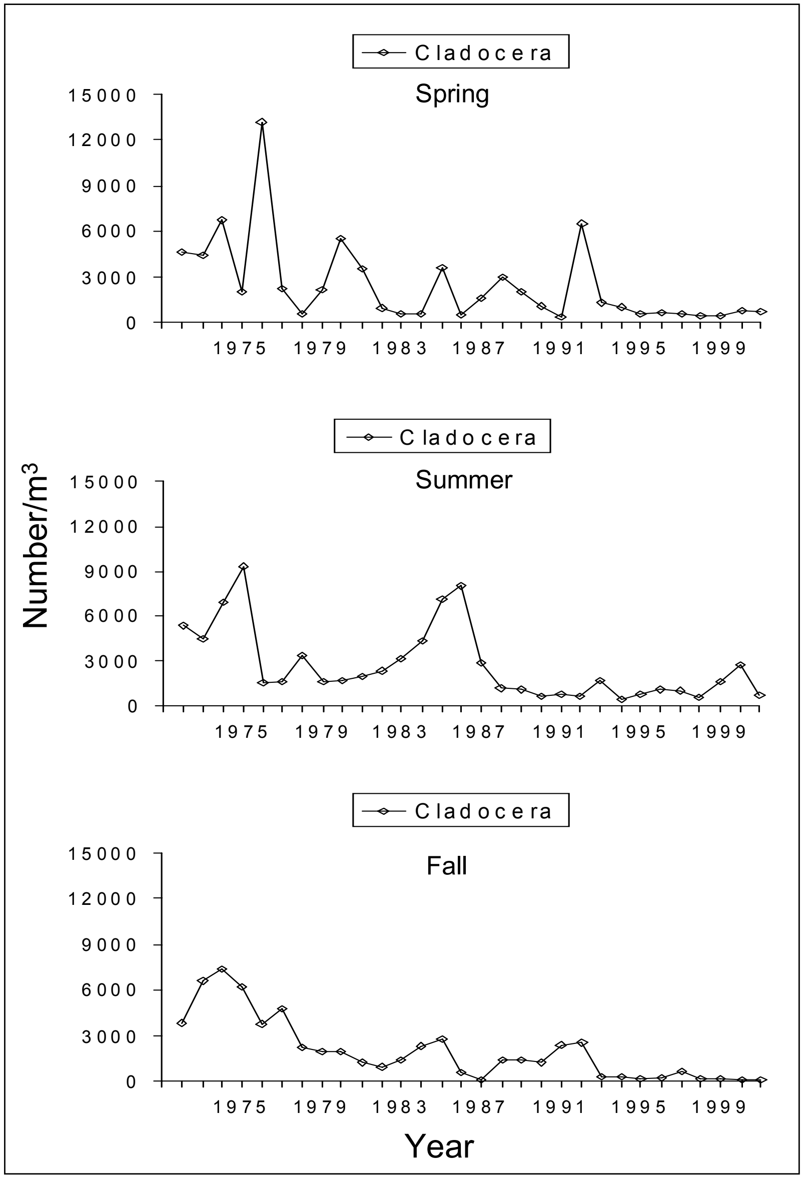

Figure 6 Mean abundance of cladocera in spring, summer, and fall, 1972–2001

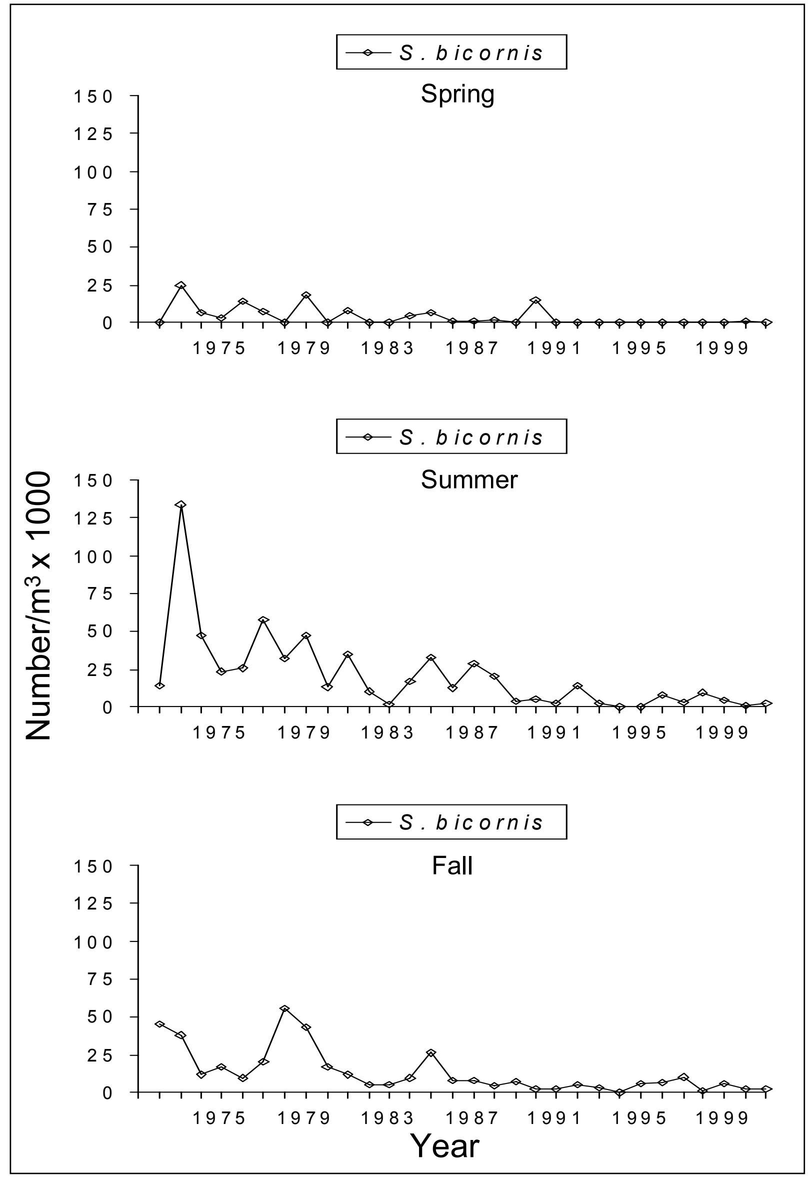

Figure 7 Mean abundance of *Synchaeta bicornis* in spring, summer, and fall, 1972–2001

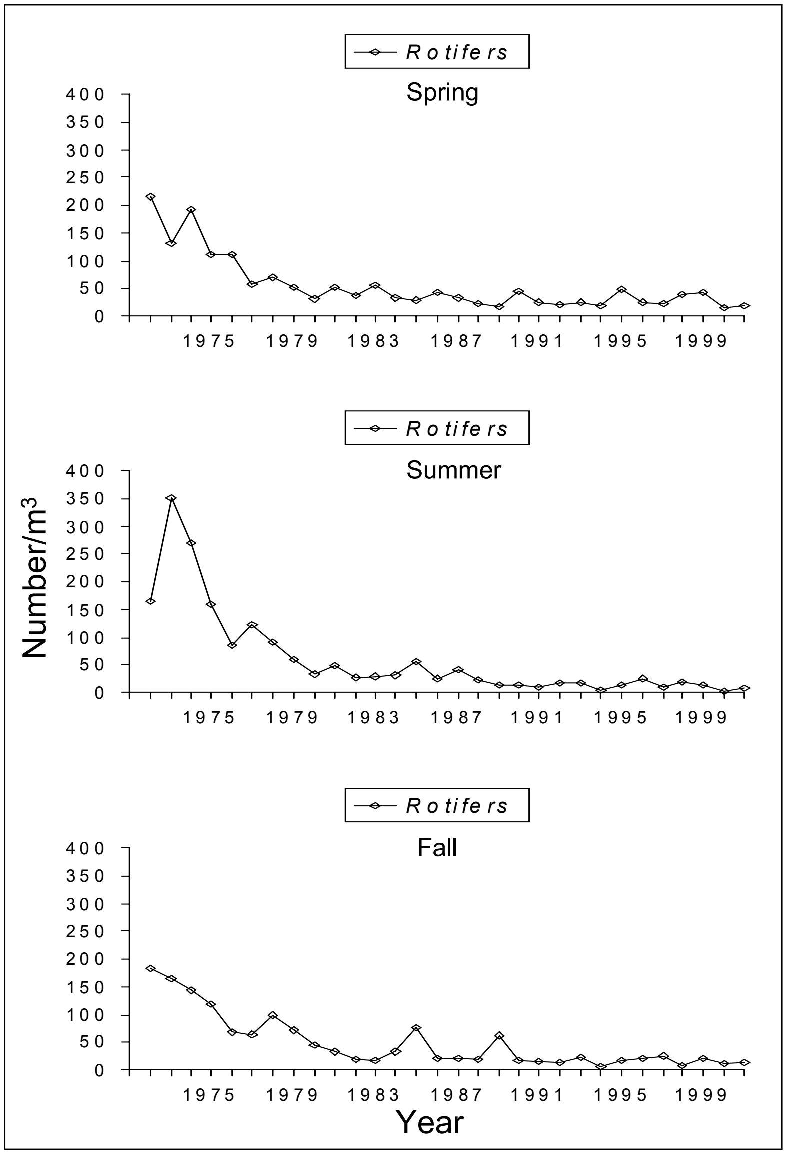

Figure 8 Mean abundance of rotifers other than *Synchaeta bicornis* in spring, summer, and fall, 1972–2001

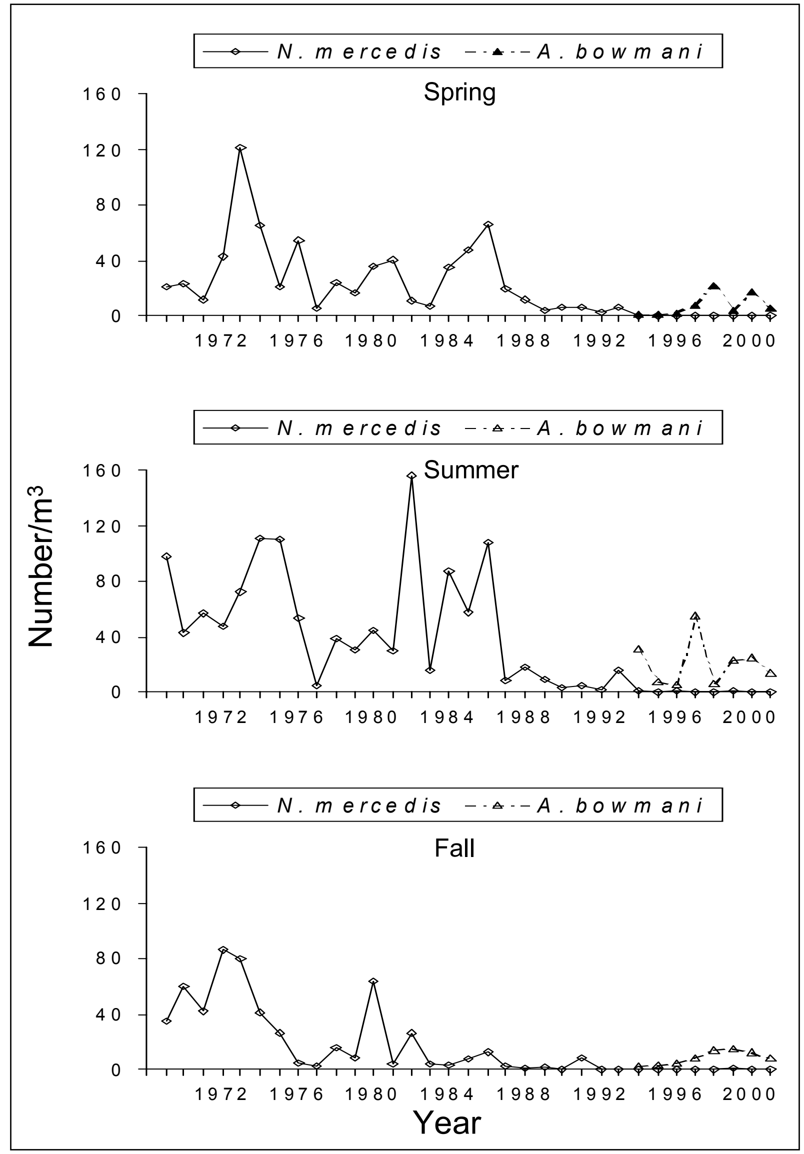

Figure 9 Mean abundance of *Neomysis mercedis* and *Acanthomysis bowmani* in spring, summer, and fall, 1972–2001

San Francisco Bay Species Abundance and Distribution

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In this article, I summarize annual abundance trends and distribution patterns for *Cancer magister*, the Dungeness crab, and the most commonly collected fishes from San Francisco Bay in 2001. Shrimp indices from 2001 are not included, as processing of the 2001 shrimp samples was not completed as of early 2002. The trend information reported here is obtained from IEP's Bay-Outflow Study, which includes monthly trawling by the California Department of Fish and Game (DFG) at 52 stations distributed from South San Francisco Bay to the Delta. Summary life history information was included in the 1997 status and trends reports for many of these species (DeLeón 1998 and Hieb 1998). Additional life history information can be found in IEP Technical Report 63 (Orsi 1999).

Ocean temperature, ocean upwelling, and freshwater outflow are three important factors controlling abundance and distribution of species in the Bay. Gulf of the Farallones ocean temperatures have been below average since 1999, and based on the annual mean sea surface temperature (SST), 2001 was the second coolest year for the study period (1980–2002). Overall 1999 SSTs were slightly cooler than in 2001; however, monthly average SSTs in fall 2001 were below those of fall 1999. Upwelling indices in 2001 for the coastal area near the Bay were well above average (period of record 1946–2001) from April-October, indicating strong summer upwelling, which contributed to the below average SSTs. Water year 2001 was classified as "dry," with an average daily outflow of 15,978 cfs for January–May. This average was the lowest winter-spring outflow since 1994, well below the January–May 2000 average of 50,164 cfs.

The 2001 age-0 *Cancer magister* abundance index was the second greatest for the study period (Figure 1). This was probably due to ocean conditions in winter 2000–2001 that were favorable to the survival and retention of *C. magister* larvae in the Gulf of the Farallones. Cool ocean temperatures and a relatively weak northward Davidson Current are thought to result in increased survival and retention of larvae and increased nearshore settlement. Age-0 crabs were first collected in May in Central Bay and lower San Pablo Bay. Crabs moved upstream over the next two months and by July were common in upper San Pablo Bay and Carquinez Strait and remained there through December.

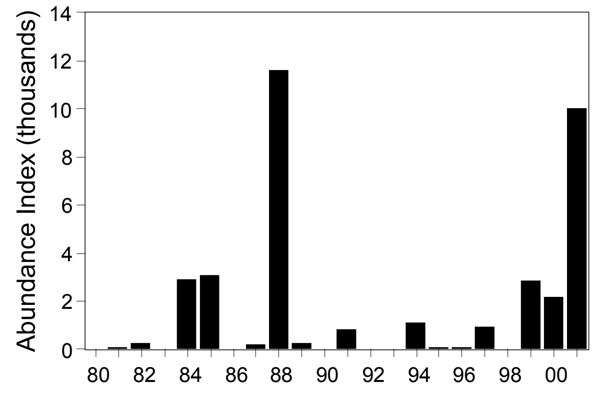

Figure 1 Annual abundance of age-0 *Cancer magister* collected by otter trawl, May–July, 1980–2001

The 2001 age-0 Pacific herring abundance index was the greatest index since 1986, slightly greater than the 2000 index (Figure 2). Juvenile Pacific herring were widely distributed from South Bay to western Suisun Bay through May, with the greatest catches in San Pablo Bay in April and May. By June, most age-0 Pacific herring were collected in Central Bay, and by August most had emigrated from the bay.

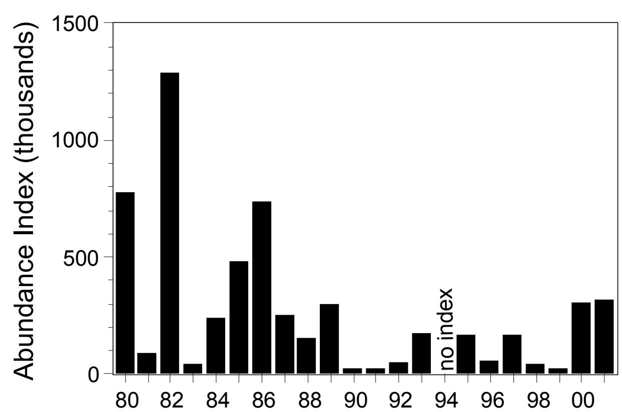

Figure 2 Annual abundance of age-0 Pacific herring collected by midwater trawl, April–September, 1980–2001

The 2001 northern anchovy abundance index was the second lowest for the study period (Figure 3), and was only slightly greater than the 1980 index. We collected northern anchovy from South Bay to western Suisun Bay in 2001—the greatest catches came from the South Bay channel, Central Bay, and western San Pablo Bay stations.

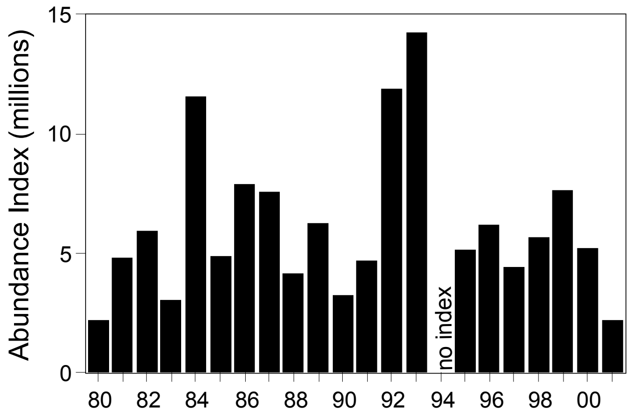

Figure 3 Annual abundance of northern anchovy (all sizes) collected by midwater trawl, April–October, 1980–2001

The 2001 age-0 longfin smelt abundance indices from both the otter and midwater trawls declined substantially from 2000 (Figure 4), reflecting the low winter freshwater outflow. The 2001 midwater trawl index was the lowest since 1996, while the 2001 otter trawl index was the lowest since 1992. Most age-0 longfin smelt were collected from Suisun Bay in late spring and early summer. Distribution expanded both upstream and downstream through summer, with fish collected from South Bay to the western Delta by fall.

The 2001 age-0 jacksmelt abundance index was the greatest since 1985 (Figure 5). Most fish were collected in South and Central bays, with a few from San Pablo Bay.

The 2001 age-0 staghorn sculpin abundance index was the greatest for the study period (Figure 6). From February through May, fish were most common in South Bay, south of the San Mateo Bridge. Through the summer, as fish left shallow subtidal areas, catches were greatest in Central Bay. Age-0 staghorn sculpin were also regularly caught in San Pablo and Suisun bays through summer and fall, but were almost absent from South Bay in these months.

Age-0 white croaker abundance decreased slightly in 2001 from 2000 (Figure 7). Although the age-1+ abundance index also decreased, it was still ten times greater than the lowest indices of the early 1980s. White croaker were most commonly collected at South Bay and Central Bay channel stations, with a few fish from San Pablo Bay and one from Suisun Bay.

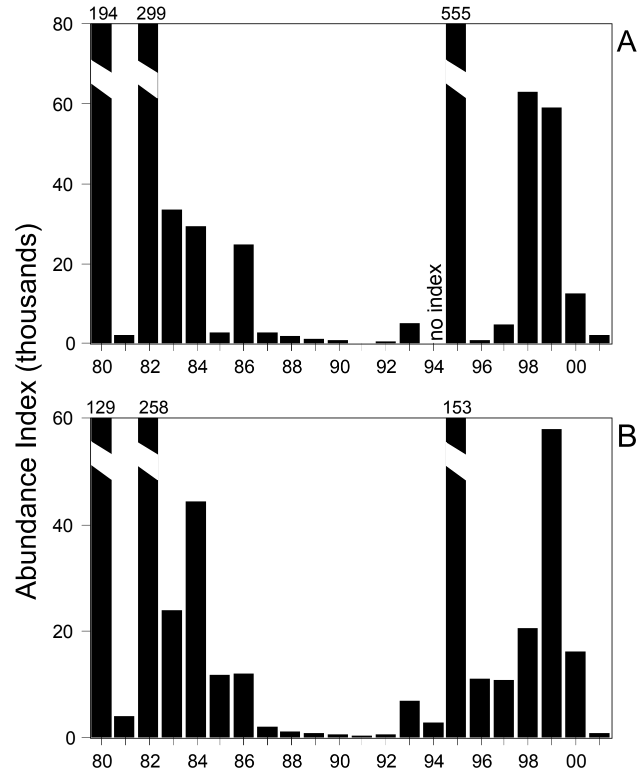

Figure 4 Annual abundance of age-0 longfin smelt, May–October, 1980–2001: (A) midwater trawl; (B) otter trawl

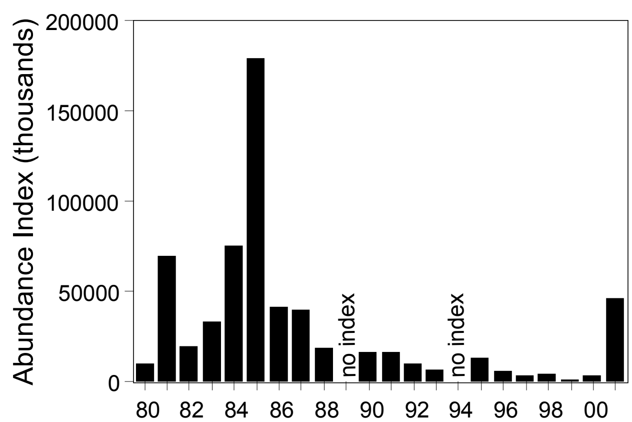

Figure 5 Annual abundance of age-0 jacksmelt collected by midwater trawl, July–October, 1980–2001

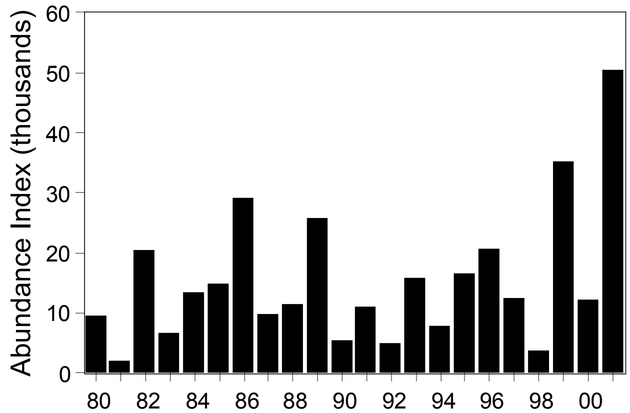

Figure 6 Annual abundance of age-0 staghorn sculpin collected by otter trawl, February–September, 1980–2001

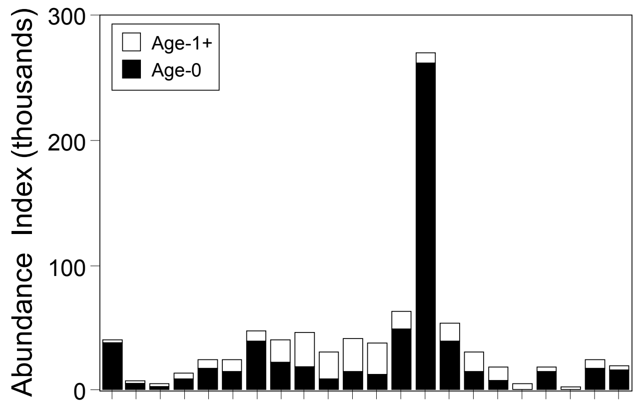

Figure 7 Annual abundance of age-0 and age-1+ white croaker collected by otter trawl, February–October, 1980–2001

The age-0 shiner perch abundance index increased in 2001 (Table 1) and was the second greatest index since 1986. Most fish were collected in Central Bay and the western South Bay shoal stations (between Coyote Point and Hunters Point) in 2001. The 2001 age-0 walleye surfperch abundance index was the second greatest for the study period (Table 1), with over 100 age-0 fish collected in the year. Most of these fish were from the Alameda Island, Berkeley Pier, and Point Pinole shoal stations. Abundance of age-0 pile perch was 0 in 2001 (Table 1), continuing a trend of very low or 0 indices since 1987. We did collect three pile perch in 2001, but these fish were either collected in months or by gear not used for the abundance index. Barred surfperch abundance remained very low in 2001 (Table 1). Only a single fish was collected from our shoal station just south of Hunters Point. The white seaperch index increased in 2001 (Table 1), but represented only two fish. One was from our shoal station near Coyote Point and the other was from our channel station near Angel Island.

Table 1 Annual abundance indices for the most common species of surfperches[a]

Year	*shiner perch* *age-0*	*walleye surfperch* *age-0*	*pile perch* *age-0*	*barred surfperch* *all*	*white seaperch* *all*
1980	16673	1724	857	483	586
1981	42650	11672	998	942	1220
1982	43703	2460	472	335	348
1983	16147	994	778	1330	277
1984	14386	5589	110	673	872
1985	16616	543	301	73	137
1986	24582	454	289	0	311
1987	18069	2180	0	239	271
1988	7746	693	0	134	152
1989	6687	2046	153	101	47
1990	8181	681	0	79	95
1991	2724	32	0	84	0
1992	6142	665	0	41	0
1993	6341	925	0	43	0
1994	3241	no index	0	80	0
1995	6336	0	0	0	0
1996	4404	906	0	59	0
1997	23896	94	0	155	0
1998	4384	467	75	48	36
1999	6237	548	0	46	0
2000	4640	1843	31	43	0
2001	20594	10813	0	55	106

[a] The shiner perch age-0, pile perch age-0, and white seaperch (all sizes) indices are from May–October, the barred perch (all sizes) index from April–September, and age-0 walleye surfperch from May–August. The walleye surfperch indices are from the midwater trawl, indices for all other species are from the otter trawl.

The 2001 bay goby index was the second greatest for the study period at over twice the 2000 index (Figure 8). The greatest catches were from Central Bay stations north of Angel Island and South Bay stations north of Hunters Point. Bay goby were also common in San Pablo Bay and a few were collected in Carquinez Strait.

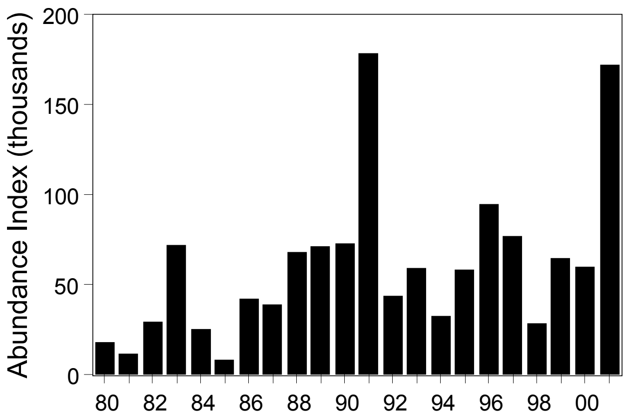

Figure 8 Annual abundance of bay goby (all sizes) collected by otter trawl, February–October, 1980–2001

Age-0 yellowfin goby abundance decreased in 2001 to the lowest level since 1991 (Figure 9). In 2001, the yellowfin goby was again the most widely distributed species in the estuary: it was collected at all of our stations upstream of Central Bay, except for one in the San Joaquin River, and at most of our South Bay and Central Bay stations. Most age-0 fish were collected in Suisun Bay and the lower Sacramento River.

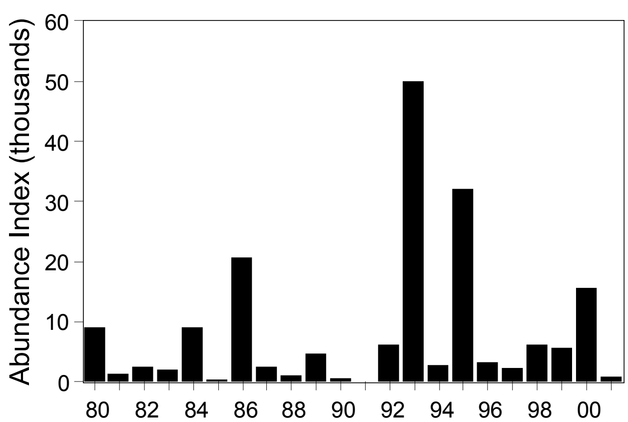

Figure 9 Annual abundance of age-0 yellowfin goby collected by otter trawl, May–October, 1980–2001

Our catches of the shokihaze goby, *Tridentiger barbatus*, increased dramatically in 2001, with an average of almost one fish per tow (Figure 10). Most of the smaller fish (<20 mm TL) were collected in the lower Sacramento River, while the larger fish (>20 mm TL) were collected from San Pablo Bay to the lower Sacramento and San Joaquin rivers.

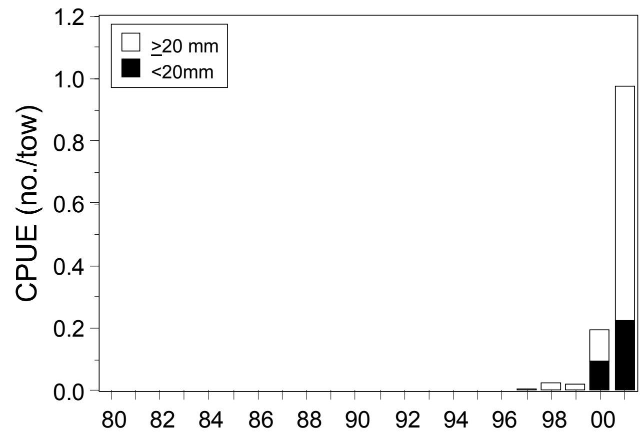

Figure 10 Annual CPUE (number per otter trawl tow) of <20 mm TL and >20 mm TL shokihaze goby, January–December, 1980–2001

In 2001, no age-0 or age-1 California halibut were collected, and the age-2+ index declined (Figure 11). The continued lack of juvenile fish was expected, as SSTs in the Gulf of the Farallones were below the minimum reported for reproduction (14 °C) for all but one month in 2000 and for all of 2001. Most of the age-2+ fish continued to be from the 1997 and 1998 year classes, as SSTs were >14 °C from November 1997 to May 1998. The majority of California halibut was collected at the Central Bay channel stations in 2001. This is in contrast to recent years, when the smaller fish that dominated our catch were most common at South and Central bay shoal stations.

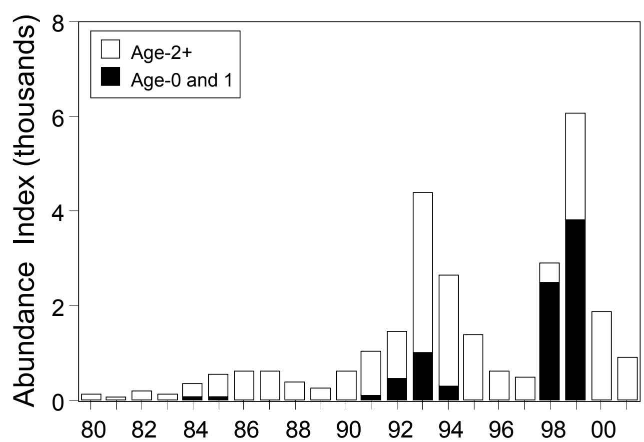

Figure 11 Annual abundance of juvenile (age-0 and age-1) and age-2+ California halibut collected by otter trawl, February–October, 1980–2001

The 2001 age-0 English sole abundance index was the third successive record index, reaching a level almost two times the previous index of 2000 (Figure 12). It is thought that cooler ocean temperatures in winter were a major factor influencing these recent strong year classes. Age-0 fish were widely distributed over the shoals from South to San Pablo bays in late winter and spring; catches were also great at our channel station near Angel Island. By July, as South Bay and San Pablo Bay temperatures increased, fish were concentrated in Central Bay, with most collected at our channel stations.

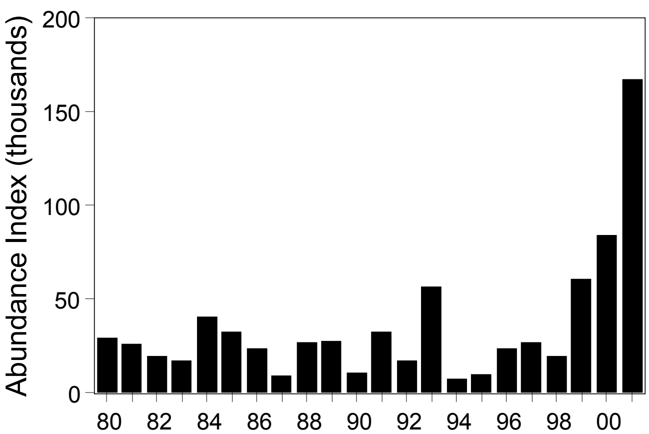

Figure 12 Annual abundance of age-0 English sole collected by otter trawl, February–October, 1980–2001

In 2001, abundance of speckled sanddab also reached a third successive record index (Figure 13). Speckled sanddab was again the most abundant species of flatfish in the Bay, although the 2001 index was only slightly greater than that of English sole. It was most common in Central Bay during all months, with the greatest catches at channel stations near Angel Island and the Southhampton shoal station. Distribution was broadest from January to May, with some fish collected as far upstream as Carquinez Strait. During this period, young fish were settling to the bottom and bay temperatures were uniformly cool.

The age-0 starry flounder abundance index was only 11, the second lowest for the study period, continuing a decline that began in 1998 (Figure 14A). Only five age-0 fish were collected in 2001, but four of these were from a San Joaquin River shoal station added to the survey in 1994 and not used for index calculation. The 2001 age-1 starry flounder index also declined (Figure 14B), reflecting the low 2000 age-0 abundance index.

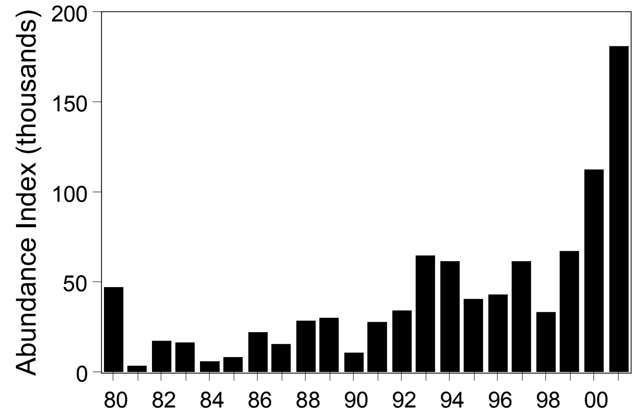

Figure 13 Annual abundance of speckled sanddab (all sizes) collected by otter trawl, February–October, 1980–2001

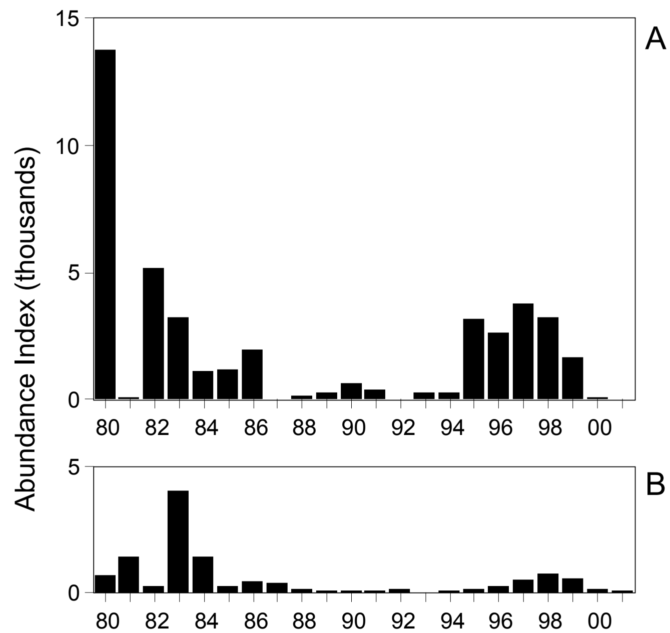

Figure 14 Annual abundance of starry flounder collected by otter trawl: (A) age-0, May–October, 1980–2001; (B) age-1, February–October, 1980–2001

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Chinese Mitten Crab Abundance

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The Chinese mitten crab (*Eriocheir sinensis*) has been one of the most successful of the recently introduced species to the San Francisco Estuary. In summer 2001, the mitten crab ranged throughout the estuary and local watersheds to north of Colusa in the Sacramento River basin, and to the confluence of the San Joaquin and Merced rivers in the San Joaquin River basin (Figure 1). Although the 2001 distribution appeared to be very similar to the 1998 distribution, crabs were not reported from as far north or as far south in 2001 as in 1998. In summer 2001, most reports of age-1 crabs were from the Sacramento-San Joaquin Delta and the Sacramento River basin, with relatively few reports from the San Joaquin River basin. In fall 2001, adult mitten crabs were most common in Suisun Bay; through winter 2001–2002, there was a gradual movement downstream to San Pablo Bay, although the greatest catches were in Carquinez Strait.

Adult mitten crab catches increased in 2001 for all surveys or data sources that are routinely tracked (Table 1). IEP catch per unit effort (CPUE, catch per tow) for "North Bay" stations, from Central Bay to the western Delta, was greatest in winter 2001 (Table 1). UC Davis (UCD) Suisun Marsh catch per tow increased several orders of magnitude from 2000 to 2001, but the 2001 value was substantially lower than the greatest value of 1999. From 2000 to 2001, numbers collected in the South Delta at the U.S. Bureau of Reclamation's (USBR) Tracy Fish Collection Facility increased by one order of magnitude, while at the Department of Water Resources' (DWR) Skinner Delta Fish Protective Facility collection nearly doubled. Salvage of fish was much lower, however, compared to 1998 and 1999 totals.

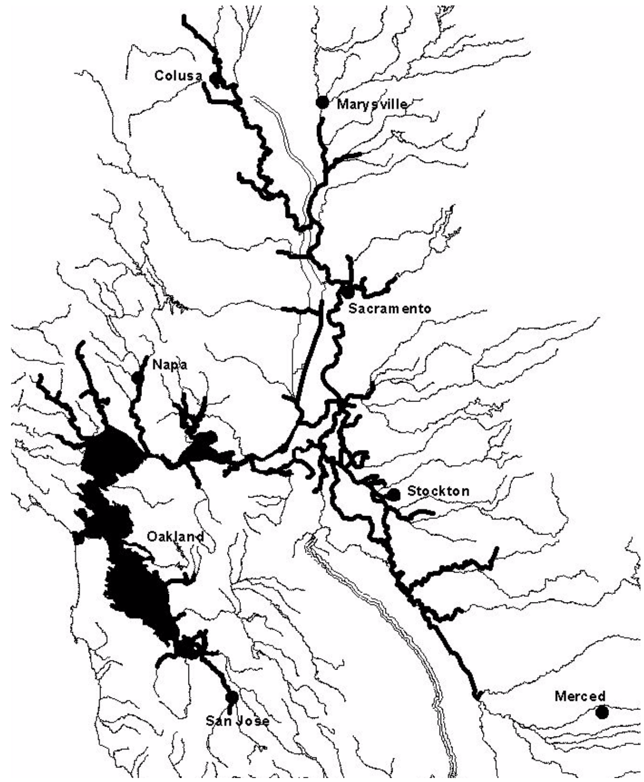

Figure 1 Distribution of the Chinese mitten crab in the San Francisco Estuary and its watershed in 2001. Solid black area or lines indicates presence of the crab in the estuary and tributaries, broken line indicates presence in the California Aqueduct.

Table 1 Catch per unit effort (annual catch per tow) of adult Chinese mitten crabs from UCD's Suisun Marsh trawl survey and IEP's San Francisco Bay Study, and total catch of adult mitten crabs at USBR's and DWR's fish facilities, 1996–2001

Year	*IEP CPUE*	*UCD CPUE*	*USBR catch*	*DWR catch*
1996	0.02	0.00	50	no data
1997	0.30	0.07	20,000	no data
1998	2.51	0.89	750,000	no data
1999	0.96	1.08	90,000	34,000
2000	0.92	0.02	2,500	4,700
2001	3.22	0.17	27,500	7,300

A larger portion of crabs reared in the Sacramento River watershed in 2001 than in previous years, which may explain the apparent discrepancy in catch per tow between IEP CPUE and USBR and DWR catches. Such a scenario could result in fewer crabs collected by the fish facilities, which are located in the South Delta and are not in the usual migratory route for crabs moving from north of the Delta to Suisun and San Pablo bays.

The mitten crab's major effects continue to be interference with fish salvage activities at USBR's and DWR's pumping facilities in the South Delta, bait stealing from sport anglers, and clogging power plant cooling water systems in the western Delta.

Acknowledgments

I thank Robert Schroeter (UC Davis) for the Suisun Marsh data and Steve Foss (DFG) for the fish facilities salvage data.

Townet Survey and Fall Midwater Trawl Survey

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Introduction

The California Department of Fish and Game has two long-term monitoring surveys designed to track relative abundance and distribution of age-0 striped bass (*Morone saxatilis*) in the San Francisco Estuary: the Summer Townet Survey (TNS) and the Fall Midwater Trawl Survey (FMWT). These surveys have been running since 1959 (TNS) and 1967 (FMWT) and provide annual abundance indices for age-0 striped bass and delta smelt (*Hypomesus transpacificus*). The FMWT also provides annual abundance indices for longfin smelt (*Spirinchus thaleichthys*), threadfin shad (*Dorosoma petenense*), American shad (*Alosa sapidissima*), and splittail (*Pogonichthys macrolepidotus*). This article describes recent abundance indices, distribution, and long-term trends from the TNS and FMWT surveys.

Survey Areas and Methods

The FMWT survey samples 116 stations from San Pablo Bay, east to Stockton on the San Joaquin River, and Hood on the Sacramento River. The index calculation (the same for all species) uses catch data from 100 of the 116 stations sampled monthly from September to December (the remaining 16 stations increase the spatial coverage for delta smelt sampling). These stations are grouped into 14 areas. The mean monthly catch for each area is multiplied by a weighting factor representing the volume of water in that area. This value is summed for all areas to obtain a monthly index. The sum of the four monthly indices constitutes the annual FMWT abundance index.

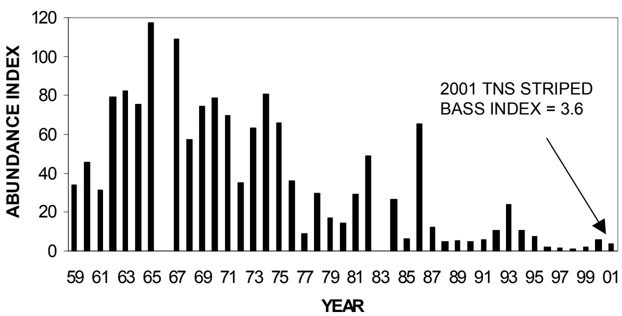
The TNS samples 32 stations biweekly (only 31 are used in the index), usually between June and July, but sometimes extending into August. Up to three, 10-minute stepped-oblique tows are conducted at each station. Sampling stations range in location from the eastern edge of San Pablo Bay, upstream to Stockton on the San Joaquin River, and to the southern tip of Grand Island on the Sacramento River. Each survey index is calculated by summing the catch at each station and multiplying by a weighting factor that represents the volume of water at that station. The weighted catches are summed for the 31 stations and divided by 1000 (for reporting convenience), resulting in a survey index. For the annual striped bass TNS index, the two surveys that bracket the period of time when striped bass reach a mean size of 38.1-mm fork length are log-transformed and the index is interpolated between the two surveys (Chadwick 1964; Turner and Chadwick 1972). The TNS delta smelt index is calculated by averaging the first two survey indices.

Striped Bass

Although the 2001 TNS striped bass abundance index (3.6) decreased from the 2000 index (5.5), it is the second greatest index since 1995 (Figure 1A). The 2001 FMWT striped bass index (731) nearly doubled from 2000 (390), the lowest index of record (Figure 1B). Both surveys exhibited a declining trend in age-0 abundance from historical levels.

Distribution of striped bass in the TNS showed a movement downstream over time. During TNS surveys 1 (June 12–16) and 2 (June 26–29), the greatest concentration of striped bass occurred in the Sacramento and San Joaquin rivers. During survey 3 (July 10–14), distribution remained considerable in the Sacramento and San Joaquin rivers, but the percent of index from Suisun Bay increased from 10% to 33%. Distribution in the FMWT showed a contrary movement from striped bass in the TNS. During September, San Pablo Bay accounted for the greatest proportion of the striped bass monthly index (37%). This is different from 2000 when the eastern Delta accounted for the majority of striped bass catch in September and October (42% and 32%, respectively) and San Pablo Bay did not contribute to the index at all. The concentration of striped bass proceeded to shift east throughout the survey, and at least 54% of each monthly index was accounted for by catch in Suisun Bay and the lower Sacramento River.

A



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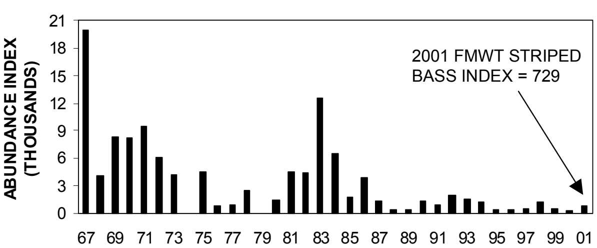
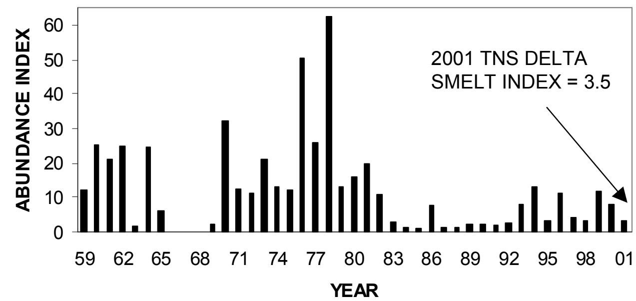


Figure 1 Age-0 striped bass abundance indices for (A) TNS 1959–2001 (no sampling occurred in 1966; the index was invalid in 1983 due to high flows) and (B) FMWT 1967–2001 (no sampling occurred in 1974 and 1979)

Delta Smelt

Both 2001 TNS and FMWT abundance indices for delta smelt decreased from 2000 (Figure 2A and 2B). The 2001 TNS delta smelt index (3.5) is less than 1999 (11.9) and 2000 (8.0) but comparable to recent years (1995, 1997, and 1998) when the index ranged from 3.2 to 4.0. The 2001 FMWT delta smelt index (603) decreased by 20% from 2000 (756). Both surveys exhibited an overall trend of decline in the last three years, but this decline seems more pronounced in the TNS where the 2001 delta smelt index is 95% lower than the greatest index of record (62.5 in 1978).

A



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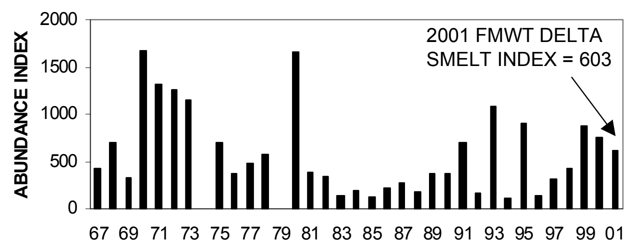

Figure 2 Delta smelt abundance indices for (A) TNS 1959–2001 (no sampling occurred in 1966, and delta smelt were not enumerated in 1967–1968) and (B) FMWT 1967–2001 (no sampling occurred in 1974 and 1979)

Both surveys displayed little variation in distribution. During the TNS, the majority of delta smelt was caught in the Sacramento River near Sherman Island Lake (76% to 90% of the total catch) every survey. The FMWT caught 72% to 92% of its delta smelt in the same area as the TNS in each month, except November, when the majority of delta smelt was caught in Suisun Bay (57%). Monthly catch of delta smelt was relatively low, and October accounted for 79% (408 fish) of all delta smelt caught during the 2001 FMWT.

Longfin Smelt

The 2001 FMWT abundance index for longfin smelt (247) declined by a large amount (93%) from 2000 (3438). The 2001 index was the fifth lowest of record and comparable to indices from the late 1980s and early 1990s (Figure 3). Distribution of longfin smelt was centered in the Suisun Bay area, which is consistent with recent years, although they were collected from San Pablo Bay to the lower Sacramento River region.

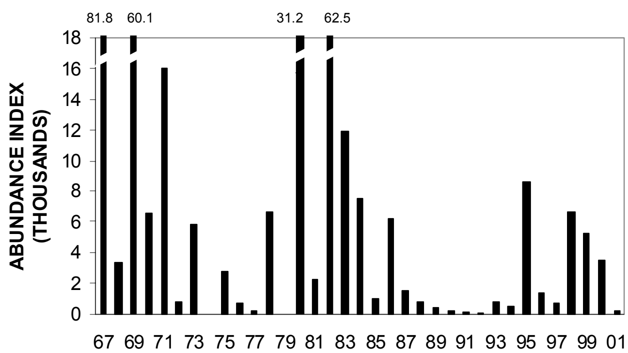

Figure 3 Longfin smelt abundance indices for FMWT 1967–2001 (no sampling occurred in 1974 and 1979)

Threadfin Shad

The 2001 FMWT index (14,401) for threadfin shad was the second greatest for the period of record. Since 1997, the FMWT has recorded its three greatest threadfin shad indices, indicating an overall increase in relative abundance (Figure 4). In both surveys, the majority of threadfin shad was caught in the Stockton Deep Water Ship Channel between the Calaveras River and Fourteenmile Slough. This is consistent with distribution from 2000 and with findings from distribution studies conducted in the Delta during 1963 and 1964 (Turner 1966).

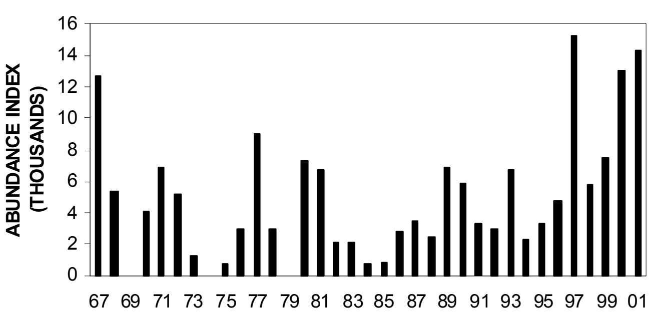

Figure 4 Threadfin shad abundance indices for FMWT 1967–2001 (no sampling occurred in 1974 and 1979)

American Shad

The 2001 FMWT index (764) for American shad did not change from 2000. It has remained relatively low since 1999 (715), and recent years continue to be the lowest indices since 1977 (650). Before 1999, the FMWT index was showing an overall increasing trend. Indices from 1993 to 1998 are some of the greatest for the period of record (Figure 5). Distribution of American shad in the FMWT was more widely dispersed than threadfin shad. American shad were found throughout the eastern Delta, lower Sacramento and lower San Joaquin rivers. However, the FMWT caught American shad in San Pablo Bay and Carquinez Strait, where 61% of the December 2001 monthly index was accounted for by catch west of the Benicia Bridge. Prior to December, catch of American shad in this area was infrequent. This deviates from the distribution of American shad in 2000 when at least 35% of every monthly index (except October) was accounted for by catch west of Benicia Bridge.

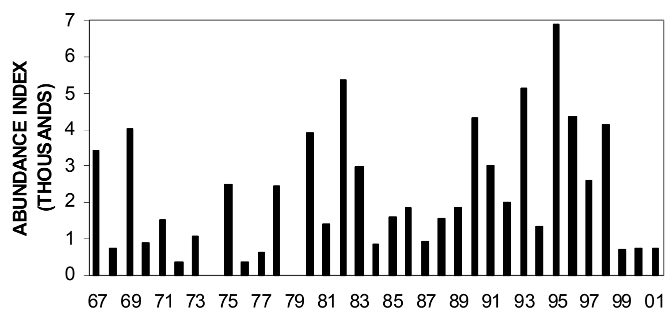

Figure 5 American shad abundance indices for FMWT 1967–2001 (no sampling occurred in 1974 and 1979)

Splittail

The 2001 FMWT splittail index (all ages combined) was 27. Although an increase from the 2000 index (10), the 2001 index is considerably lower than the strong year class of 1998 (281) (Figure 6). The age-0 component of the 2001 splittail abundance index is 10. Catch in the 2001 FMWT was dominated by age-1+ fish (67%), whereas catch in the 2000 FMWT was dominated by age-0 fish (80%). A total of 24 age-0 and age-1+ splittail was caught throughout the survey. In September, 92% of the catch was accounted for by a single station on the western side of Montezuma Slough. No fish were caught in November, and in December splittail were caught from the Napa River to the Sacramento River near Threemile Slough.

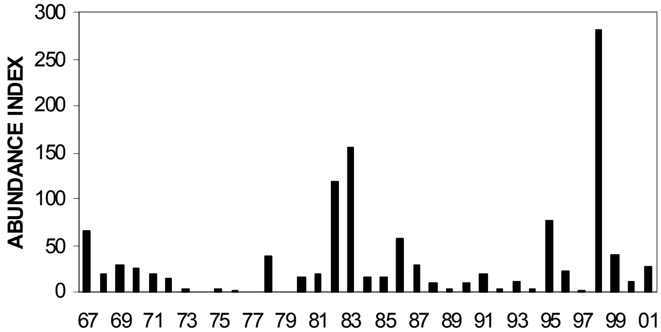

Figure 6 Splittail (all ages) abundance indices for FMWT 1967–2001 (no sampling occurred in 1974 and 1979)

Conclusion

The FMWT demonstrates decreasing trends in catches of native species (delta smelt, longfin smelt) and increasing trends in the total catch of introduced species (with the exception of striped bass). This is particularly apparent with the introduced threadfin shad. Since 1997 threadfin shad catch has been steadily increasing beyond historical levels. Both monitoring projects will continue to determine whether these trends persist or not. Due to the variable number of surveys each year and the short duration of the survey, the TNS does not have a method to calculate abundance indices for fish other than striped bass and delta smelt. More work is needed to develop these methods.

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Resident Fish Surveys

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In April 2001, DFG staff resumed year-round random sampling for the IEP the Delta Resident Shoreline Fishes Monitoring Project at the request of the IEP Management Team. The random sampling design is similar to the method used for resident fish monitoring from 1980 to 1983, but modified from the fixed-site sampling method used from 1995 to 1999. This modification of the sampling design will provide more statistically valid results concerning trends in resident fish abundance and community structure in the Sacramento-San Joaquin Delta. A stomach content analysis component also was added to examine trophic interactions in the nearshore fish community.

The Resident Fishes Monitoring Project samples 15 randomly selected 500-m long sites each month. The Delta is stratified into five areas and sampling effort in each area corresponds approximately to the relative abundance of resident fishes. Four sites each are sampled monthly in the East and Central Delta, two sites each are sampled in the North and West Delta, and three sites are sampled in the South Delta (Figure 1). Shoreline habitat types, along with chemical and physical variables, are recorded for each site. Stomach contents are collected from a maximum of five fish per species using gastric lavage or dissection.

Since stratified random sampling began in April 2001, a total of 40 species from 17 families has been observed (Table 1). Nonnative centrarchids (primarily bluegill, largemouth bass, and redear sunfish), comprise 53% of the catch. Threadfin shad accounted for an additional 28%, followed by nonnative cyprinids at 5% (Figure 2). Native cyprinids and catostomids each contributed less than 1% of the total catch (Table 2, Figure 2).

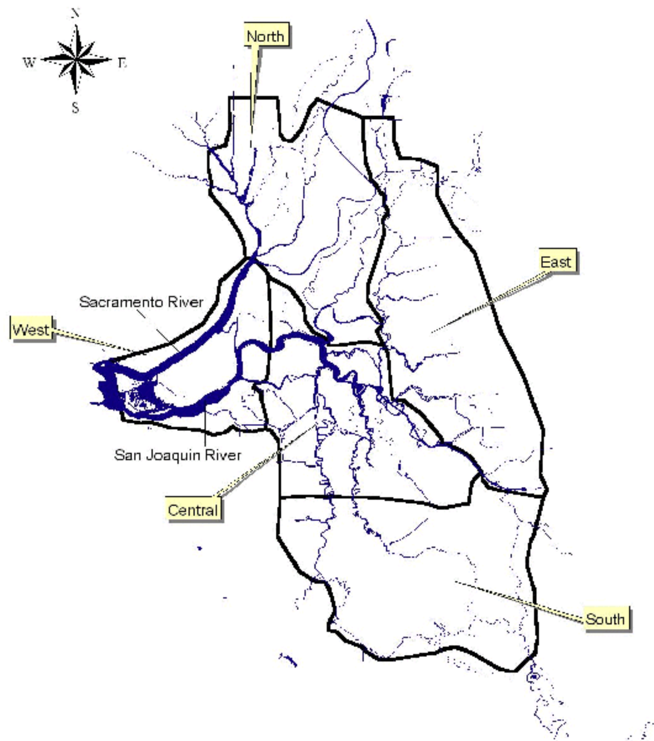

Figure 1 Delta Resident Shoreline Fishes Monitoring stratified sampling areas

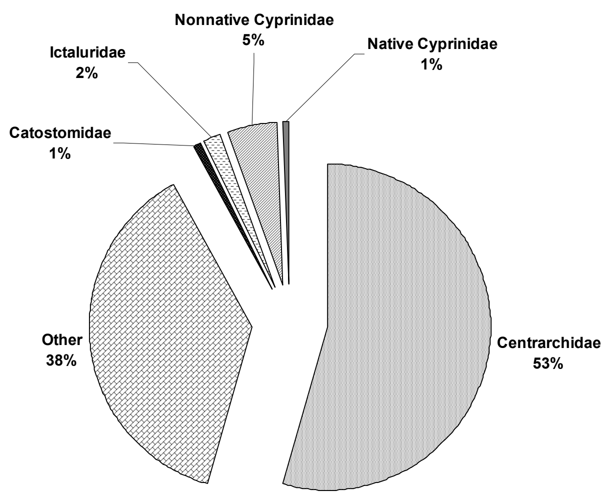

Figure 2 Catch of common families observed during resident fish monitoring in the Sacramento–San Joaquin Delta in 2001–2002

Because the resident fishes sampling project has been active in its current form for less than a year, it is not yet possible to determine trends in resident fish abundance and community structure. Likewise, stomach content sampling has not produced sufficient data for analysis at this time. Comparisons to resident fish data collected in 1995–1999 are possible, but should be treated with caution, as these data were collected at twenty, 1-km long fixed stations sampled in February, April, June, and August.

The total number of species and families collected was the same in both 1995–1999 and 2001–2002 (Table 1). Centrarchids dominated the resident fish communities in both periods, while native cyprinids and catostomids remained consistently scarce (Figures 2 and 3). Catch-per-unit-effort (CPUE) is similar for nearly all of the common families and species observed during 1995–1999 and 2001–2002 (Figure 4, Table 2). However, CPUE of centrarchids, atherinids (inland silversides), and clupeids (threadfin shad) was greater in 2001–2002 than in 1995–1999 (Table 2, Figure 4). The increase in these three groups is the main reason for the substantially greater total CPUE during 2001–2002 compared to 1995–1999 (Table 2). This increase is unexplained, but may be related to the use of a new electrofishing boat in 2001 that may be more efficient than the boat used in earlier years.

Table 1 Fish species observed during resident fish sampling in the Sacramento–San Joaquin Delta in 1995–1999 and 2001–2002

Family and species	*Classification*[a]	*Years observed* 1995–99	*Years observed* 2001–02
Atherinidae			
Inland silverside	(i,r)	X	X
Catostomidae			
Sacramento sucker	(n,fwe)	X	X
Centrarchidae			
Black crappie	(i,r)	X	X
Bluegill	(i,r)	X	X
Green sunfish	(i,r)	X	X
Largemouth bass	(i,r)	X	X
Pumpkinseed	(i,r)		
Redear sunfish	(i,r)	X	X
Smallmouth bass	(i,r)	X	X
Spotted bass	(i,r)		X
Sunfish (Lepomis sp.)	(i,r)		
Warmouth	(i,r)	X	X
White crappie	(i,r)	X	X
Clupeidae			
American shad	(i,a)	X	X
Threadfin shad	(i,fwe)	X	X
Cottidae			
Pacific staghorn sculpin	(n,me)		X
Prickly sculpin	(n,fwe)	X	X
Riffle sculpin	(n,fwe)	X	
Cyprinidae			
California roach	(n,fwe)	X	
Common carp	(i,r)	X	X
Golden shiner	(i,r)	X	X
Goldfish	(i,r)	X	X
Hardhead	(n,fwe)		X
Red shiner	(i,r)	X	
Sacramento blackfish	(n,fwe)	X	X
Sacramento hitch	(n,r)	X	X
Sacramento pikeminnow	(n,fwe)	X	X
Splittail	(n,fwe)	X	X
Cyprinodontidae			
Rainwater killifish	(i,me)	X	
Embiotocidae			
Tule perch	(n,r)	X	X
Gasterosteidae			
Threespine stickleback	(n,fwe)	X	X
Gobiidae			
Shimofuri goby	(i,r)	X	X
Yellowfin goby	(i,fwe)	X	X
Ictaluridae			
Black bullhead	(i,r)	X	X
Brown bullhead	(i,r)	X	
Channel catfish	(i,r)	X	X
White catfish	(i,r)	X	X
Mugilidae			
Striped mullet	(i,r)		
Osmeridae			
Delta smelt	(n,fwe)	X	X
Longfin smelt	(n,fwe)		X
Percichthyidae			
Striped bass	(i,a)	X	X
Percidae			
Bigscale logperch	(i,r)	X	X
Petromyzontidae			
Pacific lamprey	(n,a)	X	X
River lamprey	(n,fwe)	X	X
Pleuronectidae			
Starry flounder	(n,r)		X
Poecilidae			
Mosquitofish	(i,r)	X	X
Salmonidae			
Chinook salmon	(n,a)	X	X
Steelhead rainbow trout	(n,a)	X	X

[a] Classification: n = native, i = introduced, r = resident, a = anadromous, fwe = freshwater euryhaline, me = marine haline.

Table 2 Catch per unit effort (fish per kilometer) of common species observed during resident fish monitoring in the Sacramento–San Joaquin Delta in 1995–1999 and 2001–2002

Family and species	*1995*	*1997*	*2000*	*2001*	*2002*
Atherinidae					
Inland silverside	0.5	0.9	1.3	9.7	6.6
Catostomidae					
Sacramento sucker	0.8	2	2.9	2	0.2
Centrarchidae					
Black crappie	0.9	1.3	0.8	1	0.5
Bluegill	41.3	55.6	47.6	61.1	111.1
Green sunfish	0.3	1	0.5	0.8	0.3
Largemouth bass	20.1	22.5	20.8	34.7	24.9
Redear sunfish	12.6	23	20.2	31.3	51.9
Smallmouth bass	1.7	2.4	0.6	0.7	0.4
Warmouth	2.6	5.6	4.5	3.8	14.5
Clupeidae					
American shad	0	0.3	0	1.5	0
Threadfin shad	4.5	6	2.2	88.5	16.3
Cottidae					
Prickly sculpin	0.9	1.2	1.5	0.5	0.2
Cyprinidae					
Common carp	2.1	3.4	4.7	5.7	2.3
Golden shiner	9.1	6.3	3.7	8.3	2.7
Goldfish	0.2	0.4	0.3	0.4	0.2
Red shiner	0.01	0.05	2	0	0
Sacramento blackfish	0.01	0.3	0.3	0.2	0.3
Sacramento pikeminnow	1.1	0.7	1.4	0.9	2.1
Splittail	3	0.4	0.5	0.3	0.7
Embiotocidae					
Tule perch	3.1	4.1	1.4	2.8	0.7
Gobiidae					
Shimofuri goby	0.3	0.05	0.01	0.04	0.07
Yellowfin goby	0.7	1.1	0.2	4.5	0
Ictaluridae					
Brown bullhead	1.1	1.4	1	0.6	0.3
Channel catfish	0.8	0.4	0.9	1.2	0.3
White catfish	6.5	6.2	5.4	4.2	0.3
Osmeridae					
Delta smelt	0.1	0.1	0	0.1	0.07
Percichthyidae					
Striped bass	0.8	0.6	0.8	6.6	1.2
Percidae					
Bigscale logperch	0.3	0.2	0.1	2.1	0.1
Petromyzontidae					
Pacific lamprey	0.1	2	0.2	0.1	0.3
Poecilidae					
Mosquitofish	0.1	0.1	0.05	0.1	0.1
Salmonidae					
Chinook salmon	3.6	1.1	3.2	0.5	2.6
Steelhead rainbow trout	0.5	0.1	0.3	0.03	0.3
Total	119.22	150.7	129.06	274.24	241.24

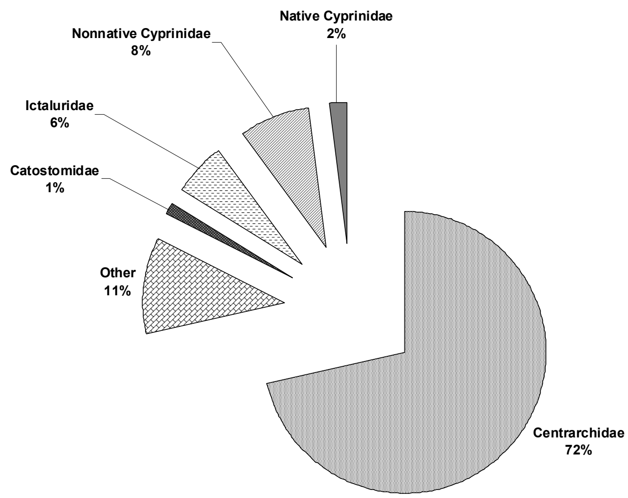

Figure 3 Catch of common families observed during resident fish monitoring in the Sacramento–San Joaquin Delta in 1995, 1997, and 1999

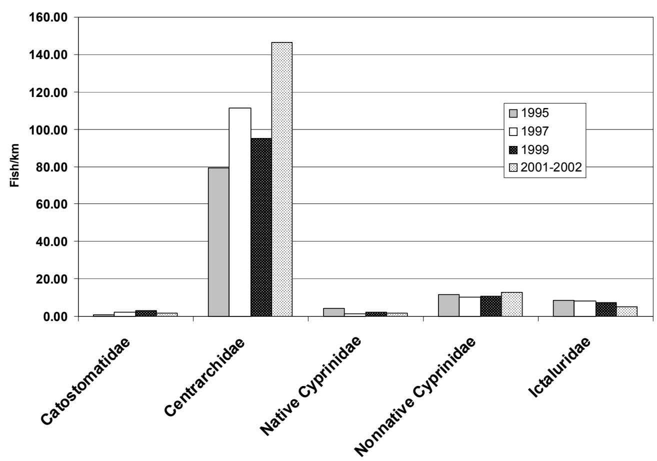

Figure 4 Catch per unit effort (fish per kilometer) of common families observed during resident fish sampling in the Sacramento–San Joaquin Delta in 1995–1999 and 2001–2002

Juvenile Chinook Salmon Abundance in the San Francisco Estuary

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U.S. Fish and Wildlife Service staff have employed a number of sampling methods since the late 1970s to monitor the abundance of juvenile chinook salmon in six areas within the Sacramento–San Joaquin Delta. Current methods include beach seining, midwater trawling, and Kodiak trawling. The lower Sacramento River beach seine survey is conducted on the Sacramento River between Elkhorn and Colusa (Area 1), the Delta area beach seine survey (North, Central, and South Delta) conducted from Discovery Park in Sacramento downstream on the Sacramento River to and throughout the Delta (Area 2, 3, and 4), the San Joaquin River beach seine survey from Mossdale upstream to the mouth of the Tuolumne River (Area 5), and the Bay Area beach seine in San Francisco and San Pablo Bay (Area 6) (Figure 1). Trawling areas include the Sacramento midwater and Kodiak trawls conducted just downstream from Sacramento on the Sacramento River at Sherwood Harbor (Area 2), the Mossdale Kodiak trawl conducted just downstream from Mossdale on the San Joaquin River (Area 5), and the Chipps Island midwater trawl conducted below the confluence of the Sacramento and San Joaquin rivers to south of Chipps Island (Area 3) (Figure 1).

For the period covered in this report (January 1, 2001, through December 31, 2001), the water year ending September 2001 was considered dry. While November and December 2001 were wet months, peak flows for the season were nearly as low as 1994, a critically dry season. These lower flows may have contributed to the overall lower catches for the season.

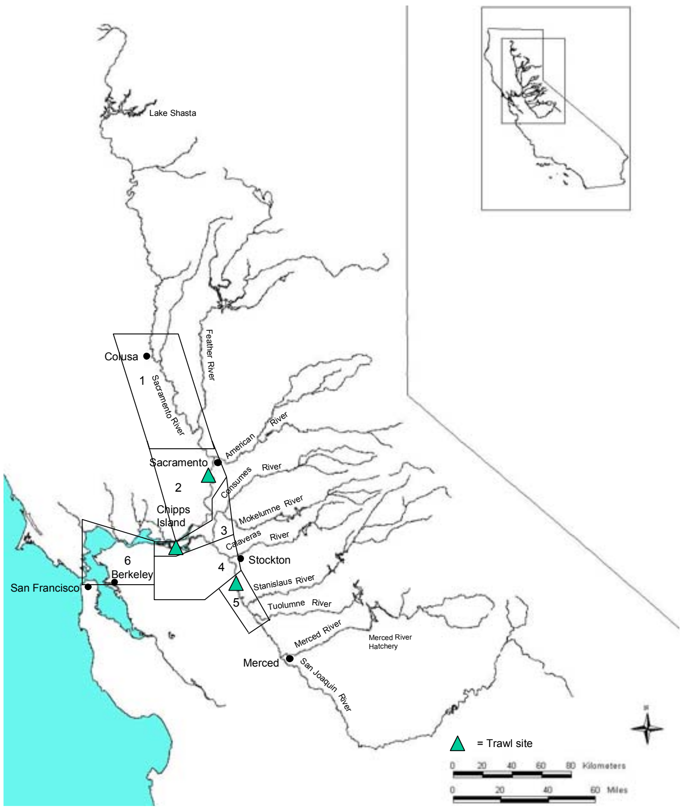

Figure 1 The San Francisco Estuary with areas sampled (boundaries indicated). 1 = lower Sacramento River, 2 = North Delta, 3 = Central Delta, 4 = South Delta, 5 = lower San Joaquin River, and 6 = San Francisco/San Pablo Bay.

Fall-run and spring-run chinook salmon fry (<70 mm) began entering the Delta in January, as in 2000 when low catches occurred (Figure 2). Fry or smolts were absent during December of 2000 and 2001, unlike 1993–1999. Peak emigration occurred between February and March in 2001; the run continued through July. A few smolts continued to enter the Delta from August through November. Consistent with past years, peak emigration occurred during a period of increasing flows. The greatest number of fry left the Delta at Chipps Island between April and May, coinciding with large hatchery smolt releases. The lower Sacramento River beach seine catches increased somewhat over the past year, but was still well below the peak in 1999. Delta area beach seine catches have fluctuated over the last decade and declined since 1999. Trawling catches at Sacramento continue to decline since 1996, with 2001 catches the lowest since 1993. This trend continued at Chipps Island where catches have declined since 1998; overall, 2001 catches were lower than 2000.

Between 1993 and 1999, late fall-run fry were caught each spring in the lower Sacramento River beach seine, but this did not occur in 2000 or 2001. This area produced the lowest seasonal catches since 1993, but some smolts were seen in November and December. Delta area beach seines showed a different trend: young of the year were caught in April and a larger number of smolts were caught in November and December. This produced a substantial increase in catch per cubic meter for 2001, although less than the peak years of 1998 and 1999. Sacramento trawls produced the third greatest catches since 1993 and an increase over the past three years. Chipps Island catches were fairly consistent over the past two years, but less than the peak in 1998. Peak emigration of late fall-run juveniles has not necessarily coincided with periods of greater flows, unlike with other races of juvenile chinook.

Of the four races of juvenile chinook salmon, only winter-run numbers have been generally increasing (Figure 4). In 2001, the lower Sacramento River beach seine produced the second, third, and fourth greatest monthly peak catches since 1993, with only November 1998 being greater. Except for 1999–2000, the trend has been a steady increase. Even with the cyclic fluctuations in the Delta area beach seines, the trend has been the same. November and December 2001 produced the greatest catches since 1993. Except for November 1998, the Sacramento trawls have produced the greatest catches since 1996, and the trend has been increasing since the low catch in 1997. Only at Chipps Island has this increase in catch not been evident for winter run. Instead, catches have remained relatively constant and well below the peak catches in 1995 and 1996. Like fall and spring run, peak emigration for winter run tends to occur around peak flow periods. Winter run tend to emigrate as smolts, whereas the majority of fall and spring run may emigrate as fry.

Numbers of fall-run juveniles captured in the lower San Joaquin River beach seine have continued to decline since the peak catches of 1998 and 1999 (Figure 5).

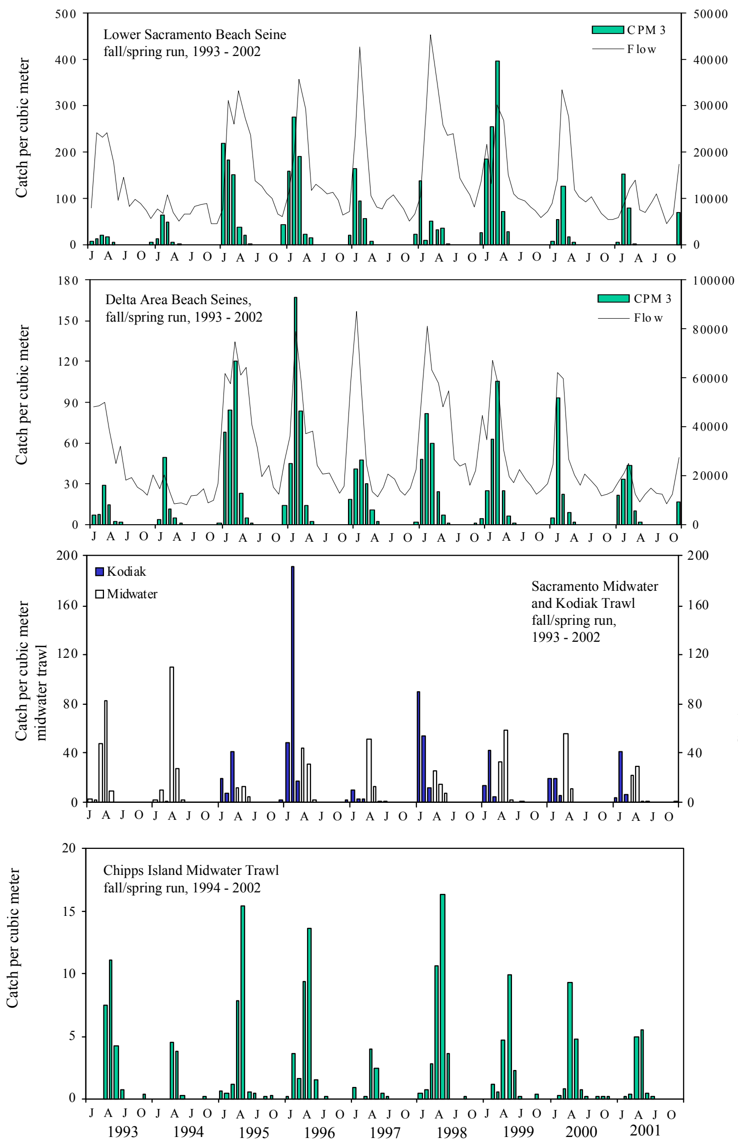

Figure 2 Juvenile fall- and spring-run chinook average monthly catch per cubic meter in the lower Sacramento River beach seine, Delta area beach seines, Sacramento midwater and Kodiak trawls, and Chipps Island midwater trawl (August 1, 1993, through December 31, 2001). Flows taken at Colusa and Freeport.

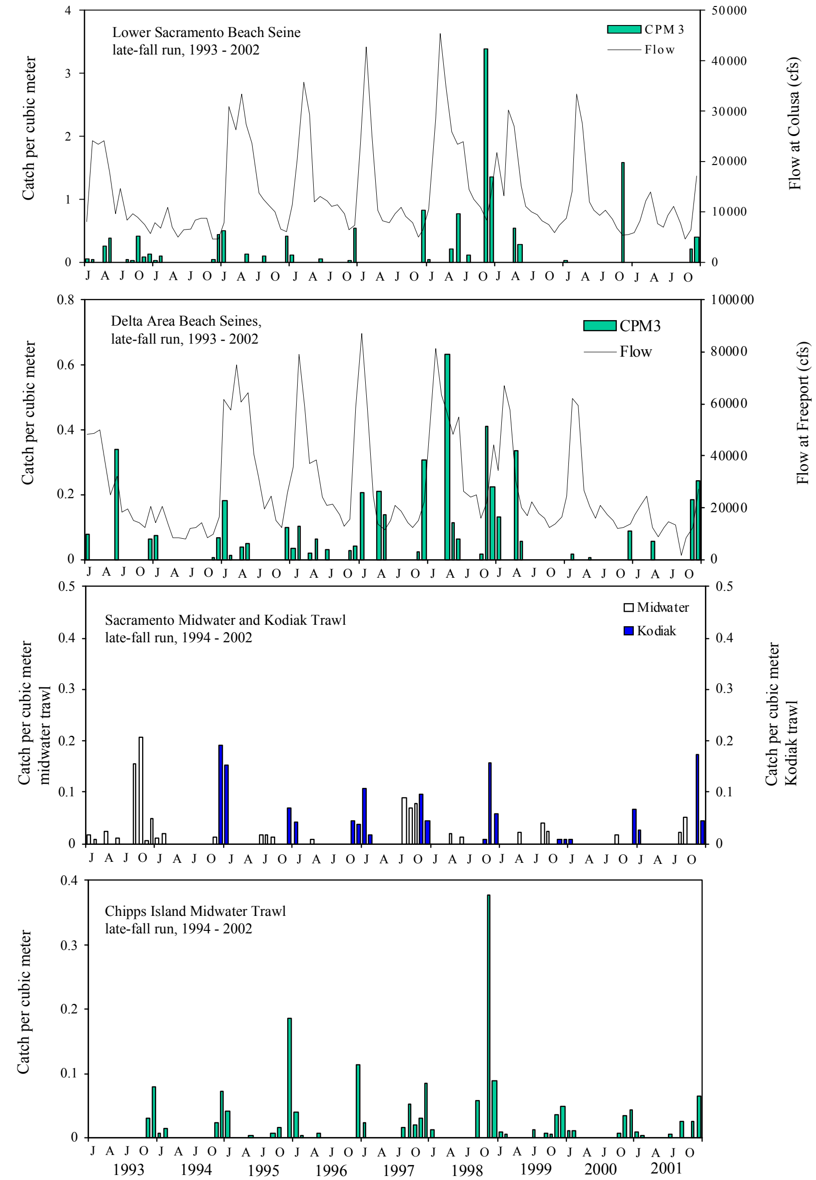

Figure 3 Juvenile late fall-run chinook average monthly catch per cubic meter in the lower Sacramento River beach seine, Delta area beach seines, Sacramento midwater and Kodiak trawls, and Chipps Island midwater trawl (August 1, 1993, through December 31, 2001). Flows taken at Colusa and Freeport.

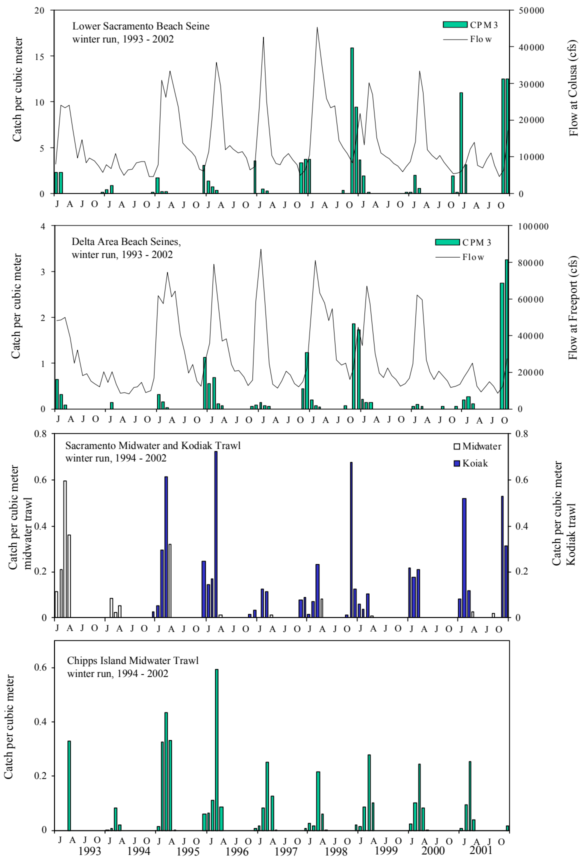

Figure 4 Juvenile winter-run chinook average monthly catch per cubic meter in the lower Sacramento River beach seine, Delta area beach seines, Sacramento midwater and Kodiak trawls, and Chipps Island midwater trawl (August 1,1993, through December 31, 2001). Flows taken at Colusa and Freeport.

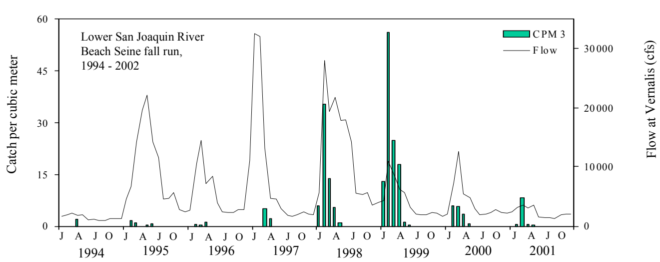

Figure 5 Juvenile fall-run chinook average monthly catch per cubic meter in the lower San Joaquin River beach seine (January 1994 through December 31, 2001). Flows taken at Vernalis.

In contrast to the beach seine results, the Mossdale Kodiak trawl has continued to show increasing numbers of fall-run juveniles in 2001, even with the lower flows (Figure 6). Unlike in 1999 and 2000, when two distinct peaks occurred each year, the first from natural production and the second from a hatchery component, catches in 2001 did not see comprise many juvenile chinook before the hatchery releases began in April. This may have been due to the lack of a peak flow early in the year. Without this indicator, fish may have held upstream for a longer period.

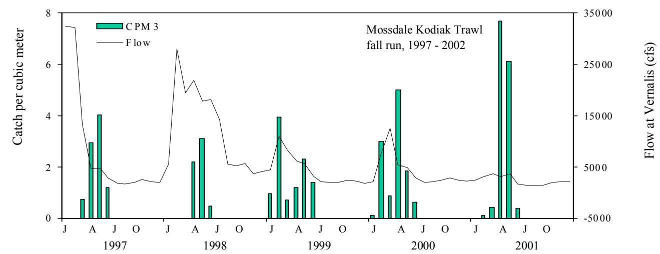

Figure 6 Juvenile fall-run chinook average monthly catch per cubic meter in the Mossdale Kodiak trawl (September 1996 through December 31, 2001). Flows taken at Vernalis.

The number of fry seen in the San Francisco–San Pablo Bay beach seines have declined since 1998 (Figure 7). In 2001, juveniles were only captured in May, making this the most abbreviated year in which fall run were detected. Typically they have been detected in the bay as early as January and have continued through May.

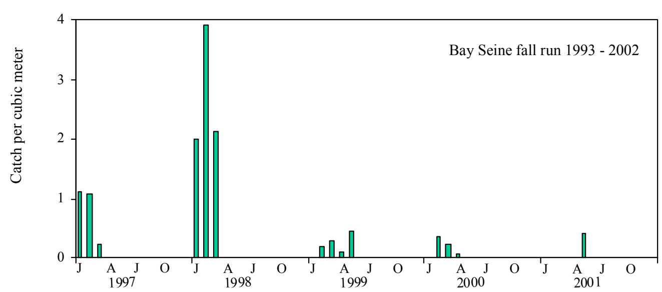

Figure 7 Juvenile fall-run and spring-run chinook average monthly catch per cubic meter in the San Francisco–San Pablo Bay beach seine (January 1997 through December 31, 2001). No late fall-run or winter-run chinook juveniles were captured during this sampling period.

Chinook Salmon Catch and Escapement

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The Pacific Marine Fisheries Council (PMFC) develops harvest levels to protect listed Central Valley winter-run and spring-run chinook, as well as Klamath River fall-run chinook. The council sets minimum size limits, gear restrictions, and seasonal restrictions to manage the fisheries south of Point Arena, California. These restrictions reduce harvest of all chinook runs, including fall and late fall runs. Most of the following information comes from the PMFC's *Review of the 2001 Ocean Salmon Fisheries*, published in February 2002.

Central Valley Fall-Run Chinook Salmon Ocean Harvest Index

The PMFC's Central Valley chinook fall-run ocean harvest index is an approximate harvest rate that is calculated by dividing the total ocean catch south of Point Arena by the catch plus escapement. The ocean harvest index does not include inland harvest, which may account for up to 25% of returning adults. In 2001 the PMFC's Central Valley fall-run chinook ocean harvest index dropped dramatically to 27%, a result of having both the greatest adult escapement and lowest ocean catch in the last 31 years (Figure 1). Central Valley fall-run escapement peaked at 561,500 spawners, while the ocean harvest dropped to about 219,000 (Figure 2).

The decrease in catch may be attributed to both a decrease in effort and the distribution of chinook. For the commercial fishery, the number of days fished (effort) decreased from 20,000 in 2000 to 12,500 in 2001. The number of recreational angler trips decreased from 214,400 in 2000 to 163,000 in 2001. In 2001 the commercial catch south of Point Arena was the lowest since 1971; however, in Oregon the commercial catch was the greatest since 1989, indicating that chinook may have been further north this year. In the last year alone the PMFC reported that the commercial catch in Oregon more than doubled from about 136,000 in 2000 to 277,000 in 2001.

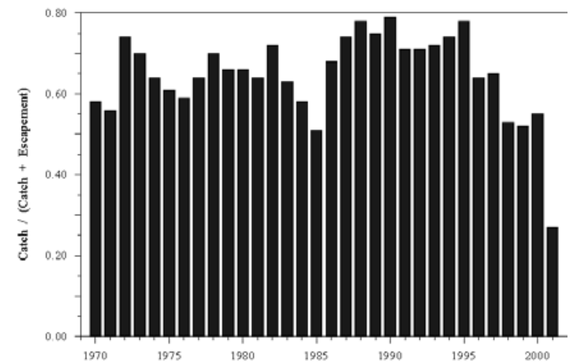

Figure 1 PFMC Central Valley fall-run chinook salmon ocean harvest index, 1970–2001

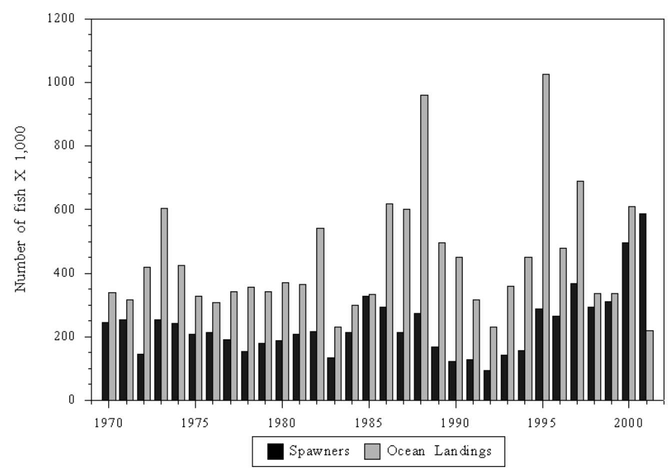

Figure 2 PFMC Central Valley chinook salmon ocean catch and fall-run adult spawner escapement, 1970–2001

Central Valley Fall-Run Chinook Salmon Escapement

In 2001 the Central Valley fall-run chinook escapement to the mainstem Sacramento River, the American River, and the Feather River were greatest for the 1970–2001 period of record (Figures 3, 4 and 5).

I calculated the cohort escapement by adding three-year-olds from the current year and two-year-olds from the previous year. In 2001 the PMFC set the escapement goal at a range of 122,000 to 180,000 natural and hatchery adults for the mainstem Sacramento River. In 2001 the estimated number of natural spawners was 504,400, far exceeding management goals (Figure 3). Natural spawner escapement in the American River increased from about

100,000 in 2000 to 180,700 in 2001 (Figure 4). In the Feather River the estimated natural spawner escapement increased from about 108,000 in 2000 to 170,000 in 2001 (Figure 5).

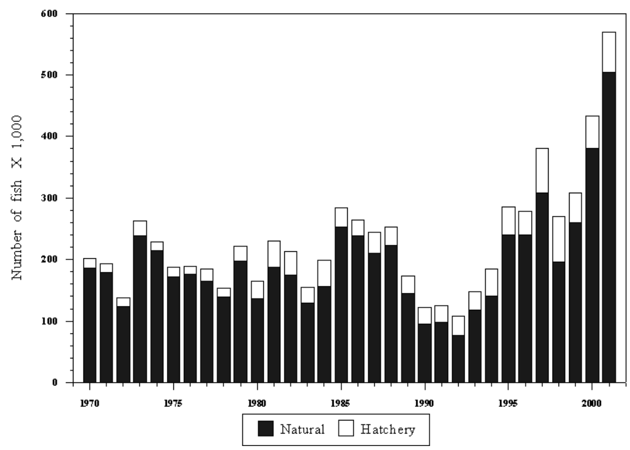

Figure 3 Annual fall-run escapement to the Sacramento River and major tributaries, natural and hatchery contribution

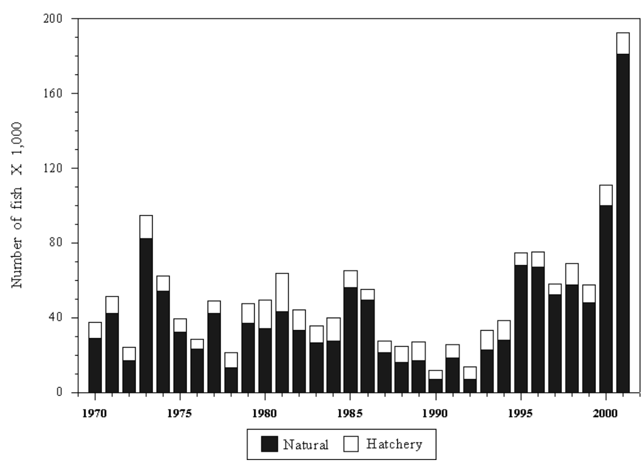

Figure 4 Annual fall-run escapement to the American River, natural and hatchery contribution

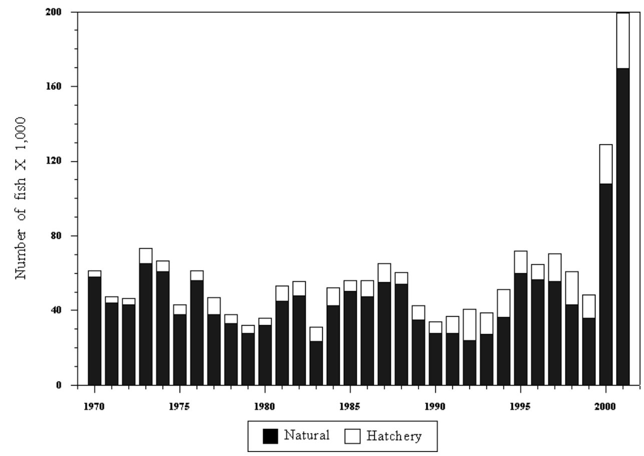

Figure 5 Annual fall-run escapement to the Feather River, natural and hatchery contribution

The fall-run cohort escapement (about 494,000) was also the greatest recorded in the last three decades (Figure 6).

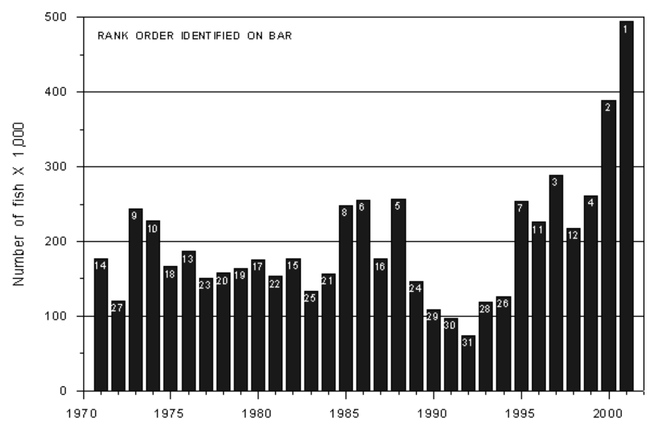

Figure 6 Annual natural fall-run cohort escapement to the Sacramento River and major tributaries

The estimated 2001 Yuba River fall-run escapement increased from 2,000 to about 22,000, but decreased from the 31,000 spawners three years earlier (Figure 7). Even though the number of spawners in 2001 was less than observed in 1998, the escapement was still greater than the 30-year average of 14,380.

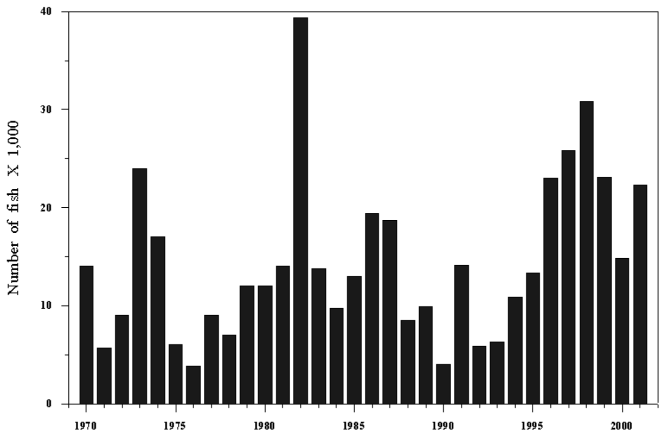

Figure 7 Annual natural fall-run escapement to the Yuba River

The estimated escapement on the San Joaquin River system decreased to about 22,000 in 2001 (Figure 8). However, it was greater than the 30-year average and increased slightly from the escapement three years earlier, indicating a positive cohort replacement rate. The San Joaquin River system includes spawners from the Mokelumne, Stanislaus, Tuolumne, and Merced rivers and has constituted less than 10% of the total Central Valley spawner escapement since 1986.

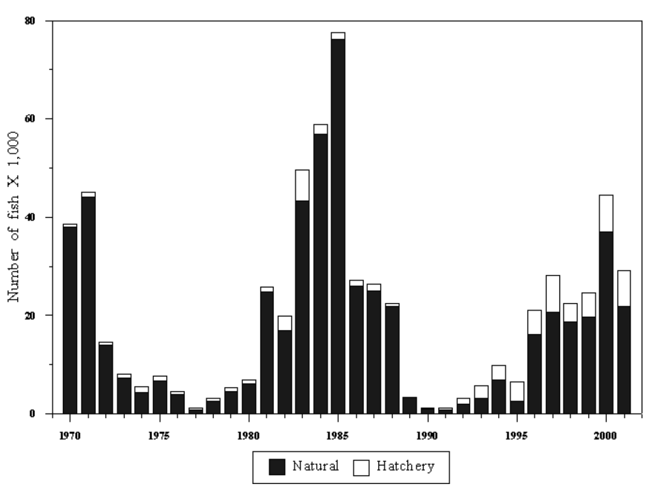

Figure 8 Annual fall-run escapement to the San Joaquin River system, natural and hatchery contribution

Sacramento River System Spring-Run Chinook Salmon Escapement

Annual spring-run escapement to the upper Sacramento River (1,000 fish) was at the greatest level since 1990. The number of natural spawners also increased on Mill and Deer creeks to an estimated 1,104 and 1,622, respectively. In 2001 Mill Creek showed the greatest escapement since 1975, and the number of spawners more than doubled from 1998. The Deer Creek escapement dropped slightly from approximately 1,880 in 1998.

The Butte Creek escapement continues to surpass the other spring-run tributaries and the mainstem Sacramento River with an estimated escapement of 9,605 (Figure 9). The only year with a greater escapement since 1956 was 1998, when it exceeded 20,000 spawners (Figure 9).

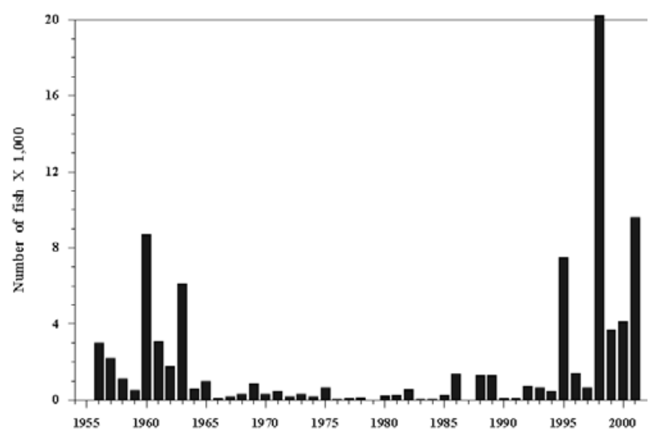

Figure 9 Annual spring-run escapement to Butte Creek, 1956–2001

Winter-Run Chinook Salmon Escapement to the Sacramento River Below Keswick Dam

The PMFC reported winter-run escapement to be 5,500 based on the extrapolated counts at Red Bluff Diversion Dam in 2001 (Figure 10). This was the greatest escapement since 1981 but over half (3,800) were jacks. Using the 1,700 returning three-year-olds, the three-year cohort replacement rate was 0.94, less than the PMFC target rate of 1.77. The gates at Red Bluff Diversion Dam were raised during much of the upstream migration to allow the passage of winter-run chinook. This change in operation results in a lower portion of the population being observed as they move up the ladders.

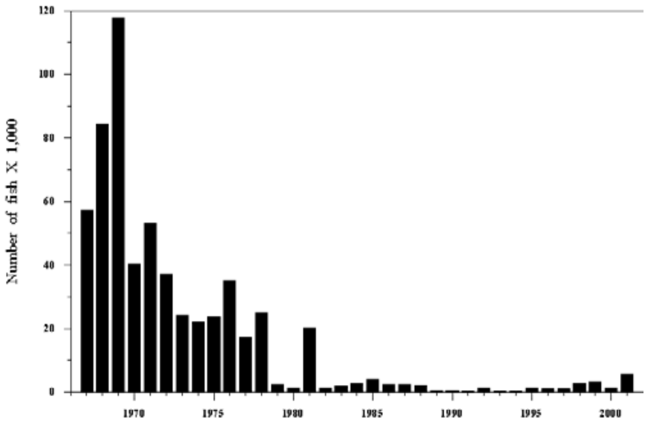

Figure 10 Annual winter-run escapement to the upper Sacramento River, 1967–2001

The National Marine Fisheries Service (NMFS) and California Department of Fish and Game (DFG) have used carcass surveys as an alternate method of estimating escapement. Based on the results from the carcass survey, NMFS and DFG estimated winter-run escapement to be 10,400 in 2001, compared to 5,400 in 1998. These results change the three-year cohort replacement rate to 1.94, greater than the PMFC target rate of 1.77. Currently, the two methods for estimating escapement are under review by NMFS, DFG, and PMFC.

A copy of the PMFC report, *Review of the 2001 Ocean Salmon Fisheries,* is available by calling (503) 326-6352. I thank Colleen Harvey Arrison (DFG) who provided data on the estimated spring-run chinook escapement to Mill, Deer, and Butte creeks.

Adult Striped Bass Abundance

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Adult striped bass abundance is estimated using the Petersen mark-recapture estimator. Each year, 4,000–18,000 legal-sized (>42 cm fork length) fish are captured and tagged in the spring when they are spawning in the western Sacramento-San Joaquin Delta and Sacramento River. These fish are caught in gill nets in the western Delta and in fyke traps in the Sacramento River. All fish in good condition are tagged below the spinous dorsal fin with an external, sequentially numbered, plastic disk-dangler tag. This large-scale tagging program began in 1969. We tagged annually until 1994; since then we have tagged every second year (even-numbered years).

Tag recaptures for abundance estimates come from our netting and trapping efforts during tagging in subsequent years and from a year-round creel census. Because reliable abundance estimates require observing as many tagged fish as possible, the creel census is designed to sample where the most striped bass are being landed.

Estimated abundance of legal-sized striped bass exhibited a long-term decline beginning in the early 1970s, when abundance averaged about 1.7 million fish, through 1994, when abundance reached a low of 600,000 (Figure 1). Since then, estimated abundance has increased dramatically, to about 1 million in 1996 and to over 3 million in 2000.

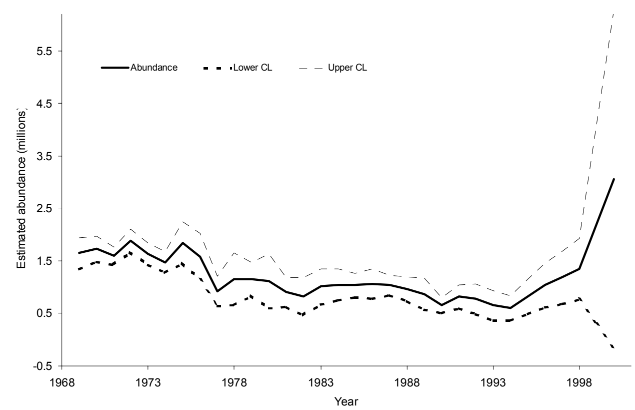

Figure 1 Trend in estimated adult striped bass abundance in the San Francisco Estuary from 1969 through 2000. Dashed lines depict the upper and lower 95% confidence limits for the estimates.

Unfortunately, and despite tagging more fish in 2000 than in any year since 1974, the number of recaptures that the 2000 abundance estimate is based on is very low, especially for three-year-old males (only one recapture). Thus, the precision of the 2000 estimate is poor, as shown by its wide confidence interval (Figure 1). As sample size increases with the inclusion of recaptures from this year's tagging and future creel censuses, precision should increase.

The reason for the increase in adult striped bass abundance since 1994 is unknown. Stocked fish, either from net pens or from hatcheries, have contributed only 2% to 6% of the population, far too little to account for a five-fold increase in abundance. Better spawning success or first-year survival do not provide an explanation because young-of-the-year abundance, measured by both the Summer Townet Survey and the Fall Midwater Trawl Survey, remained at historically low levels during the 1990s (see article by Souza and Bryant, p. 21). Density-dependent change in survival between the first year of life and recruitment to the fishery at age 3 has been suggested as a mechanism for the unexpected increase in adult abundance. However, the survival increase for the 1997 year class, among others, would have to be unrealistically high to explain high recruitment abundance in 2000.

Adult White and Green Sturgeon Abundance

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The California Department of Fish and Game began tagging sturgeon in the San Francisco Estuary in 1948. The present large-scale tagging program began in 1954, when the sport fishery reopened after being completely closed since 1917 (Pycha 1956). We have tagged sturgeon intermittently, primarily targeting white sturgeon, which is much more common than green sturgeon in the estuary.

We usually catch and tag sturgeon in September and October; however in 2001, we also sampled in August to target green sturgeon (Kogut 2002). We catch sturgeon in San Pablo Bay with a 366-m, variable-mesh, drift trammel net and attach disk-dangler reward tags below the dorsal fin of legal-sized sturgeon (117 to 183 cm total length, TL) (Chadwick 1963; Schaffter and Kohlhorst 1999). We identify sturgeon to species, and measure, tag, and release them on site.

We initially estimate white sturgeon abundance from recaptures of tagged fish during the same year using multiple-census methods (Ricker 1975). When recaptures occur in subsequent tagging years, we use the Petersen method (Ricker 1975) to replace the initial abundance multiple-census estimate. We calculate all abundance estimates for sturgeon >102 cm TL, the minimum legal size limit established before 1990 (Schaffter and Kohlhorst 1999).

We estimate green sturgeon abundance by multiplying white sturgeon abundance estimates by the ratio of green sturgeon to white sturgeon (>102 cm TL) caught during tagging. No independent estimates of green sturgeon abundance are available because no tagged green sturgeon have been recaptured during tagging.

Assumptions inherent is abundance estimates include equal vulnerability of both species to capture and similar movements and temporal distribution of both species. Because these assumptions are not likely met, green sturgeon abundance estimates should be viewed with caution.

White and green sturgeon abundance estimates have varied substantially (Figures 1 and 2). Recently, white sturgeon abundance estimates have been large (ranging from 120,000 in 2001 to 144,400 in 1998), although estimates have not changed significantly since 1954 ($F_{1,12} = 0.47$, $P = 0.50$).

The estimated green sturgeon abundance in 2001 (8,421) was the greatest of record. Green sturgeon abundance estimates since 1954 have shown no significant trend ($F_{1,11} = 2.05$, $P = 0.18$), unless data from 2001 are included ($F_{1,12} = 6.16$, $P = 0.03$).

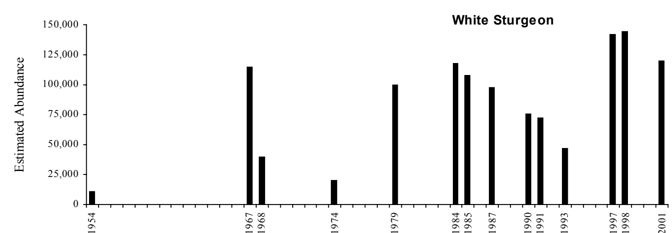

Figure 1 Estimated abundance of white sturgeon (>102 cm TL) in the San Francisco Bay Estuary, 1954–2001

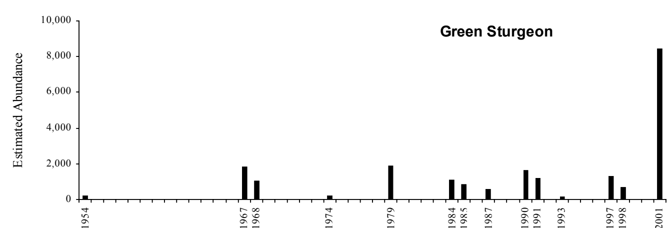

Figure 2 Estimated abundance of green sturgeon (>102 cm TL) in the San Francisco Bay Estuary, 1954–2001

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Fish Salvage at the State Water Project and Central Valley Project

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Introduction

Two large fish salvage facilities in the Sacramento-San Joaquin Delta, the Central Valley Project's Tracy Fish Collection Facility (TFCF) and the State Water Project's Skinner Delta Fish Protective Facility (SDFPF), remove (salvage) fish from exported water. Both facilities use a louver-bypass system to collect entrained fish, which are then transported to release sites in the Delta. The TFCF began operation in 1957 and the SDFPF in 1968. The total number of collected fish (salvage) is estimated from sub-samples of fish collected at least every two hours while water is being pumped.

Water Exports in 2001

State Water Project (SWP) water exports totaled about 2.85 billion m^3 (2,319,000 acre-feet) in 2001, compared to about 4.61 billion m^3 (3,739,000 acre-feet) in 2000. During 2001, monthly water exports at the SWP ranged from a low of about 13.65 million m^3 (11,100 af) in June to a high of about 463.16 million m^3 (376,500 af) in December (Figure 1). This range was lower than the 2000 range of about 120.5 million m^3 (97,700 af) to about 518.4 million m^3 (420,300 af). SWP water exports in 2001 were lower than those in every month of 2000, except for March and December. Water exports were especially low in June 2001 due to shut-downs for repairs to the California Aqueduct.

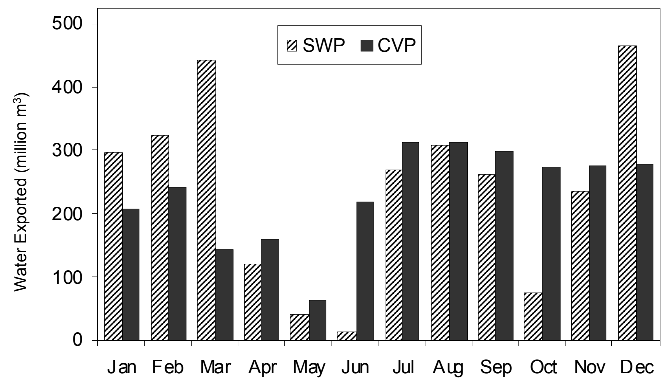

Figure 1 SWP and CVP monthly water exports in 2001

Central Valley Project (CVP) water exports totaled about 2.79 billion m^3 (2,263,000 af) in 2001, compared to about 3.16 billion m^3 (2,558,000 af) in 2000. Monthly water exports at the CVP in 2001 ranged from a low of about 64.9 million m^3 (53,000 af) in May to about 313 million m^3 (about 254,000 af) in both July and August (Figure 1), slightly lower than the 2000 range of about 102.4 million m^3 (83,000 af) to about 332.5 million m^3 (269,600 af). CVP water exports in 2001 were greater than SWP water exports from April through November.

Water Temperatures

On average, water temperatures were warmer at the CVP than at the SWP (Figure 2). The mean annual water temperature at the SWP was 15.4 °C and 17.9 °C at the CVP facility. Water temperatures peaked around July 5 to approximately 26 °C. Water temperatures were coolest during the third week of January at both export facilities, decreasing to about 6 °C at the SWP and about 8 °C at the CVP. The SWP experienced a precipitous rise and fall in temperature from May 4 through May 14; water temperatures rose 7.6 °C during an eight-day period, but then dropped 5 °C during the following three days.

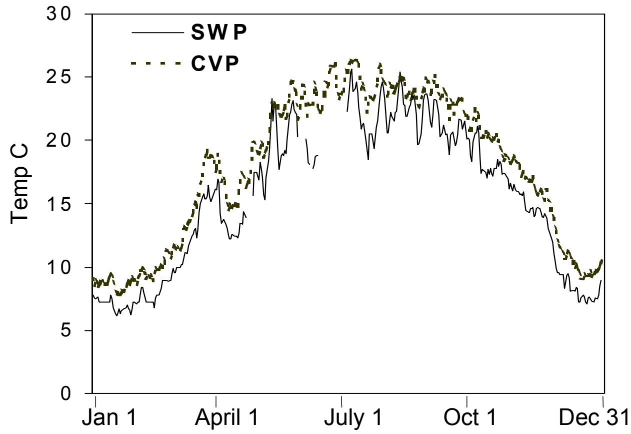

Figure 2 Daily water temperatures at the SWP and CVP fish facilities in 2001

Fish Salvage

In 2001 almost 5.2 million fish were salvaged at the SWP, and over 5.4 million fish were salvaged at the CVP. At both facilities, threadfin shad was the predominant species. Threadfin shad accounted for 72.6% of the annual salvage at the SWP (Figure 3) and 65% of the annual salvage at the CVP (Figure 4).

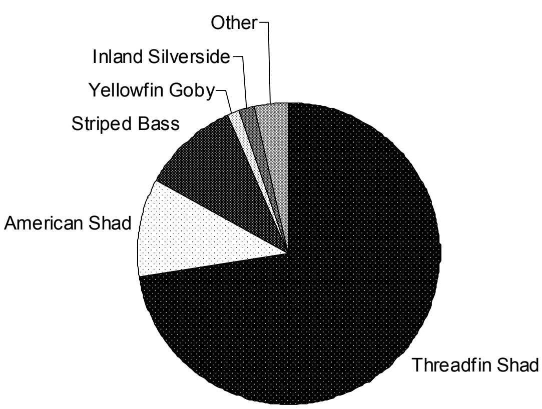

Figure 3 Relative species contribution to 2001 total annual salvage at the SWP

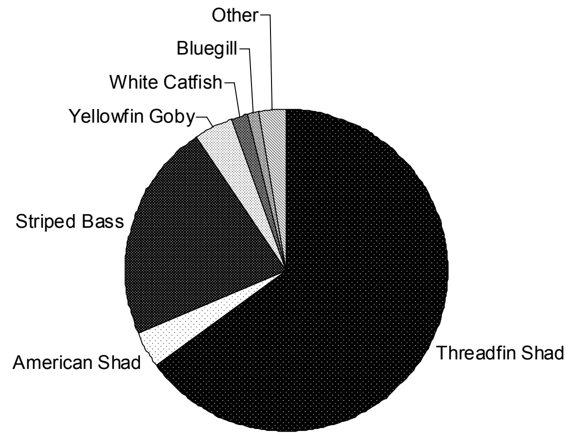

Figure 4 Relative species contribution to 2001 total annual salvage at the CVP

Density of fish (numbers of fish salvaged per 10,000 m^3 of water exported) was greatest at the SWP in July (129) and at the CVP in June (71) (Figure 5). Threadfin shad accounted for most of the salvage in July at the SWP (81%), and striped bass and threadfin shad together comprised most of the CVP salvage during June (95%).

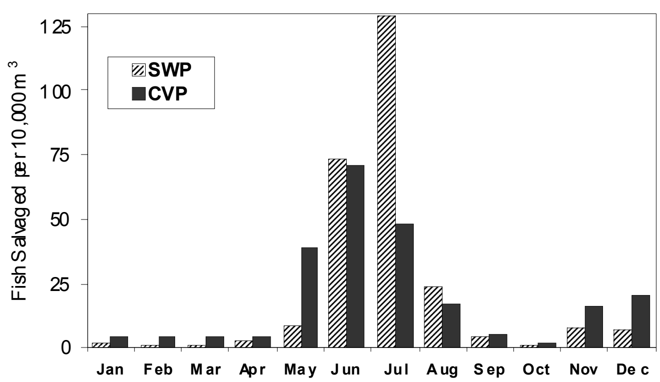

Figure 5 Fish salvage density at the SWP and CVP in 2001

Delta Smelt

Estimated delta smelt salvage at the SWP in 2001 was 13,219, fewer than the 85,000 salvaged in 2000. About half of the delta smelt at the SWP were salvaged during May (Figure 6).

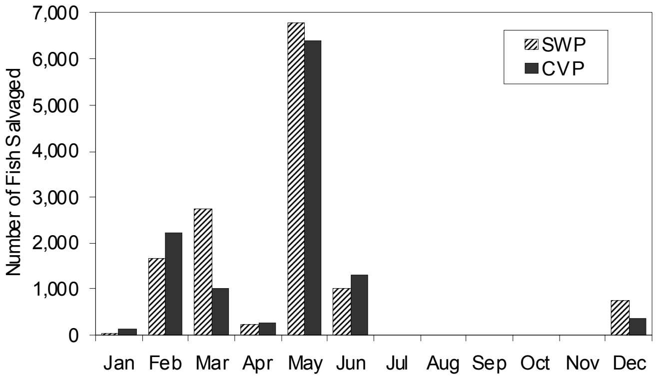

Figure 6 Monthly salvage of delta smelt at the SWP and CVP in 2001

About 11,700 delta smelt were salvaged at the CVP in 2001. More than 2,200 adults were salvaged in February (Figure 6), continuing a three-year trend of unusually large delta smelt salvage in February not seen since the early 1980s. About 7,700 young-of-the-year (YOY) delta smelt were salvaged in May and June, about a third of the 2000 YOY salvage and only about a sixth of the YOY salvage in 1999.

Chinook Salmon

Combined (SWP + CVP) salvage of chinook salmon for 2001 was 57,806, less than half of the 123,800 salvaged in 2000, lower than the 1991–2000 average (86,209), and much lower than the 1981–1990 average (343,630). About 4.4% of the salmon salvaged last year were adipose fin clipped, indicating hatchery origin (Table 1).

Of the naturally-produced salmon, over half (56%) were fall run (as determined by fork length), 32% were spring run, and the remainder (11%) were winter run (Figure 7).

Table 1 Chinook salmon salvage at the CVP and SWP in 2001

	SWP		*CVP*		
Race	*Clipped*	*Un-clipped*	*Clipped*	*Un-clipped*	*Total*
Fall	507	14,318	630	16,620	32,075
Late Fall	70	40	36	0	146
Winter	732	4,520	264	1,753	7,269
Spring	150	7,962	120	9,972	18,204
Total	1,459	26,840	1,050	28,345	57,694

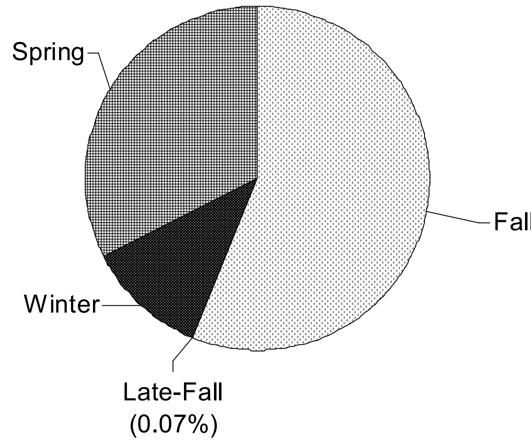

Figure 7 Percent of chinook salmon runs in 2001 salvage at the SWP and CVP. Race determined solely by fork length.

The CVP and SWP salvaged nearly equal numbers of chinook salmon during 2001 (Figure 8). Salmon salvage at both facilities peaked in April; almost 75% of the annual salmon salvage at the CVP was collected in April (Figure 9).

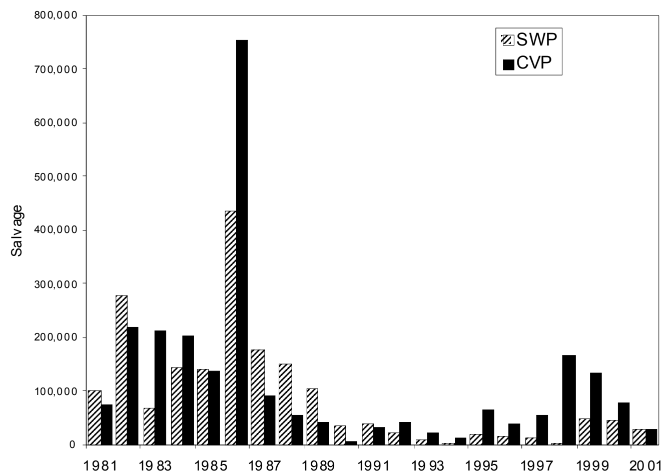

Figure 8 Annual chinook salmon salvage at the SWP and CVP

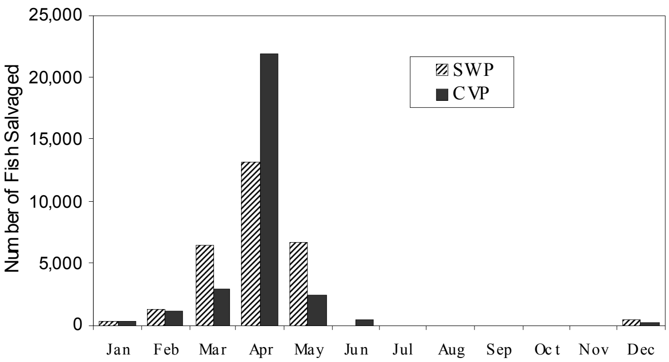

Figure 9 Monthly salvage of chinook salmon at SWP and CVP

Salmon loss, an estimate of mortality resulting from entrainment at the export facilities, is based on pre-screen loss (predation), louver efficiency, and handling and trucking mortality. Total salmon loss (SWP + CVP) in 2001 was about 135,000, more than twice the salmon salvage. Approximately 5% of the salmon lost were adipose fin clipped (Table 2). SWP loss was much greater than CVP loss (Table 2), reflecting the large, estimated predation mortality rate (75%) in Clifton Court Forebay.

Table 2 Chinook salmon loss at the CVP and SWP fish salvage facilities in 2001

	SWP		*CVP*		
Race	*Clipped*	*Un-clipped*	*Clipped*	*Un-clipped*	*Total*
Fall	2,335	61,418	510	11,953	76,217
Late Fall	303	177	23	0	503
Winter	3,234	19,949	193	1,266	24,642
Spring	630	33,911	96	6,758	41,396
Total	6,502	115,455	822	19,978	142,757

Steelhead Trout

Steelhead salvage at both facilities in 2001 was the greatest since 1993. The SWP salvaged 8,104 steelhead, almost twice the 1991–2000 mean of 4,261, and the CVP salvaged 4,553, exceeding the 1991–2000 mean of 3,332. Steelhead salvage was greatest during February at the CVP and during March at the SWP (Figure 10).

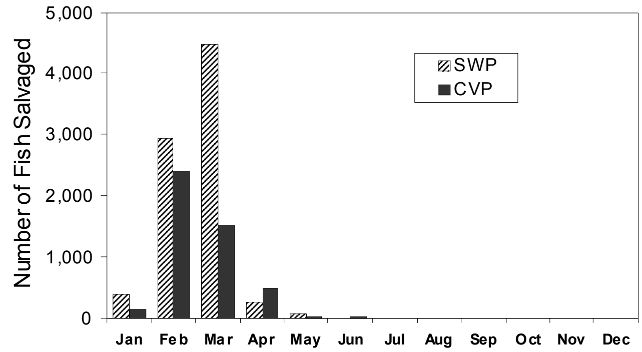

Figure 10 Monthly salvage of steelhead at SWP and CVP

About 65% of the steelhead salvaged at both facilities were adipose fin clipped, indicating hatchery origin. In 2000, 65% of steelhead salvaged at the SWP were hatchery reared, but only 44% of steelhead salvaged at the CVP were hatchery reared.

Striped Bass

In 2001, the SWP salvaged about 534,000 striped bass, far below the 1991–2000 average of 2.22 million. At the CVP, more striped bass were salvaged (1.18 million) than in any year since 1994, and salvage was only slightly less than the ten-year average of 1.3 million (Figure 11). Striped bass salvage density peaked in June at both facilities (Figure 12). However, relative SWP salvage was very low because of the abnormally low water exports that month due to repairs to the California Aqueduct.

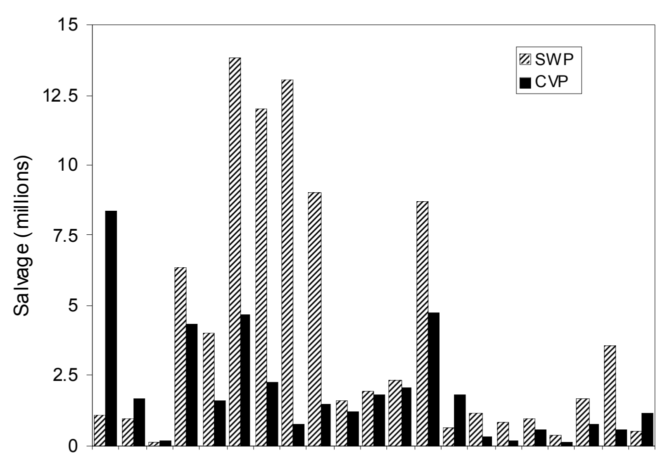

Figure 11 Annual striped bass salvage at SWP and CVP

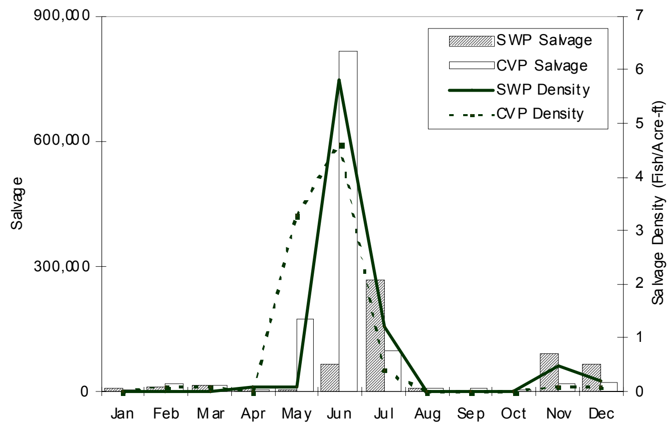

Figure 12 Monthly salvage and salvage density of striped bass at SWP and CVP

American Shad

About 541,000 American shad were salvaged in 2001 at the SWP and about 196,000 at the CVP, both lower than the 1991–2000 average (Figure 13). Salvage of American shad at the SWP peaked at just over 300,000 in July. In contrast, relatively few American shad were salvaged in July at the CVP (<7,000). At the CVP, salvage of American shad was greatest in December. Since 1981, American shad salvage at both facilities has generally increased (Figure 13).

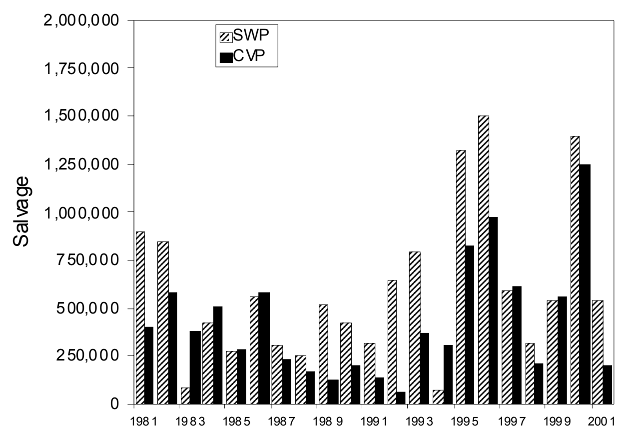

Figure 13 Annual American shad salvage at SWP and CVP

Splittail

Combined (SWP + CVP) splittail salvage in 2001 was only 13% of the combined total in 2000. Combined splittail salvage in 2001 was also lower than in most years since 1980, except 1994 and 1992 (Figure 14). Splittail salvage totals in 1986, 1995, and 1998 dwarf the salvage totals in 2001 and all other years since 1980.

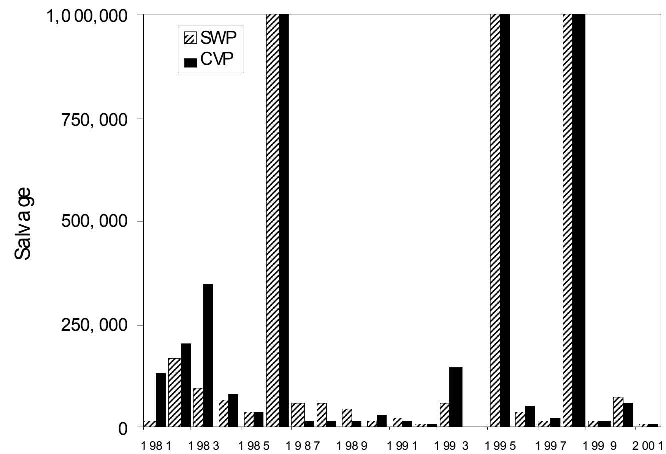

Figure 14 Annual splittail salvage at SWP and CVP. Salvage numbers for 1986, 1995, and 1998 were truncated for scale: 1986; 1,160,305 (SWP) and 1,231,283 (CVP); 1995; 2,190, 517 (SWP) and 3,143,156 (CVP); 1998; 1,042,484 (SWP) and 2,046,704 (CVP).

Adult splittail salvage from January through April in 2001 was much greater at the SWP than at the CVP (Figure 15). Adult salvage was also greater than young-of-the-year (YOY) salvage at the SWP, mainly because of drastically reduced water exports in June. YOY salvage at the CVP occurred later in 2001 than in 2000; in 2001 salvage was greatest in June, whereas the peak occurred in May in 2000. In 1999, splittail salvage peaked in July at both facilities.

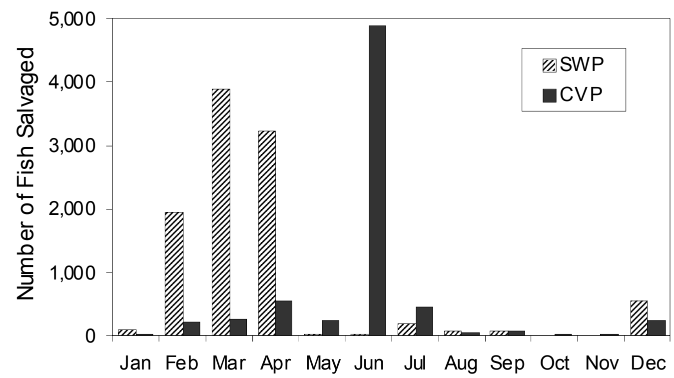

Figure 15 Monthly splittail salvage at SWP and CVP

Longfin Smelt

Many more longfin smelt were salvaged in 2001 than in any year since 1994; 2,175 were salvaged at the SWP and 4,404 at the CVP. Most of the salvage occurred in May at the SWP and in April at the CVP.

Chinese Mitten Crab

Mitten crabs are considered a nuisance at the SWP and CVP fish facilities because they interfere with effective fish salvage. Control devices have been designed and used at both facilities to exclude mitten crabs from fish holding tanks. No crab control device was installed at the SWP in 2001. A traveling screen, originally designed to remove debris (Siegfried 1999; White and others 2000) has been placed in the secondary channel at the CVP. The traveling screen consists of a belt of vertical plastic-coated cables held in place by horizontal rods (White and others 2000) and has undergone many modifications since it was first tested in 1998. As the rods grasp the cable, crabs are lifted from the channel by the rotating belt and, after being dislodged by a high-pressure water stream, crabs are deposited into a hopper and then moved by conveyer to a disposal container. Crabs are then counted and sexed.

The greatest numbers of adult Chinese mitten crabs are collected at the fish facilities during their downstream migration from September through December. During the period of greatest crab salvage, crabs removed by the traveling screen were usually counted twice per day, at 0700 and 1700 h. Using data only from days when counts were performed twice daily and the traveling screen was operational for the full 24-hour period, about 81% of the mitten crabs were counted in the 0700-h count, indicating more crabs were removed during the hours between 1700 to 0700.

At the CVP, the first adult mitten crab of the fall 2001 migration season was salvaged on August 7. Daily crab counts peaked at the CVP on September 29, when almost 1,000 crabs entered the facility (Figure 16). About 18,144 crabs entered the holding tanks and an additional 9,294 crabs were removed by the traveling screen, making a total of 27,438 crabs salvaged at the CVP in 2001. The number of crabs salvaged in 2001 was much greater than in 2000, but less than in 1999 (about 40,000). Including the traveling screen counts, 66% of the crabs were male.

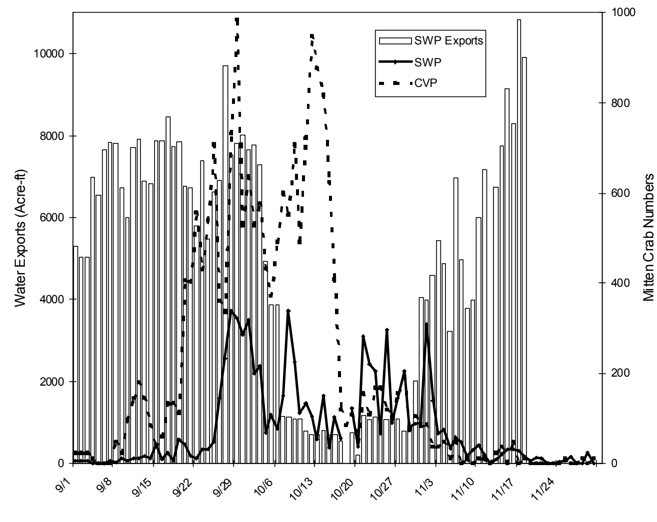

Figure 16 Daily mitten crab counts at the SWP and CVP and SWP water exports in 2001

During the 2001 fall migration season, 7,293 mitten crabs were salvaged at the SWP, far less than the number salvaged at the CVP. This was due mainly to a water export curtailment at the SWP that occurred during the height of crab migration. As mitten crab counts increased at both facilities in early October, SWP water exports were reduced substantially due to water quality concerns, keeping the number of crabs entering the state facility low (Figure 16). Crab numbers at the SWP reached a maximum of 340 per day in early October, while crab numbers at the CVP regularly exceeded 500 per day and were as great as 984 per day (Figure 16).

For further information about salvage at the SWP and CVP, access the DFG Central Valley Bay Delta Branch website at http://www.delta.dfg.ca.gov/data/salvage.

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CONTRIBUTED PAPERS

Exposure of Delta Smelt to Dissolved Pesticides in 2000

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Introduction

Delta smelt abundance in San Francisco Estuary has been declining since 1983. The exposure of delta smelt to toxic pesticides during larval and juvenile life stages may be one possible factor of this decline (Bennett and Moyle 1996; Moyle and others 1996). Although pesticides have been detected in the Delta (MacCoy and others 1995; Kuivila and others 1999), minimal data on pesticide concentrations and the duration of occurrence in delta smelt habitat are documented. A three-year study (1998–2000) was undertaken by the U.S. Geological Survey (USGS) to quantify the exposure of larval and juvenile delta smelt to dissolved pesticides. Moon and others (2000) reported on the exposure of delta smelt to dissolved pesticides in 1998 and 1999, and this article follows up on Moon's work and reports the results from late spring and summer of 2000.

Survey Area and Methods

Delta smelt typically spawn in spring in shallow areas throughout the Sacramento–San Joaquin Delta (Moyle and others 1992, 1996). Specific spawning locations vary from year to year, depending on environmental conditions; however, delta smelt have been consistently found spawning in the northwestern Delta, including Cache and Lindsey sloughs (Figure 1). As juveniles, delta smelt move downstream and congregate near the confluence of the Sacramento and San Joaquin rivers (Figure 1) in waters of salinity near 2 ppt (Moyle and others 1992, 1996).

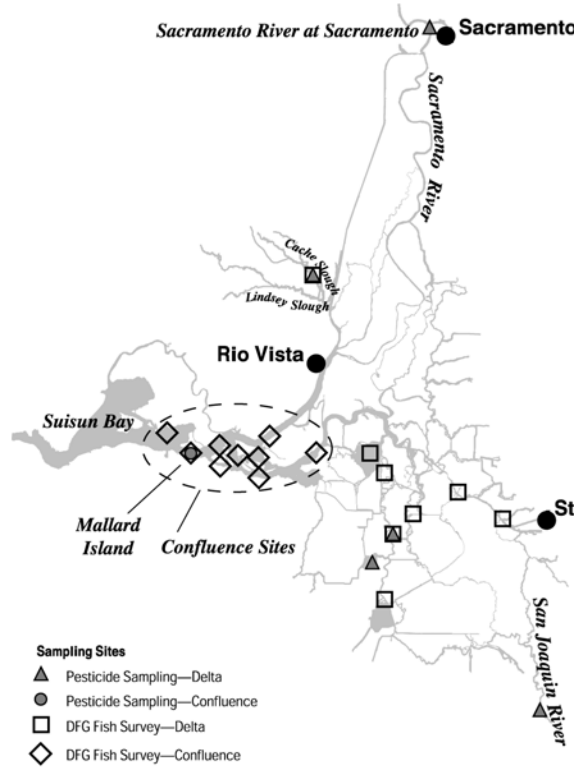

Figure 1 Map of sampling locations for the USGS pesticide analysis and DFG 20-mm Survey in areas of delta smelt habitat in the Sacramento–San Joaquin Delta

The USGS collected water samples for pesticide analysis at six sites from late April to late July, when larval and juvenile delta smelt were expected to occur. Water samples were collected every two weeks at four Delta sites and weekly at two sites (Sacramento River at Sacramento and Suisun Bay at Mallard Island, Figure 1). Samples were analyzed for selected dissolved pesticides using the methods described in Crepeau and others (2000). Total pesticide concentrations were calculated as the sum of all pesticides measured in a single sample.

Concurrent with the USGS pesticide analysis sampling, the California Department of Fish and Game collected delta smelt density data from 17 sites (Figure 1) as part of their 20-mm Survey, which collects both larval and juvenile delta smelt. This concurrent sampling allowed direct comparison of pesticide concentrations and fish abundances.

Exposure of delta smelt to dissolved pesticides was estimated by examining the overlap of measured fish densities and measured dissolved pesticides. To compare pesticide concentrations and fish densities within the Delta, pesticide concentrations from four of five Delta sites (marked with triangles in Figure 1) were averaged and compared with fish densities averaged for eight Delta sites (marked with squares in Figure 1) for each sampling date. The Sacramento River at Sacramento site was sampled as a primary source of pesticides to delta smelt habitat and was considered a Delta site for the purpose of this article. To compare pesticide concentrations and fish densities at the confluence, total pesticide concentrations were sampled at Suisun Bay at Mallard Island and fish densities were averaged over nine sites (marked with diamonds in Figure 1) within the confluence area.

Results

Measured Pesticide Concentrations in Delta Smelt Habitat

Water samples collected in from delta smelt habitat during spring and summer 2000 contained 19 detected pesticides (Table 1). Fifty-four samples were collected, each containing from 3 to 12 pesticides (Figure 2).

Table 1 Percentage of pesticides detected and maximum concentrations in water samples collected from delta smelt habitat in 2000

Constituent	*Samples detected[a] (%)*	*Maximum concentration (ng/L)*
Alachlor	6	17
Atrazine	54	32
Butylate	11	22
Carbaryl	17	72
Carbofuran	57	50
Chlorpyrifos	11	32
Cycloate	11	38
Dacthal	8	11
Diazinon	24	30
EPTC	52	550
Ethafluralin	4	30
Fonofos	4	5
Metolachlor	91	210
Molinate	83	3,000
Oxyfluorfen	7	80
Pendimethelin	19	31
Simazine	57	49
Thiobencarb	76	1,300
Trifluralin	59	44

[a] Values given are the percentage of samples (n = 54) in which each pesticide was detected.

Metolachlor, the most frequently detected pesticide, was detected in 91% of the samples. Molinate and thiobencarb were detected in 83% and 76% of the samples, respectively. Other frequently detected pesticides (52% to 59%) included atrazine, carbofuran, EPTC, simazine, and trifluralin. Molinate and thiobencarb also had the greatest concentrations, with maximum levels reaching 3,000 and 1,300 ng/L, respectively (Table 1).

In general, nearly the same pesticides were detected with similar frequency in all three years of the study. Only atrazine and trifluralin were detected more frequently (three to five times) in 2000 than in 1998 and 1999, but their concentrations were relatively low with maximum concentrations of 32 and 44 ng/L, respectively (Table 1). In all three years, the pesticides with the greatest concentrations were EPTC, molinate, and thiobencarb.

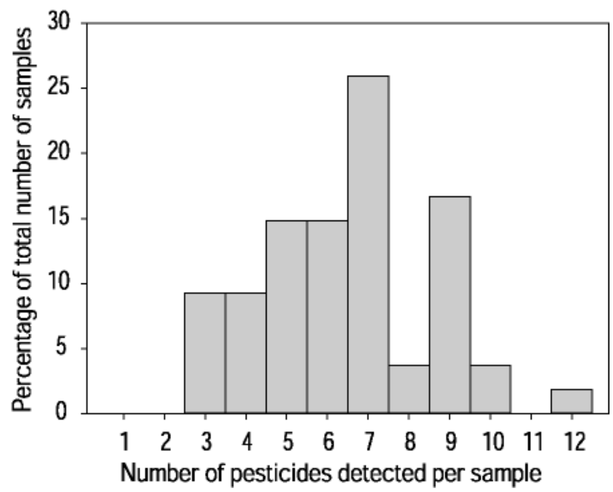

Figure 2 Number of pesticides detected per water sample collected from delta smelt habitat in 2000

Exposure of Delta Smelt to Dissolved Pesticides

Delta smelt were present in the Delta from mid-April through the end of the fish sampling surveys in late June, and their densities remained relatively constant (Figure 3A). Concentrations of pesticides in the Delta were elevated throughout this same period, especially in mid-May; therefore, larval delta smelt were exposed to dissolved pesticides for weeks to months in the Delta (Figure 3A). Total pesticide concentrations at the Sacramento River at Sacramento site were much greater than at other Delta sites (note different scale) and are shown separately in Figure 3A. This difference occurred because of the input of rice field water, which contained elevated concentrations of molinate and thiobencarb, into the Sacramento River (Crepeau and Kuivila 2000).

Delta smelt migrated toward the confluence and continued to be exposed to elevated concentrations of dissolved pesticides through mid-June (Figure 3B). In contrast to Delta sites, fish abundance in the confluence peaked in the first week of June. We observed the greatest number of delta smelt co-occurred with the greatest total concentrations of pesticides at the confluence on June 14 (Figure 3B). The observed peak in pesticide concentration was primarily due to the two rice pesticides, molinate and thiobencarb.

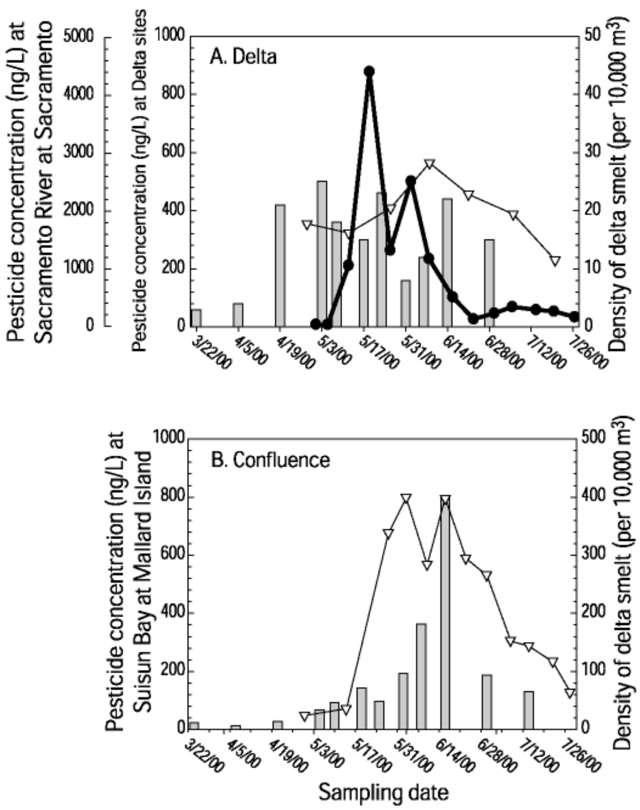

Figure 3 Co-occurrence of pesticides and delta smelt in the Sacramento-San Joaquin Delta (A) and at the confluence of the Sacramento and San Joaquin rivers (B). (A) Circles represent total pesticide concentration at Sacramento River at Sacramento; triangles represent average of total pesticide concentrations at the other four Delta sites; and bars represent average fish abundance at eight Delta sites. (B) Triangles represent total pesticide concentrations at Suisun Bay at Mallard Island and bars represent average fish abundance at nine Confluence sites.

Conclusions

Overall, the detection of multiple pesticides in all samples collected in delta smelt habitat in spring and summer of 2000 was similar to the findings in 1998 and 1999 (Moon and others 2000). Elevated pesticide concentrations in the Delta and at the confluence co-occurred with the presence of larval and juvenile delta smelt for weeks to several months. Although these concentrations are well below LC50 values (Tomlin 1997), the concentrations could potentially cause sublethal effects on delta smelt, especially during early larval development. The combination of multiple pesticides and chronic exposure could hinder growth rate, reproduction, and swimming performance, or indirectly, cause such effects as alteration of diet (Rand 1995). More information on chronic exposure to pesticide mixtures is needed to evaluate the potential effects of environmental pesticide exposures on the delta smelt population.

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Adult Chinook Salmon Migration Monitoring at the Suisun Marsh Salinity Control Gates, Sept.–Nov. 2001

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Introduction

In October 1988, the Suisun Marsh Salinity Control Gates (SMSCG) were installed in Montezuma Slough to meet water quality criteria in Suisun Marsh. The structure consists of three radial gates, a section of removable flashboards, and a boat lock. As part of the permit to build the gates, a monitoring program was developed to study the effects of the gates on migratory fish. Of special concern were winter-run chinook salmon, one of four races of adult salmon, which may use Montezuma Slough during upstream migration.

Since its first application in 1960, biotelemetry has been commonly used for studies of fish migration, orientation, mechanisms, and movement patterns at obstructions (Stasko and Pincock 1977). Studies conducted in 1998 and 1999 focused on modifying the flashboard structure with openings to allow passage of migrating salmon during full-bore operations. This modification was one of several mitigation options proposed for adult and juvenile salmon passage at the SMSCG (DWR 1997). From September 24 through November 1, 2001, as a continuation of telemetry studies started in 1993 (Tillman and others 1996; Edwards and others 1996), adult fall-run chinook salmon, *Oncorhynchus tshawytscha*, were used as a proxy for winter-run chinook salmon and were monitored for passage time and passage rate through the SMSCG. The 2001 study focused on the possible use of the existing boat lock as a means of fish passage for migrating adult chinook salmon.

Methods

Adult fall-run chinook salmon were captured using a large mesh gill net, tagged internally with ultrasonic transmitters, and released downstream of the SMSCG. Each tag was coded with a unique pulse interval and frequency to allow identification of individual fish. Ultrasonic signals were detected by stationary monitoring equipment consisting of a hydrophone, receiver, and palmtop computer to determine the locations of tagged fish. Monitoring sites were located upstream, downstream, and on the SMSCG (Figure 1).

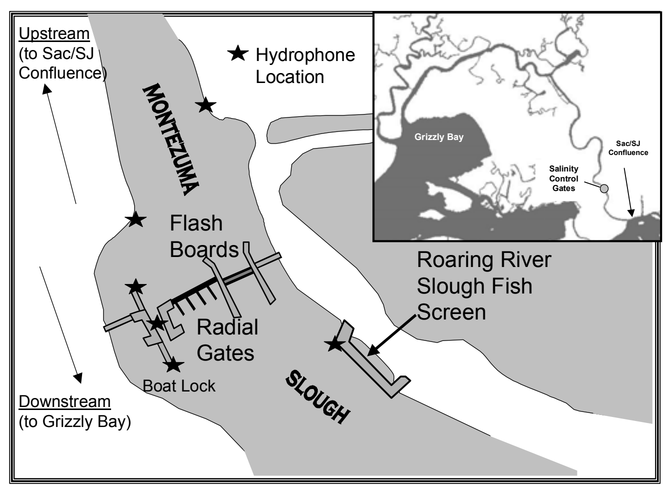

Figure 1 Hydrophone locations at the Suisun Marsh Salinity Control Gates, September through November 2001

Sixty-six tagged salmon were released at the beginning of each two-week operational phase and monitored for passage rate and passage time through the SMSCG. Tagged fish ranged in size from 600 to 1070 mm fork length and, overall, fish were evenly distributed between male and female sexes (Table 1). No fish under 600 mm or adipose fin clipped fish were tagged. All fish were tagged and released near the Grizzly Island boat ramp, approximately 1.5 miles downstream of the SMSCG.

Table 1 Adult chinook salmon tagged from September 24 through November 1

Date tagged	*Operational phase*	*Sex*	*Number tagged*
September 24–26	Phase I	M	22
		F	43
		Unsexed	1
October 9–11	Phase II	M	35
		F	25
		Unsexed	6
October 22–23	Phase III	M	40
		F	24
		Unsexed	2

Salmon passage was studied during three different operational phases: Phase I (flashboards out, gates up, boat lock closed), Phase II (flashboards in, gates operating, boat lock open), and Phase III (flashboards in, gates operating, boat lock closed) (Figure 2). Mobile monitoring was used to track fish movement in Montezuma Slough and to locate dead fish. Additional mobile monitoring tracked tagged salmon in the Sacramento and San Joaquin rivers after they left Montezuma Slough. Passage time data were analyzed using an Analysis of Variance and a Tukey Post Hoc to test for significance.

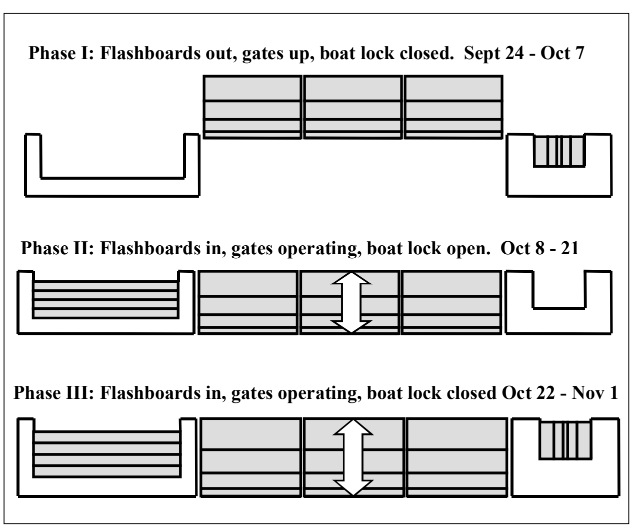

Figure 2 The three operational phases of the Suisun Marsh Salinity Control Gates for September – November 2001

Results

Of the 198 fish caught, 112 fish were tagged during daylight and 86 were tagged at night. A total of 118 tagged salmon passed through the gates, with the largest percentage passing during Phase II (Figure 3). Fifty-eight tagged salmon moved back downstream into Montezuma Slough, and 22 were removed from the sample population due to non-detection or mortality after tagging. Nine fish were subsequently found by mobile monitoring in the Sacramento and San Joaquin rivers after non-detection at the gates. There was no significant difference for passage rates among all three phases.

Average times for fish passage ranged from 15.3 to 47.4 hours (Figure 4). There was no significant difference in passage times between Phase I and Phase II, though there was a significant difference between Phase I and Phase III ($P < 0.05$) (Table 2).

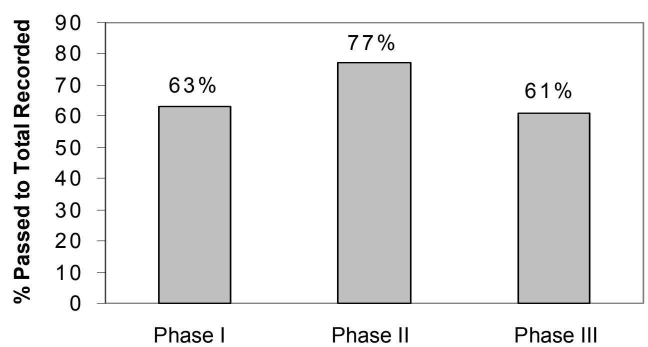

Figure 3 Fish passage by phase at the Suisun Marsh Salinity Control Gates, September and October 2001

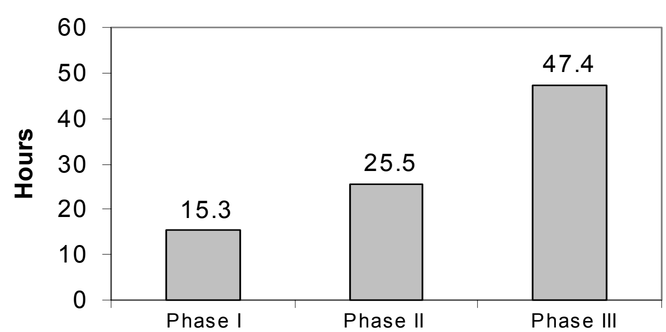

Figure 4 Passage time by phase at the Suisun Marsh Salinity Control Gates, September–November 2001

Table 2 Tukey HSD multiple comparison probabilities for chinook salmon passage times at the Suisun Marsh Salinity Control Gates in 2001

Phase comparison	*P value*
Phase I vs. Phase II	0.486
Phase I vs. Phase III	0.002[a]
Phase II vs. Phase III	0.040[a]

[a] Indicates a significant difference at the $P < 0.05$ level.

Phase I

Phase I was conducted from September 24 to October 7. Of the 66 salmon tagged during September 24–26, thirty-eight tagged fish (63%) were recorded passing the gates. Of these, ten went back downstream. Twenty-two tagged fish turned back downstream without approaching the gates. Six fish were removed from the study population, five were recorded at the upstream site only and one was found dead near the boat launch ramp. Fish ranged from 600 to 970 mm fork length, consisting of 43 females, 22 males, and one unsexed. The average time for the fish to move past the gates was 15.3 hours.

Phase II

Phase II was conducted from October 8 to 21. Of the 66 adult chinook salmon tagged during October 9 to 11, forty-four (77%) were recorded passing the gates, with seven moving back downstream. Thirteen tagged fish turned back downstream without approaching the gates. Nine fish were removed from the analysis, eight fish were not detected and one was detected at the upstream site only. Fish ranged from 600 to 1010 mm fork length, consisting of 25 females, 35 males, and six unsexed. The average time for the fish to move past the gates was 25.5 hours. Of the 44 tagged salmon to pass the gates, 14 (32%) were recorded using the boat lock (Figure 5). The average time spent in the boat lock was 13 minutes. Tagged fish passed through the boat lock equally during flood and ebb tides.

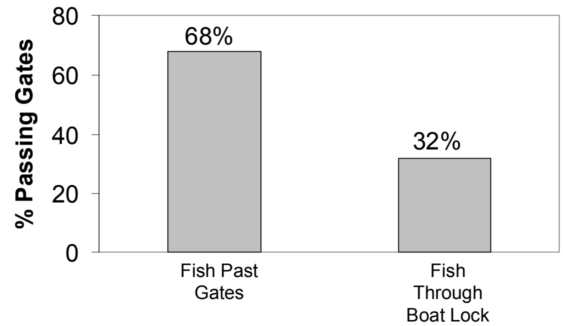

Figure 5 Fish passage at the Suisun Marsh Salinity Control Gates Boat Lock, October 8–21, 2001

Phase III

Phase III ran from October 22 to November 2. Of the 66 adult chinook salmon tagged during October 22–23, thirty-six (61%) were recorded passing the gates with five moving back downstream. Twenty-three tagged fish turned back downstream without approaching the gates. Seven fish were not included in the passage analysis, three fish were not detected, three were detected at the upstream site only, and one was found dead by the mobile monitoring crew. The fish ranged from 610 to 1070 mm fork length, and consisted of 24 females, 40 males, and two unsexed. The average time for the fish to move past the gates was 47.4 hours.

Mobile Monitoring

Mobile monitoring tracked 57 tagged salmon in Montezuma Slough from October 1 through November 1. Of these, 27 passed through the gates and returned downstream, 26 did not pass the gates and went downstream, one was found dead by the boat launch ramp, and three were never detected after tagging. Monitoring crews in the Sacramento and San Joaquin rivers tracked 41 tagged fish: 28 on the Sacramento, six on the San Joaquin, and seven moving between both rivers.

Discussion

Phase II had the greatest percentage of fish passage, although it was not statistically different from the other phases. During this configuration, passage through the boat lock was available to migrating salmon 24 hours a day for the entire two weeks. Passage through the radial gates during this phase was available only 12 hours a day due to tidal operation closing the gates for 6-hour periods twice daily. The boat lock represented 7% of the available area for passage compared to 93% for the radial gates. While not significant when compared to the other configurations, fish were using the boat lock for passage, even when a larger area was available through the radial gates. Of more importance is the difference in passage times over the three phases of the SMSCG.

Mobile monitoring showed a tendency for some migrating salmon to hold or exhibit milling behavior in Montezuma Slough. Similar behavior was observed in tagged fish leaving Montezuma Slough and entering the Sacramento–San Joaquin Delta. Concurrent CALFED salmon telemetry studies at the Delta Cross Channel tracked the tagged fish moving within the Delta using the same equipment. Although tracking data indicates some salmon do not migrate directly to their spawning grounds, we cannot judge the effect that any delay may have on survival or spawning success.

Telemetry studies in 1993 and 1994 confirmed that the SMSCG may have some effect on salmon movement through Montezuma Slough under partial and full operational conditions (Tillman and others 1996; Edwards and others 1996). Salmon passage was greater during the full open configuration (Phase I), and passage times increased from the Phase I configuration to the full operational configuration, Phase III. Based on this information, mitigation measures were developed and evaluated including structural modifications to the flashboard section in the form of openings or passages (DWR 1997). Telemetry studies in 1998 and 1999 included a modification of the existing flashboards to include two 3-ft by 66-ft openings to facilitate salmon passage. Results from these studies suggest the modified flashboards did not improve salmon passage. The 2001 study focused on using the existing boat lock as a fish passageway and initial results showed an improvement over passage delay times when compared with past studies (Figure 6).

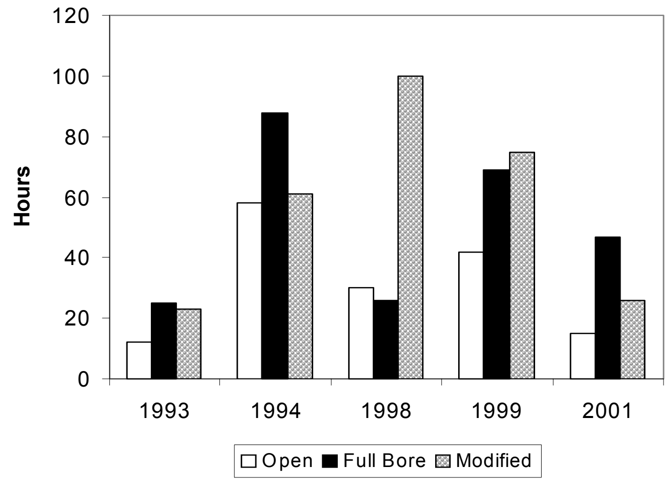

Figure 6 Mean passage times by phase at the Suisun Marsh Salinity Control Gates, 1993–2001

The feasibility of using the boat lock for fish passage looks promising based on the results of the 2001 study. This study will be repeated in 2002 and 2003 to confirm results. If the boat lock proves to be an effective salmon passageway, this method could be useful in other fish passage situations, such as the Delta Cross Channel, where radial gates are used to control water flows.

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CALFED Activities

CALFED Science Program Workshop: Water Operations and Environmental Protection in the Delta

Zach Hymanson (CALFED), zachary@water.ca.gov

The CALFED Science Program recently convened a two-day workshop on water project operations and environmental protection issues in the Bay-Delta. The April 22–23 event brought together more than 100 policy makers, scientists and stakeholders with the goal of holding a balanced discussion among these representatives to characterize the scientific issues underlying water operations affecting the San Francisco Estuary and associated watersheds. This workshop focused on three water operation issues: (1) the X2 standard, (2) the Delta Cross Channel; and (3) state and federal regulations associated with CVP and SWP water exports. CALFED agencies hope to hold similar workshops in the future to develop recommendations for using tools such as the Environmental Water Account for the greatest environmental benefit. A written workshop summary is expected in May 2002. More information about the CALFED Science Program can be found at http://calfed.water.ca.gov/programs/sp/Science.htm.

CALFED Brown Bag Seminars

Lauren Buffaloe (CALFED), buffaloe@water.ca.gov

CALFED's Ecosystem Restoration Program has hosted six scheduled brown bag seminars as of this writing. The seminars are being held between 12:30 p.m. and 1:30 p.m. at the Resources Building (1416 9th Street) in Sacramento. Dan Castleberry of CALFED is moderator for the series and has done an excellent job of scheduling talks by experts on a variety of topics.

I attended the first two seminars given by Jeff Mount, Director of the Integrated Watershed Center at UC Davis and Peter Moyle, Professor in the UC Davis Department of Wildlife, Fisheries, and Conservation Biology and author of the recently published *Inland Fishes of California, Revised and Expanded edition*. While no one offered me a "free lunch," I felt I came away with a wealth of cutting-edge knowledge about scientific studies being conducted in the Cosumnes watershed and fish communities of the Mokelumne basin and Cosumnes watershed. Getting straight scientific talk from experts like Dr. Mount and Dr. Moyle are priceless, and I commend Dan Castleberry for his efforts in getting the results of these important studies communicated to those in need of the information.

Dates, presenters and topics for seminars scheduled for late June through August are listed below. Meeting dates are tentative, but can be confirmed by calling the CALFED Bay-Delta Program office at (916) 657-2666.

Ecosystem Restoration Program Brown Bag Lunch Seminars

Resources Building, 1416 Ninth Street
Sacramento, CA 95814
12:30 p.m. – 1:30 p.m.

Wednesday, June 26 . . . . Room 435
Speaker: Graham Fogg
Topic: Impacts of Regional Groundwater Withdrawal

Thursday, June 27. . . . . Room 1142
To Be Announced

Thursday, July 11 . . . . Room 1142
Speaker: Greg Pasternack
Topic: Restoring Spawning Gravels

Wednesday, July 24 or Thursday, July 25 . . . . Room 435
Speaker: Jim Quinn
Topic: Information Sharing and Adaptive Management

Thursday, August 8 . . . . Room 1142
Speaker: Lev Kavvas
Topic: Modeling Hydrology and Climate Change

Scientific Community News

Marty Kjelson Retires

Randy Brown (CALFED), rl_brown@pacbell.net

On April 25, 2002, Marty Kjelson completed nearly 25 years of working on Central Valley salmonid issues that focused on survival of juvenile chinook salmon through the Sacramento-San Joaquin Delta. During the early years Marty had limited resources and staff, however, in recognition of his technical knowledge, management skills, and the growing importance of salmonids, his staff and resources expanded dramatically. During the past decade or so Marty supervised many staff involved in implementing the Anadromous Fish Restoration Plan (AFRP) sections of the 1992 Central Valley Project Improvement Act. He also served as coordinator for the IEP and for the past few years chaired the IEP's Central Valley Salmonid Team.

Those of us who worked closely with Marty found he has his priorities straight—family and church, work, fishing, hunting and golf—although the order of the last five activities could change on a daily and seasonal basis. We also learned that he approaches all activities with a sense of dedication and thoroughness that can make less dedicated people look on in awe—just ask hunting and fishing buddies like Pete Chadwick, Perry Herrgesell, and Rick Morat.

Like most good managers Marty assembled, trained, and motivated a highly qualified staff. Although this staff will help make a new manager's transition relatively seamless, it will be tough to fill Marty's shoes as an IEP coordinator, lead salmon scientist, and all the other roles he filled. His ethics and ability to work with a variety of folks with very different perspectives and backgrounds make for a tough act to follow. In the spirit of providing a record of his work, Marty left several binders of notes he took during many of the meetings he attended or chaired. Staff may have to bring him back to help sort them out. (You have to have seen the notes to make sense of this.)

Unlike some of us, Marty is actually retiring. He plans on doing a lot of fishing, hunting, traveling, and golfing. More importantly he will have more time to devote to his daughters and to his church. He will be remaining in Stockton and has promised to keep in contact. We all can help by staying in touch as well. (He might even discuss salmonid related issues if the discussion doesn't distract from other more pressing activities.) I am sure I speak for all those who worked with Marty over the years in wishing him a happy, productive, and healthy retirement.

Publications in Print

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California Department of Fish and Game's Fish Bulletin 179: Contributions to the Biology of Central Valley Salmonids

DFG published its latest addition to the Fish Bulletin series in October 2001, *Fish Bulletin 179: Contributions to the Biology of Central Valley Salmonids*. This two-volume work include research on various Central Valley salmon and steelhead populations, ocean fishery management, history of the upper Sacramento River hatchery operations, and steelhead management policy.

Initially, papers came from presentations made at the Bodega Bay Salmonid Symposium held on October 22–24, 1997. During the bulletin's development, however, editor Randall L. Brown chose to include salmonid research on the Tuolumne and Mokelumne river watersheds and two historical narratives, among other papers, to "make the [bulletin] a more balanced compendium."

In the Foreword, Brown urges readers to "consider recommendations made specifically by L. B. Boydstun, Peter Baker, Emil Morhard, Wim Kimmerer and others, and John Williams, about the need to (1) better coordinate salmonid related work in the Central Valley, the estuary and the ocean; (2) focus more on collecting and analyzing data that can be used to validate conceptual and mechanistic models, and (3) make the information more readily available in the open literature.

It's my opinion that an assembled work on Central Valley salmonids as significant as this one will not be published for a number of years. If you are interested in a obtaining a copy, please contact me by e-mail at the address above.

IEP Technical Reports

Four technical reports have recently been published through the IEP Technical Reports series. If you are interested in obtaining a copy of any of the reports summarized below or would like to be included on the technical reports mailing list, please contact Lauren Buffaloe at (916) 227-1375 or buffaloe@water.ca.gov

Technical Report 69: Proceedings of the Eighteenth Annual Pacific Climate (PACLIM) Conference Proceedings

A workshop was held in 1984 on "Climatic Variability of the Eastern North Pacific and Western North America," from a growing concern about climate variability and its societal and ecological impacts. From it has emerged an annual series of workshops held at Asilomar Conference Grounds at Pacific Grove, California, and the Wrigley Institute for Environmental Studies at Two Harbors, Santa Catalina Island, California. These annual meetings, which involve 80–100 participants, have come to be known as the Pacific Climate (PACLIM) Workshops, reflecting broad interests in the climatologies associated with the Pacific Ocean and western Americas in both the northern and southern hemispheres. A major goal of PACLIM is to provide a forum for exploring the insights and perspectives of each of these many disciplines and for understanding the critical linkages between them. From observed changes in the historical records, the conclusion is evident that climate change would have large societal impacts through effects on global ecology, hydrology, geology, and oceanography.

Technical Report 68: Suisun Ecological Workgroup Final Report to the State Water Resources Control Board

In the *1995 Bay-Delta Plan Water Quality Control Plan*, the State Water Resources Control Board directed the Department of Water Resources to convene an interagency workgroup to evaluate the technical basis of the Suisun Marsh water quality objectives and their effects on beneficial uses. Consequently, the Suisun Ecological Workgroup (SEW) was formed in May 1995 to recommend channel water salinity objectives to protect the beneficial uses of the Suisun Marsh. SEW completed this task by forming technical subcommittees to examine the effect of various salinity regimes on the following ecosystem components of Suisun Marsh: brackish marsh vegetation, waterfowl, aquatic habitat, and wildlife. This long-awaited final report contains (1) each subcommittee's discussion of relevant scientific findings; (2) recommendations for salinity objectives, future monitoring, and special studies; and (3) a description of data analyses and model studies conducted by a hydrodynamics and water quality support team.

Technical Report 60: Hydroacoustic Monitoring of Fish Movement in Clifton Court Forebay Outlet Channel, June 1–4, 1988

Abstract

In June 1988, a fixed-location hydroacoustic system was used to measure the flux of juvenile and small fish in the outlet channel at Clifton Court Forebay and to document their horizontal, vertical, and diel distributions. The effectiveness of the hydroacoustic equipment and their transducer array were also evaluated. The results suggest that hydroacoustic monitoring could be used to estimate prescreeen loss at Clifton Court Forebay. Fish behavior in the outlet channel show that fish exhibit more milling behavior near the trashboom than away from this structure. Diel fish distribution suggests that both surface- and bottom-oriented transducers should be used in future hydroacoustic monitoring programs in the outlet channel. The results also suggest that the State Water Project could modify operations to benefit fisheries using hydroacoustic monitoring to measure the abundance and distribution of fish in the Sacramento-San Joaquin Delta.

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