# Comprehensive Assessment and Monitoring Program (CAMP)

# *Annual Report 1998*

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# Summary

This annual report of the Comprehensive Assessment and Monitoring Program (CAMP) documents the 1998 monitoring results and presents summary data for the first four years of anadromous fish population monitoring under the requirements of the Central Valley Project Improvement Act (CVPIA). The adult anadromous fish monitoring showed variable results in making progress towards meeting CVPIA natural production goals. Returning adult fall-run chinook salmon were at their lowest levels in 1998 relative to all years (1995-1997) previously monitored under CAMP. However, within individual watersheds such as Battle, Butte and Mokelumne, adult salmon returns were at or above the watershed-specific production targets. In addition, estimates of natural production of spring-run and winter-run chinook salmon were at the highest levels of all CAMP-monitored years. American shad numbers increased in 1998 relative to 1997; however, abundance estimates for 1998 were unavailable for steelhead, striped bass, and sturgeon.

The 1998 report includes changes in the method for estimating fall-run salmon in the mainstem Sacramento River and revised natural production estimates for the years 1995 through 1997 for all chinook salmon races. These changes were made to maintain consistency with the current estimation method used by the California Department of Fish and Game (CDFG). This method, however, is subject to complications that may not accurately reflect adult chinook salmon numbers in the mainstem Sacramento River, Clear Creek, and Battle Creek. CDFG and CAMP representatives are working to refine the methods to better estimate adult salmon numbers in these waters.

The CAMP juvenile salmon monitoring program was continued in 1998 to provide a portion of the data that will be used to evaluate the relative effectiveness of the four categories of restoration actions. Few watersheds reported juvenile production data for 1998. Based on an index of juvenile production to spawning adults, juvenile production in all reporting watersheds improved in 1998 compared to the previous CAMP-monitored years.

While the CAMP juvenile program is intended to provide long-term watershed-specific monitoring of juvenile production, these data are not sufficient to distinguish the relative effectiveness of the four categories of actions to restore anadromous fish populations. Data resulting from site-specific monitoring of AFRP restoration actions are needed to provide the critical link between the types of restoration actions implemented within a watershed to overall juvenile production within that watershed. However, without site-specific monitoring data, CAMP's goal of assessing which types of restoration actions are most effective in restoring fish populations cannot be addressed. As outlined in the CAMP Implementation Plan (USFWS 1997b), the site-specific monitoring data must be developed by each individual project, not CAMP.

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# 1. Introduction

This second annual report of the Comprehensive Assessment and Monitoring Program (CAMP) has been prepared for the Central Valley Fish and Wildlife Restoration Program Office, U.S. Fish and Wildlife Service (USFWS) and the Bureau of Reclamation (Reclamation). The report summarizes estimates of anadromous fish abundance, associated environmental data, and fish and wildlife restoration actions implemented in the Central Valley, California for 1998, pursuant to the enactment of the Central Valley Project Improvement Act (CVPIA).

## Background

The CVPIA (Public Law 102-575, Title 34) of October 1992 amends the authority of Reclamation Central Valley Project (CVP) to include fish and wildlife protection, restoration, and mitigation as an equal priority with other CVP functions, which include navigation, flood control, irrigation, and municipal water supply. Section 3406 (b) of the CVPIA directs the Secretary of Interior through the USFWS to develop and implement programs and actions to ensure that by 2002 the natural production of anadromous fish in Central Valley streams will be sustainable, on a long-term basis, at levels at least twice the average levels of natural production during the 1967 through 1991 baseline period.

The Anadromous Fish Restoration Program (AFRP) was established by Section 3406 (b)(1) of the CVPIA. The AFRP established baseline production numbers for Central Valley streams for naturally produced chinook salmon (all races), steelhead, striped bass, American shad, white sturgeon, and green sturgeon. Baseline production estimates were developed using monitoring data collected from 1967 through 1991. Production targets for anadromous fish were determined by doubling the baseline production estimates.

The CAMP, established by Section 3406(b)(16) of the CVPIA, has two distinct goals:

- To assess the overall effectiveness of actions implemented pursuant to CVPIA Section 3406(b) in meeting the AFRP production targets.
- To assess the relative effectiveness of four categories of Section 3406(b) actions (i.e., water management modifications, structural modifications [excluding fish screens], habitat restoration, and fish screens) in meeting AFRP production targets.

This section of the 1998 CAMP Annual Report includes the results of monitoring performed to estimate the natural production of anadromous fish in each watershed for which an AFRP target has been established.

The recommended methods by which data are collected to evaluate progress toward these goals were originally outlined in the CAMP Conceptual Plan (USFWS 1996). The CAMP Implementation Plan (USFWS 1997) further refined recommendations for adult and juvenile production monitoring programs necessary to achieve CAMP's two primary goals and provided detailed data management protocols, data analysis methods, and an estimated 5-year budget necessary to implement CAMP.

Progress toward meeting anadromous fish production targets (CAMP's first goal) is assessed based on estimates of the production of naturally-produced adults of all races of chinook salmon, steelhead, striped bass, American shad, white sturgeon, and green sturgeon. Data collected by adult fish monitoring programs are used to calculate annual production estimates for each species and race. The attainment of natural production goals for each species and race is determined by comparing the annual production estimates to the 1967 through 1991 baseline period estimates for each targeted watershed, as identified in the CAMP Implementation Plan. The adult monitoring program relies extensively on existing monitoring programs and is planned to be consistent and long-term (25 to 50 years duration).

Estimates of juvenile chinook salmon production, which are determined by monitoring selected watersheds, are used to evaluate the relative effectiveness of the four categories of restoration actions identified in CAMP's second goal. Discussions regarding the value of increasing instream flows compared with the value of, for example, screening diversions as the most effective way to restore anadromous fish populations will remain unresolved until sufficient information is available to address the differences among these categories. Allocation of resources to implement actions in different categories could be directed based on which category appears most effective in restoring anadromous fish populations.

Unlike the monitoring effort to assess progress toward achieving doubling goals, which relies on monitoring the natural production of adults, distinguishing the relative effectiveness of categories of actions is accomplished by evaluating juvenile salmon production. Juvenile production is the most direct measure of the effectiveness of categories of actions because, unlike adult fish that have spent most of their lives in the ocean, juveniles have been exposed only to the conditions present in their natal stream. Monitoring juvenile production in selected streams, the actions in each category implemented in each stream, and associated environmental variables provides the best opportunity to measure the effect of a category of action on juvenile production. By monitoring individual streams, categories of actions can be isolated; mainstem rivers impede isolation because they bear the additive or multiplicative effects of numerous CVPIA and non-CVPIA environmental variables. Coupling adult and juvenile production estimates for these selected streams allows the relative effectiveness of categories of actions to be related to progress toward meeting the doubling goals for anadromous fish populations.

Rotary screw trap sampling is used to estimate juvenile production in selected Central Valley streams. A workshop involving agency biologists was held in June 1997 to develop standardized methods for rotary screw trap sampling. During the 1998 sampling season, rotary screw trapping was performed on the Upper Sacramento River, Deer Creek, Mill Creek, the Merced River, the Tuolumne River, Butte Creek, the Yuba River, Battle Creek, Clear Creek, the Mokelumne River, the Stanislaus River, the Feather River, and the American River.

# CAMP Methods

## CAMP Implementation Goals

The CAMP Implementation Plan describes the components of the recommended adult and juvenile monitoring programs. The recommended adult fish monitoring program for the CAMP species (including all races of chinook salmon) is summarized in Table 1. The recommended juvenile salmon monitoring program is shown in Table 2.

To successfully monitor progress toward meeting anadromous fish production targets (CAMP's first goal), reliable methods for distinguishing hatchery and naturally produced fish will be needed. The recommended constant fractional marking program for hatchery-produced chinook salmon in the Central Valley will provide a means for improving estimates of the contribution of hatchery fish to total adult chinook salmon production. As described in the previous annual report, a workshop to discuss a hatchery marking program was conducted with agency and stakeholder representatives on October 2, 1997. Subsequent study focused on the need to standardize the marking effort to meet CAMP's goals. A recommended uniform coded wire tag and fin-clipping program is expected in 1999, with implementation in 2000.

To evaluate the relative effectiveness of the various AFRP actions (CAMP's second goal), it is important to distinguish the effects of key environmental variables that may affect juvenile abundance independently of actions. Flow, temperature, and turbidity measurements have been compiled as part of the juvenile monitoring program for most of the streams shown in Table 2. Temperature and turbidity were collected incidental to trap operations. Flow data were obtained from other sources, including U.S. Geological Survey (USGS) and Department of Water Resources (DWR) flow monitoring gages. Also important in achieving CAMP's second goal is the implementation of a standardized, site-specific monitoring program to evaluate the effectiveness of individual restoration actions. The AFRP has begun planning this monitoring program. Program implementation will provide valuable information in the overall evaluation of the relative effectiveness of restoration actions analyzed as part of the CAMP juvenile monitoring program. CAMP is currently reviewing existing and planned fish screen facilities to select representative locations for conducting focused evaluations of the effectiveness of fish screens in meeting AFRP goals. A pilot program to evaluate fish screen effectiveness is expected to be initiated in 2000.

**TABLE 1**
CAMP: Recommended Adult Fish Monitoring Programs

| Watershed | Species/Race | Adult Fish Monitoring Programs |
|---|---|---|
| ***Chinook Salmon*** | | |
| American River | Fall-run Chinook Salmon | Spawning escapement, hatchery marking, hatchery returns, in-river harvest |
| Battle Creek | Fall-run Chinook Salmon | Spawning escapement, hatchery marking, hatchery returns |
| | Late Fall-run Chinook Salmon | Spawning escapement, hatchery marking, hatchery returns |
| | Winter-run Chinook Salmon | Hatchery marking, hatchery returns |
| Butte Creek | Fall-run Chinook Salmon | Spawning escapement |

**TABLE 1**
CAMP: Recommended Adult Fish Monitoring Programs

| Watershed | Species/Race | Adult Fish Monitoring Programs |
|---|---|---|
| | Spring-run Chinook Salmon | Snorkel survey |
| Clear Creek | Fall-run Chinook Salmon | Spawning escapement |
| Deer Creek | Fall-run Chinook Salmon | Spawning escapement |
| | Spring-run Chinook Salmon | Snorkel survey |
| Feather River | Fall-run Chinook Salmon | Spawning escapement, hatchery marking, hatchery returns, in-river harvest |
| Merced River | Fall-run Chinook Salmon | Spawning escapement, hatchery marking, hatchery returns |
| Mill Creek | Fall-run Chinook Salmon | Spawning escapement |
| | Spring-run Chinook Salmon | Ladder counts |
| Mokelumne River | Fall-run Chinook Salmon | Ladder counts, hatchery marking, hatchery returns, in-river harvest [1] |
| | Late Fall-run Chinook Salmon | Hatchery Returns [2] |
| Sacramento River | Fall-run Chinook Salmon | Ladder counts, spawning escapement, aerial redd counts, in-river harvest |
| | Late Fall-run Chinook Salmon | Aerial redd counts, In-river harvest |
| | Winter-run Chinook Salmon | Ladder counts, spawning escapement, aerial redd counts |
| | Spring-run Chinook Salmon | Ladder counts, In-river harvest |
| San Joaquin River | Fall-run Chinook Salmon | In-river harvest [1] |
| Stanislaus River | Fall-run Chinook Salmon | Spawning escapement, In-river harvest [1] |
| Tuolumne River | Fall-run Chinook Salmon | Spawning escapement |
| Yuba River | Fall-run Chinook Salmon | Spawning escapement, in-river harvest |
| Pacific Ocean | Fall-run Chinook Salmon | Ocean harvest |
| | Late Fall-run Chinook Salmon | Ocean harvest |
| | Winter-run Chinook Salmon | Ocean harvest |
| | Spring-run Chinook Salmon | Ocean harvest |
| ***Steelhead*** | | |
| Battle Creek | Steelhead | Hatchery marking, hatchery returns |
| Mokelumne River | Steelhead | Hatchery returns [3] |
| Sacramento River | Steelhead | In-river harvest |
| ***Striped Bass*** | | |
| Sacramento-San Joaquin Delta and Rivers | Striped bass | Mark-recapture program every other year |
| ***American Shad*** | | |
| Sacramento-San Joaquin Delta | American Shad | Midwater trawl survey: juvenile abundance index[4] |
| ***White Sturgeon*** | | |
| Sacramento-San Joaquin Delta | White Sturgeon | Mark-recapture program for 2 years, followed by 2 non-estimate years |

**TABLE 1**
CAMP: Recommended Adult Fish Monitoring Programs

| Watershed | Species/Race | Adult Fish Monitoring Programs |
|---|---|---|
| *Green Sturgeon* | | |
| Sacramento-San Joaquin Delta | Green Sturgeon | Estimate based on ratio of Green to White Sturgeon observed during tagging |

[1] Data not collected prior to 1998.

[2] Data not collected prior to 1998 and not specifically recommended in CAMP Implementation Plan.

[3] Data collected in 1996 but not in 1997 and not specifically recommended in Implementation Plan.

[4] The juvenile abundance index from the midwater trawl survey conducted by CDFG is currently the best estimator of resulting adult American shad abundance.

**TABLE 2**
CAMP: Recommended Juvenile Salmon Monitoring Programs

| Recommended Watershed | Recommended Chinook Salmon Race | Watersheds/Years Included in this Report |
|---|---|---|
| American River | Fall-run | 1996, 1997, 1998 |
| Battle Creek | Fall, winter, and spring –run | |
| Butte Creek | Fall and spring-run | |
| Clear Creek | Fall-run | |
| Deer Creek | Fall and spring-run | |
| Feather River | Fall-run | 1996, 1998 |
| Merced River | Fall-run | |
| Mill Creek | Fall and spring-run | |
| Mokelumne River | Fall-run | 1995, 1996, 1997, 1998 |
| Stanislaus River | Fall-run | 1996, 1997, 1998 |
| Tuolumne River | Fall-run | |
| Upper Sacramento River | Fall, spring, and winter-run | |
| Yuba River | Fall-run | |

## Implementation of CAMP through 1998

Not all of the recommended CAMP programs were implemented by the end of 1998 (see Tables 1 and 2). This annual report presents the results of those monitoring programs conducted in 1998 that were consistent with the CAMP Implementation Plan protocols (USFWS 1997). The 1998 data are presented for all target CAMP species; data from the 1995-1997 annual report are presented for comparative purposes.

# 2. Adult Fish Monitoring Program: 1998

## AFRP Production Targets

The AFRP established watershed-specific restoration targets for chinook salmon and system-wide targets for all five species of anadromous fish monitored by CAMP. Not all streams for which restoration goals were established for fall-run chinook salmon are included in the CAMP monitoring program. The selected watersheds represent 97 percent of the total fall-run chinook production (CAMP Implementation Plan). Therefore, the CAMP production target for fall-run chinook is slightly lower than the overall AFRP target.

## Adult Abundance Estimates: 1998

### Chinook Salmon

#### *Estimates of Natural Production*

Estimates of the abundance of naturally produced adult chinook salmon in each watershed for monitoring year 1998 are presented in Table 3. These estimates were based on the same assumptions used by the AFRP to establish the 1967 through 1991 baseline estimates (USFWS 1995) and follow the methods outlined in the CAMP Implementation Plan (USFWS 1997). As in previous years, the estimates of total production were calculated by summing in-river estimates (e.g., carcass survey estimates or ladder counts), hatchery returns, and in-river harvest and ocean harvest estimates. Total production was then multiplied by the proportion of natural production in each watershed (estimated by CDFG [1994]) to yield the watershed race-specific natural production estimates. In the future, estimates of natural production should be calculated from actual annual estimates of the proportion of hatchery fish based on the chinook salmon constant fractional marking program at Central Valley hatcheries.

The 1998 production estimates assume that all spring-run and winter-run chinook salmon were naturally produced. Because late fall-run chinook salmon are not distinguished from fall-run fish in the in-river counts, no attempt to estimate the number of naturally produced late fall-run chinook salmon was made. For the purpose of this report, it is assumed that all naturally produced late fall-run fish are included in the fall-run chinook salmon totals. Hatchery return fish identified as late fall-run are presented in this report, but they do not contribute to the natural production totals.

**TABLE 3**
1998 Adult Chinook Salmon Production Estimates

| | In-River Estimates | | Hatchery Returns | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Watershed | Total | Hatchery Component | Total | Hatchery Component | In-River Harvest | Ocean Harvest[a] | Total Production | % Natural[b] | Natural Production |
| **Fall-Run Chinook Salmon** | | | | | | | | | |
| American River | 43,000[c] | | 10,581 | 10,581 | 19,636 | 65,244 | 138,461 | 62% | 85,846 |
| Battle Creek | 53,957[c] | | 44,350 | 44,350 | | 87,603 | 185,911 | 10% | 18,591 |
| Butte Creek | 2,500[d] | | | | | 2,228 | 4,728 | 80% | 3,782 |
| Clear Creek | 4,258[c] | | | | | 3,794 | 8,052 | 80% | 6,442 |
| Deer Creek | 270[c] | | | | | 241 | 511 | 80% | 408 |
| Feather River | 43,000[c] | | 18,699 | 18,699 | 17,908 | 70,938 | 150,545 | 61% | 91,833 |
| Merced River | 2,314[c] | | 799 | 314 | | 2,774 | 5,887 | 91% | 5,357 |
| Mill Creek | 546[c] | | | | | 487 | 1,033 | 81% | 836 |
| Mokelumne River | 6,952[f] | 3,251 | 3,251 | 3,251 | 14 | 9,104 | 19,321 | 81% | 15,650 |
| Sacramento River | 5,865[g] | | | | 9,380[h] | 13,585 | 28,830 | 63% | 18,163 |
| Stanislaus River | 2,089[c] | | | | | 1,862 | 3,951 | 100% | 3,951 |
| Tuolumne River | 7,634[c] | | | | | 6,803 | 14,437 | 100% | 14,437 |
| Yuba River | 30,802[c] | | | | 694 | 28,066 | 59,562 | 100% | 59,562 |
| **Total** | **203,187** | **3,251** | **77,680** | **77,195** | **47,632** | **292,729** | **621,229** | | **324,858** |
| **Late-Fall Run Chinook Salmon** | | | | | | | | | |
| Battle Creek | | | 7,075 | 7,075 | | 6,305 | 13,380 | | |
| Mokelumne | | | 20 | 20 | | 18 | 38 | | |
| Total | | | 7095 | 7095 | | | 13,418 | | |
| **Winter Run Chinook Salmon** | | | | | | | | | |
| **Sacramento River** | **5,501 c** | | | | | **4,902** | **10,403** | **100%** | **10,403** |
| **Spring-Run Chinook Salmon** | | | | | | | | | |
| Butte Creek | 20,200[e] | | | | | 18,000 | 38,200 | 100% | 38,200 |
| Deer Creek | 1,879[e] | | | | | 1,674 | 3,553 | 100% | 3,553 |
| Mill Creek | 424[f] | | | | | 378 | 802 | 100% | 802 |
| Sacramento River | 1,003[f] | | | | | 894 | 1,897 | 100% | 1,897 |
| **Total** | **23,506** | | | | | **20,946** | **44,452** | **100%** | **44,452** |
| **Total 1998 Natural Production of Adult Chinook Salmon** | | | | | | | | | **376,824** |

[a] Individual watershed totals based on in-river count proportions.
[b] Watershed-specific % natural component from CDFG (1994).
[c] Carcass survey.
[d] Estimate based on professional judgement of biologist working on Butte Creek during adult fall-run chinook salmon migration/spawning in 1998.
[e] Snorkel survey.
[f] Ladder count.
[g] Estimate based on RBDD ladder counts, subtracting carcass counts and hatchery returns for Battle and Clear creeks and in-river harvest.
[h] Harvest based on 8 percent of RBDD ladder count.

Returning adult fish counted at the fish ladder on the Mokelumne River, and subsequently counted entering the hatchery upstream of the ladder, were subtracted from the ladder counts to avoid duplication.

Salmon from the reach of the mainstem Sacramento River upstream of Red Bluff Diversion Dam (RBDD) were separately enumerated from fish traveling to the tributary streams of Battle Creek and Clear Creek. Mainstem numbers were estimated as RBDD ladder count estimates minus Clear and Battle Creek fish. For this report, we have accepted the Red Bluff CDFG estimate of total 1998 fall-run harvest upstream of RBDD as being 8 percent of the 1998 RBDD ladder count (8% is the 1991-1994 average percentage). Previous Sacramento River in-river harvest estimates (USFWS 1998) were estimates based on historical in-river harvests scaled to the annual run size (K. Murphy, CDFG, pers. comm.) (see Table 8).

The watershed-specific component of the ocean harvest of fall-run chinook salmon was calculated by multiplying the total ocean harvest by the watershed-specific proportion of the total in-river run size. The ocean harvest of late fall-run, spring-run, and winter-run fish was assumed to be equivalent to the proportion of the total returning population of chinook salmon that those races represented that year. As described above, the ocean harvest totals were added to other components of adult production to yield total production by watershed and race.

### *Sacramento River (Mainstem) Fall-run Chinook Salmon Production Estimates*

Estimates of adult chinook salmon production for the mainstem Sacramento River were calculated using the same methods employed by CDFG. The number of adult fish spawning in the mainstem upstream of the RBDD was calculated by subtracting tributary escapement estimates (based on carcass surveys for Clear and Battle creeks), Battle Creek hatchery returns, and estimated in-river harvest from the expanded ladder count (representing the total number of fish passing the RBDD). The resulting estimate of fish spawning in mainstem upstream of RBDD was then used to calculate an estimate of the number of fish spawning in the mainstem downstream of the RBDD by multiplying the above-RBDD spawning estimate by the ratio of redds observed by aerial redd survey below versus above RBDD to yield the below-RBDD estimate. To calculate the CAMP estimate of total production, the in-river harvest and ocean harvest estimates were added to both mainstem spawning escapement estimates to produce an estimate of total mainstem production for the year. The estimate of total production was multiplied by the expected percentage of natural fish (based on AFRP assumptions) to produce an estimate of the total natural production for the year.

This method deviates from the previous method employed by CAMP, and resulted in changes to the estimates of chinook salmon production in the mainstem Sacramento River for 1995 through 1997. The revised estimates are presented in this report. Although the CDFG method was used to maintain consistency, use of this method presents several potential complications. The estimate of the number of fish passing RBDD and the summation of upstream escapement, hatchery returns, and in-river harvest represent independent estimates of the same fish. Deriving an estimate of mainstem spawning escapement upstream of the RBDD by subtracting the estimates of upstream escapement, hatchery returns, and in-river harvest from the ladder count could, in some years, result in an escapement estimate that is negative because of the uncertainty associated with the various estimates. For example, the estimated number of fish returning to the mainstem Sacramento River above the RBDD in 1998 (calculated by subtracting the upstream escapement to Battle and Clear creeks and the hatchery return from the RBDD ladder count) was less than the in-river harvest estimate (based on the 1998 angler surveys), resulting in an estimate of spawning escapement that is a negative number. For 1998, an estimate of in-river harvest using 8 percent of the total number of fish passing RBDD was applied in order to arrive at a positive number of fish. *The discrepancy between the CDFG escapement estimate* *method and the previously employed CAMP escapement estimate method strongly suggests the need for a thorough examination of the method of choice for future escapement estimates. CDFG and CAMP representatives are currently working to refine the methods to better estimate adult salmon numbers in these waters.*

The manner in which the in-river harvest estimates are applied in the calculation also influences the estimate of adult production in the mainstem Sacramento River. Currently, the entire in-river harvest upstream of RBDD is assumed to represent only fish returning to the mainstem, even though a substantial number of the fish caught in the Sacramento River are likely destined for Battle and Clear creeks. Subtracting the entire in-river harvest estimate from the estimated number of fish in the mainstem to arrive at an estimate of the spawning escapement in the mainstem above the RBDD may result in a negative estimate as described above. Also, assuming that the entire in-river harvest is destined to spawn in the mainstem results in an underestimate of the production in Battle and Clear creeks because many of these fish were destined for these tributaries and should be included in their in-river production estimates.

### Revised Ocean Harvest Data

The ocean harvest estimates used to calculate adult chinook salmon production in 1998 were taken from the document entitled *Review of 1998 Ocean Salmon Fisheries* (Pacific Fishery Management Council 1999). In this document, values for 1998 are published as "preliminary data subject to revision." Final data for the years prior to 1998 also are presented in the 1998 review. The final values differ by as much as 3.2 percent from the preliminary values used in the 1995 through 1997 CAMP Annual Report (USFWS 1998), which translates into changes in total adult production of up to 1.81 percent. The updated final ocean harvest values for 1995, 1996, and 1997 and the revised total production estimates are presented in Table 4. Similar changes in the calculated 1998 production value and future production estimates could occur when the preliminary total ocean harvest values are finalized. However, in order to maintain consistency and timely reporting, future CAMP annual reports will continue to develop production estimates using preliminary ocean harvest data.

**TABLE 4**
Chinook Salmon Production Calculations with Preliminary and Final Ocean Harvest Values
*Ocean Harvest Values from Review of 1998 Ocean Salmon Fisheries (PFMC 1999)*

| Year | Preliminary Total Ocean Harvest | Final Total Ocean Harvest | Harvest Percent Difference | Preliminary Total Natural Production | Final Total Natural Production | Production Percent Difference |
|---|---|---|---|---|---|---|
| 1995 | 1,025,200 | 1,025,200 | **0.00** | 761,234 | 761,234 | **0.00** |
| 1996 | 462,900 | 478,200 | **3.20** | 464,642 | 473,189 | **1.81** |
| 1997 | 690,500 | 689,200 | **0.19** | 629,569 | 628,860 | **0.11** |

### Progress Toward Meeting AFRP Production Targets

As described in the CAMP Implementation Plan (USFWS 1997), progress toward meeting the AFRP production targets will be assessed using a modification of the Pacific Salmon Commission's (PSC) rebuilding assessment methods. The PSC assessment methods classify indicator races or species into three categories: (1) those that are at or above their production target, (2) those that are meeting their rebuilding schedule, and (3) those that are not rebuilding. The classification of races or species into these categories is accomplished using recent population data compared to the baseline production data for each race or species and the production target. Races or species that are classified as "above goal" are those for which at least four of the last five years of production estimates are at or above goal and for which the most recent five-year average production is equal to or greater than the goal. Beginning with next year's 1999 CAMP annual report (the fifth year of monitoring), this rebuilding assessment will be used to begin classifying target races and species, and monitor progress toward AFRP goals.

The following presents the estimates of natural production for 1995 through 1998 for each target race and species. Although the number of years of monitoring is not sufficient to perform the assessment described above, the tabulated estimates of natural production presented below provide a qualitative indication of changes in production over the past four years.

### Fall-Run Chinook Salmon

In 1998, the estimate of total natural production of fall-run chinook salmon in streams included in the CAMP (324,858) was lower than in any previous year monitored (1995 – 1997) and substantially lower than the CAMP production target (737,600) (Table 5). Watershed-specific natural production targets were exceeded only in Battle Creek, Butte Creek, and the Mokelumne River in 1998. The 1998 natural production estimates for the American, Clear, Deer, Merced, Mill, Mokelumne, Sacramento, and Yuba watersheds were lower than the estimates for 1995, 1996, and 1997. Watershed specific estimates of production for 1995 through 1998 are presented graphically in Figure 1.

The annual in-river escapement estimates (e.g., carcass surveys) and hatchery return data used as input to calculate natural production of fall-run chinook salmon during 1995-1998 generally reflected annual variation within a reasonable range (Tables 6 and 7). The 1998 estimate of in-river escapement was substantially lower than in previous years (Table 6) due, in part, to a reduced number of fish passing over the RBDD and high numbers of fish returning to the hatchery on Battle Creek. Also, the 1998 estimates of in-river harvest (Table 8) showed a substantial deviation (up to five-fold increase) from previous years, particularly for the American and Feather rivers. These increases in the in-river harvest estimates likely reflect the implementation of angler surveys in 1998 – the first angler surveys conducted since the initiation of CAMP monitoring. CAMP's previous in-river harvest estimates for 1995-1997 were based on the proportion of harvest estimated from angler surveys conducted in 1991-1994. In-river harvest during 1991-1994 may have been lower because of reduced fish abundance and angler effort as a result of drought conditions, and application of these estimates to subsequent years may have resulted in an underestimation of in-river harvest. Therefore, the increased in-river harvest in 1998 is likely the result of the combination of both increased angler pressure and harvest in 1998 and a possible underestimation of in-river harvest in previous years.

**TABLE 5**
Fall-Run Chinook Salmon Baseline Production Estimates, Production Targets and Estimates of Natural Production for 1995 Through 1998

| Watershed | AFRP Baseline Production Estimates | CAMP Production Targets | Estimate of Natural Production 1995 | 1996 | 1997 | 1998 |
|---|---|---|---|---|---|---|
| American River | 81,000 | 160,000 | 209,520 | 120,414 | 107,558 | 85,846 |
| Battle Creek | 5,000 | 10,000 | 34,054 | 17,918 | 26,340 | 18,591 |
| Butte Creek | 760 | 1,500 | 1,457 | 974 | 1,662 | 3,782 |
| Clear Creek | 3,600 | 7,100 | 30,449 | 11,537 | 17,805 | 6,442 |
| Deer Creek | 760 | 1,500 | 1,847 | 1,048 | 2,500 | 408 |
| Feather River | 86,000 | 170,000 | 187,777 | 86,511 | 89,963 | 91,833 |
| Merced River | 9,000 | 18,000 | 9,536 | 12,720 | 7,771 | 5,357 |
| Mill Creek | 2,100 | 4,200 | 5,023 | 2,850 | 1,220 | 836 |
| Mokelumne River | 4,700 | 9,300 | 28,979 | 22,995 | 25,958 | 15,650 |
| Sacramento River | 120,000 | 230,000 | 115,294 | 69,734 | 219,728 | 18,163 |
| Stanislaus River | 11,000 | 22,000 | 2,501 | 409 | 4,265 | 3,951 |
| Tuolumne River | 19,000 | 38,000 | 3,041 | 8,771 | 15,833 | 14,437 |
| Yuba River | 33,000 | 66,000 | 61,782 | 69,255 | 69,631 | 59,562 |
| **Total** | **370,000** | **737,600** | **691,261** | **425,135** | **590,234** | **324,858** |

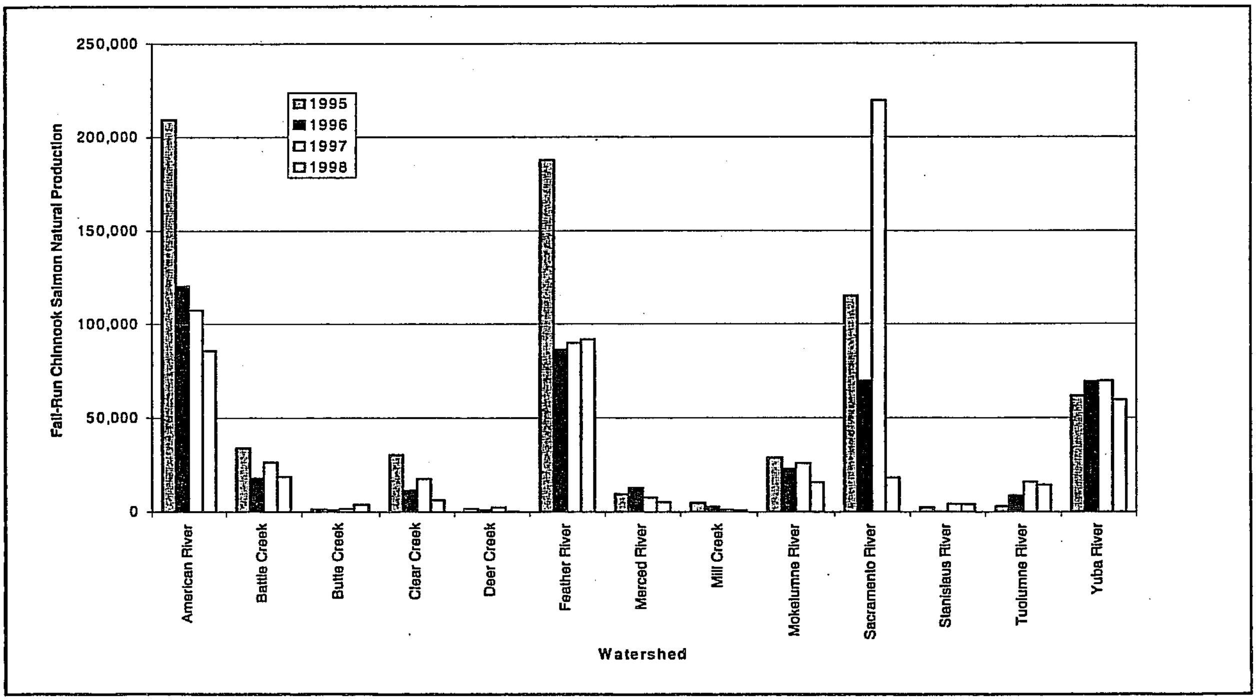


**Figure 1. Fall-Run Chinook Estimates by Watershed for 1995-1998**

**TABLE 6**
Fall-Run Chinook Salmon In-River Escapement Estimates

| Watershed | 1995 | 1996 | 1997 | 1998 |
|---|---|---|---|---|
| American River | 70,096 | 65,915 | 56,000 | 43,000 |
| Battle Creek | 56,515 | 52,404 | 50,743 | 53,957 |
| Butte Creek | 445 | 500 | 800 | 2,500[a] |
| Clear Creek | 9,298 | 5,922 | 8,569 | 4,258 |
| Deer Creek | 564 | 538 | 1,203 | 270 |
| Feather River | 59,893 | 46,301 | 38,193 | 43,000 |
| Merced River | 1,958 | 4,599 | 2,342 | 2,314 |
| Mill Creek | 1,515 | 1,445 | 580 | 546 |
| Mokelumne River | 5,417 | 7,775 | 10,163 | 6,952 |
| Sacramento River | 39,665 | 40,870 | 125,218 | 5,865 |
| Stanislaus River | 611 | 168 | 1,642 | 2,089 |
| Tuolumne River | 743 | 3,602 | 6,096 | 7,634 |
| Yuba River | 14,561 | 27,520 | 25,778 | 30,802 |
| **Total** | **261,281** | **257,559** | **327,327** | **203,187** |

[a] Estimate based on professional judgement of biologist working on Butte Creek during adult fall-run chinook salmon migration/spawning in 1998.

**TABLE 7**
Fall-Run Chinook Salmon Hatchery Returns

| Watershed | 1995 | 1996 | 1997 | 1998 |
|---|---|---|---|---|
| American River | 6,498 | 7,838 | 6,142 | 10,581 |
| Battle Creek | 26,677 | 21,178 | 50,670 | 44,350 |
| Feather River | 11,719 | 8,710 | 15,066 | 18,699 |
| Merced River | 602 | 1,141 | 946 | 799 |
| Mokelumne River | 3,323 | 3,883 | 6,494 | 3,251 |
| **Total** | **48,819** | **42,750** | **79,318** | **77,680** |

**TABLE 8**
Fall-Run Chinook Salmon In-River Harvest

| Watershed | 1995 | 1996 | 1997 | 1998 |
|---|---|---|---|---|
| American River | 5,961 | 6,003 | 4,651 | 19,636 |
| Feather River | 3,589 | 3,229 | 3,523 | 17,908 |
| Mokelumne River | - | - | - | 14 |
| Sacramento River | 5,042[a] | 4,585 | 9,066 | 9,380[b] |
| Stanislaus River | - | - | - | 0 |
| Yuba River | 532 | 920 | 1,031 | 694 |
| **Total** | **15,124** | **14,737** | **18,271** | **47,632** |

[a] Revised estimate, 9/17/99, by K. Murphy, CDFG.
[b] Estimated as 8% of RBDD ladder count by CDFG.

## Winter-Run Chinook

The watershed-specific target for winter-run chinook salmon, including estimates of natural production for 1995 through 1998, is presented in Table 9. In all four years, estimates of natural production of winter-run chinook salmon in the upper Sacramento River were substantially below the AFRP production target. However, the 1998 estimate is nearly double the 1997 estimate, the next highest estimate.

**TABLE 9**
Winter-Run Chinook Salmon Baseline Production Estimate, Production Target and Estimates of Natural Production for 1995 Through 1998

| | | | Estimate of Natural Production | | | |
|---|---|---|---|---|---|---|
| Watershed | Baseline Production Estimate | AFRP Production Target | 1995 | 1996 | 1997 | 1998 |
| Upper Sacramento River | 54,000 | 110,000 | 5,571 | 2,308 | 5,332 | 10,403 |

## Spring-Run Chinook Salmon

The watershed-specific targets for spring-run chinook salmon and the estimates of natural production by watershed for 1995 through 1998 are presented in Table 10. The total estimate of natural production was substantially below the AFRP production target for all streams in all years except for Butte Creek in 1998. Natural production estimates for Butte Creek increased nearly ten-fold in 1998 over previous years. The spring-run chinook salmon natural production estimate for the Sacramento River in 1998 also was higher than the estimates of previous years

**TABLE 10**
Spring-Run Chinook Salmon Baseline Production Estimates, Production Targets and Estimates of Natural Production for 1995 Through 1998

| Watershed | Baseline Production Estimate | AFRP Production Targets | Estimate of Natural Production | | | |
|---|---|---|---|---|---|---|
| | | | 1995 | 1996[a] | 1997[a] | 1998 |
| Butte Creek | 1,000 | 2,000 | 5,281 | 1,546 | 3,636 | 38,200 |
| Deer Creek | 3,300 | 6,500 | 5,301 | 1,495 | 1,210 | 3,553 |
| Mill Creek | 2,200 | 4,400 | 1,770 | 680 | 519 | 802 |
| Sacramento River | 29,000 | 59,000 | 1,486 | 794 | 491 | 1,897 |
| Total | 35,500 | 71,900 | 13,838 | 4,515 | 5,856 | 44,452 |

## Total Chinook Salmon Production Relative to Other West Coast Watersheds

Figure 2 compares the Central Valley natural production of chinook salmon and natural production of chinook salmon in the Klamath River, Columbia River, and Puget Sound. The in-river run size is based on total escapement plus in-river harvest minus hatchery returns as reported in the *Review of 1998 Ocean Salmon Fisheries* (PFMC 1999). For the purpose of consistency, the numbers for the Central Valley in-river escapement contained in the PFMC report were used even though they differ slightly from the CAMP estimates. Also, the estimates depicted in the figure do not include ocean harvest. In-river run size in the Central Valley over the past four years has been variable, and follows a pattern generally consistent with the Columbia River. Although no trends can be reliably discerned at this time, continued tracking of the Central Valley chinook salmon production relative to other large west coast watersheds may provide insight into the overall effectiveness of restoration efforts.

# Other Species

The AFRP also established natural production targets for steelhead, striped bass, American shad, white sturgeon, and green sturgeon. In 1998, production estimates were available only for American shad. The available natural production estimates for these species for 1995, 1996, 1997, and 1998 are presented in Table 11.

**TABLE 11**
Steelhead, American Shad, Striped Bass, White Sturgeon, and Green Sturgeon Adult Spawner Estimates for 1995 Through 1998

| Species | AFRP Restoration Target | Adult Spawner Abundance Estimate | | | |
|---|---|---|---|---|---|
| | | 1995 | 1996 | 1997 | 1998 |
| Steelhead | 13,000 | NA | NA | NA | NA |
| American Shad | 4,300 | 6,859 | 4,312 | 2,302 | 4,142 |
| Striped Bass | 2,500,000 | NA | 775,000 | NA | NA |
| White Sturgeon | 11,000 | NA | NA | 106,000 | NA |
| Green Sturgeon | 2,000 | NA | NA | 1,452[a] | NA |

[a] 1.37% of white sturgeon total

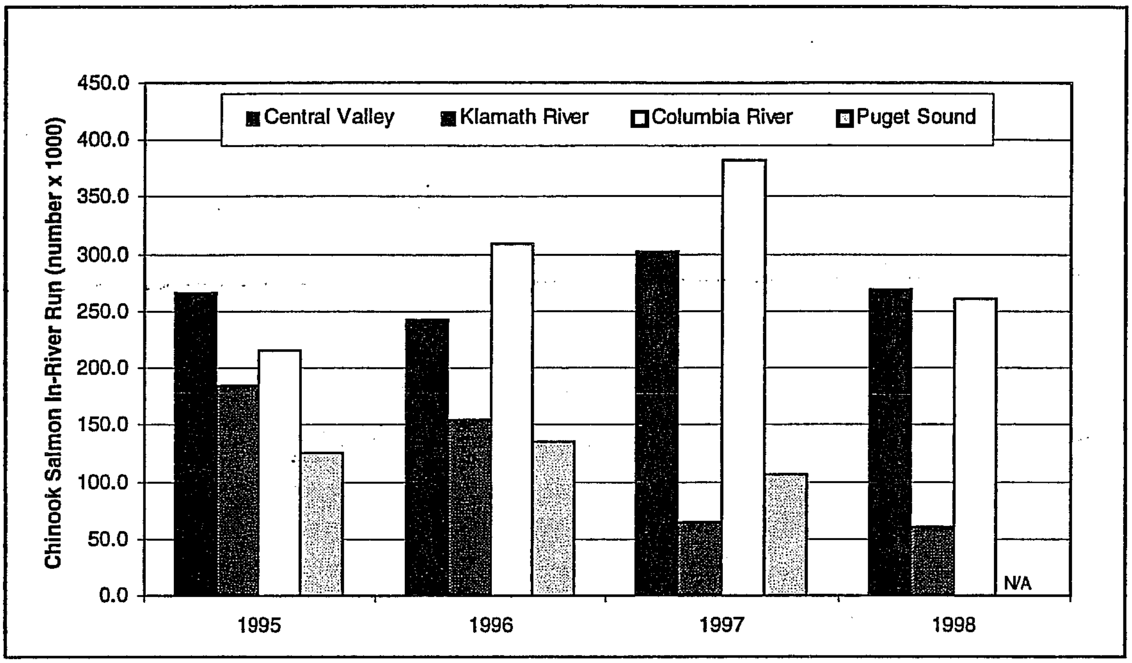


**Figure 2. Comparison of In-river Run Size (escapement + in-river harvest - hatchery returns) for Natural Chinook Salmon in Four Major Drainages on the West Coast. (Based on PFMC 1999).** Escapement data for Puget Sound are not available for 1998.

# 3. Juvenile Monitoring Program: 1998

The CAMP juvenile monitoring program was established to assess the relative effectiveness of categories of CVPIA restoration actions (water management modifications, structural modifications, habitat restoration, and fish screens) toward meeting the AFRP anadromous fish production targets. In this chapter, the effects of each of these action categories on juvenile chinook salmon abundance are evaluated for the following streams:

- American River
- Feather River
- Mokelumne River
- Stanislaus River

The target species/race for analysis in these streams was fall-run chinook salmon. Table 12 summarizes the restoration actions implemented in recent years on these streams. Appendix A discusses restoration actions in detail. Estimated numbers of juvenile chinook emigrating from each stream in 1998 are summarized in Table 13. Detailed analysis of juvenile abundance in each stream is provided in Appendix B.

The watersheds monitored to date are not markedly different in terms of completed restoration actions (Table 12). Water management modifications have been made in recent years in all four streams. Habitat restoration projects were completed at several sites in the Mokelumne, Stanislaus, and American rivers. One structural modification, reconfiguration of the shutters at Folsom Dam, was completed on the American River. No fish screening projects have been completed in these streams.

It is probable that the restoration actions completed to date have increased the success of chinook salmon spawning and rearing in these streams and have resulted in higher abundance of juveniles emigrating each winter and spring compared to previous years. The most recent years show the highest values of the index of juvenile to adult spawners over the four years of record (Table 14). Natural environmental variation, such as extreme high flows in early 1997, reduce our ability to discern differences due to action types given the limited juvenile abundance data. In all cases, pre-project monitoring was either not available or not conducted with comparable methods to the CAMP program. In addition, in some streams and years, sampling was not conducted over the entire fall-run emigration period.

In future years, comparisons of abundance over time in each stream will be improved. Also, as more watersheds are included in the program, there will be an overall wider variety of restoration actions implemented for comparison and evaluation. The current summary of juvenile data does not lend itself to statistical interpretation. However, estimates of indices of juveniles per adult spawner shown in Table 14 suggest general improvement over time among watersheds that could be attributed to the restoration actions shown in Table 12.

While the CAMP juvenile program is intended to provide long-term watershed-specific monitoring of juvenile production, these data are not sufficient to distinguish the relative effectiveness of the four categories of actions to restore anadromous fish populations. Data resulting from site-specific monitoring of AFRP restoration actions should provide the critical link between the types of restoration actions implemented within a watershed to overall juvenile production within that watershed. However, without site-specific monitoring data, CAMP's goal of assessing which types of restoration actions are most effective in restoring fish populations cannot be addressed.

**TABLE 12**
Summary of Restoration Actions Completed In Recent Years in the American, Feather, Mokelumne, and Stanislaus Rivers

| Watershed | Year Implemented | Restoration Action Type | Action |
|---|---|---|---|
| American River | Fall, 1994 and Ongoing | Water Management | Change in flow releases from Folsom Dam |
| | Summer, 1996 | Structural Modification | Reconfigured Folsom Dam shutters |
| Feather River | Ongoing | Habitat Restoration | Spawning gravel restoration at several sites |
| | Water Years 1996, 1997, 1998 and Ongoing | Water Management | Flows augmented in low flow channel |
| Mokelumne River | 1992 | Water Management | Change in flow releases from Camanche Dam |
| | Summer/fall 1992, 1993, 1994, 1996, 1997 | Habitat Restoration | Spawning gravel restoration at several sites |
| Stanislaus River | Spring 1995, 1996 and Ongoing | Water Management | Flow release augmentations, April and May |
| | Summer 1994, 1997 | Habitat Restoration | Spawning gravel restoration at several sites |

**TABLE 13**
Summary of Estimated Numbers of Juvenile Chinook Salmon Emigrating from the American, Feather, Mokelumne, and Stanislaus Rivers, 1998

| Year | Watershed | Estimated total number of YOY emigrating | Estimated number of fry < 50 mm. | Estimated number of juveniles >50 mm |
|---|---|---|---|---|
| 1998 | American River | *32,361,176 | 31,822,165 | 539,011 |
| | Feather River | 45,097,000 | 43,908,500 | 1,188,500 |
| | Mokelumne River | 1,070,645 | 976,692 | 93,953 |
| | Stanislaus River | 650,917 | NA | NA |

NA = data not available

* = preliminary estimates based on the use of historical average screw trap efficiencies.

**TABLE 14**
Index of Emigrating YOY to the Abundance of Adult Spawners

| Watershed | 1995 | 1996 | 1997 | 1998 |
|---|---|---|---|---|
| American River | | 65 | 28 | *753 |
| Feather River | | 11 | | 1,049 |
| Mokelumne River | 289 | 86 | 138 | 154 |
| Stanislaus River | | 172 | 279 | 312 |

* = preliminary estimates based on the use of historical average screw trap efficiencies.

# 4. References

California Department of Fish and Game (CDFG). 1994. Central Valley Anadromous Sport Fish Annual Run-Size, Harvest, and Population Estimates, 1967 through 1991. Compiled by T.J. Mills and F. Fisher. Inland Fisheries Technical Report. Sacramento, California.

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_______________. 1997. Comprehensive Assessment and Monitoring Program (CAMP) Implementation Plan. March, 1997. Prepared by Central Valley Fish and Wildlife Restoration Program Office, Sacramento, California. Prepared with technical assistance from Montgomery Watson, Jones & Stokes Associates, Inc., and CH2M HILL, Sacramento, California.

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# Appendix A

## CAMP Juvenile Monitoring Program: Effects of Restoration Actions on Abundance of Juvenile Chinook Salmon at Emigration

# Contents

## Section Page

APPENDIX A

# CAMP Juvenile Monitoring Program: Effects of Restoration Actions on Abundance of Juvenile Chinook Salmon at Emigration

This Appendix provides the detailed methods and results summarized in Section 3 of the 1998 CAMP Annual Report. The Appendix includes a documentation of the AFRP Actions implemented in each of the watersheds for which juvenile salmon emigration data was available. The Actions are grouped into the categories of:

- Water Management Modifications
- Habitat Restoration
- Structural Modifications
- Fish Screens

Restoration actions in three of the four action categories have been implemented for the watersheds for which juvenile salmon monitoring data are included in this report. Data for only limited number of restoration actions precludes definitive conclusions regarding the effectiveness of action categories for this first report. In the future, as more watersheds with restoration actions in the four categories are monitored over a greater number of years it is likely that links between juvenile success and restoration actions will become apparent.

## Water Management Modifications

CVPIA-related and other water management modifications have been made in recent years in each of the streams included in the juvenile monitoring analysis in this report (American, Feather, Mokelumne, and Stanislaus rivers).

### American River

On the lower American River, flow releases from Folsom Dam have been modified in recent years to reflect target release levels by the Sacramento Area Water Plan Forum based on inflow and storage levels at Folsom Reservoir. The AFRP program has adopted these release schedules into annual flow recommendations for the use of dedicated water on the lower American River.

Since 1994, higher flow releases have been made in the fall months to benefit salmonid spawning and egg incubation. Higher fall flows have been shown to result in increased spawning and incubation success. The majority of fall-run chinook emigrate from the lower American River as fry soon after emerging from the gravel, making the spawning and egg incubation stages the most critical.

The flow schedule varies releases in the fall, winter, and early spring on the lower American River between years depending on hydrologic conditions. This variation makes evaluation of the effects of the new flow targets on salmon abundance difficult without data from a large number of years.

Juvenile data prior to the flow changes were not collected using comparable techniques to the current data. As a consequence, there is no reliable relationship between the water management modifications and juvenile abundance.

## Feather River

On the Feather River, flows in the low flow channel between the Thermalito Diversion Dam and Thermalito Outlet were augmented in water years 1996, 1997, and 1998 to increase available chinook salmon spawning and rearing habitat. The base flow release in the channel prior to augmentation was 600 cfs. Between October 1, 1995 and January 15, 1996, flow releases in the channel were increased to 1,600 cfs. Between October 15, 1996 and January 15, 1997, flow releases were again increased to 1,600 cfs, although from mid-December on, higher flood releases were made. Between October 15, 1997 and February 28, 1998, flows were 900 cfs, with some flood releases in February. For the next two years, flows will be returned to the 600 cfs release, with monitoring of spawning use under the typical flow regime.

Monitoring results during augmented flow periods indicated significant salmon spawning use in the low flow channel. Juvenile data for 1996 and 1998 on the lower Feather show large variation among years. Further monitoring of adult and juvenile abundance will be needed to evaluate the effectiveness of the flow augmentations for this watershed.

## Mokelumne River

On the Mokelumne River, in water year 1992, EBMUD voluntarily implemented the basic provisions of the FERC Principles of Agreement (EBMUD, DFG, USFWS 1996) which included increased flow releases year-round for the benefit of fall-run chinook salmon and steelhead spawning, rearing, and outmigration.

Increased flow releases from implementation of the FERC provisions will probably result in long-term benefits to chinook salmon production in the Mokelumne River. However, consistent baseline data on juvenile abundance is not available prior to implementation of the new flow schedule; direct comparison of juvenile production before and after implementation of the new schedule is therefore not possible. Evaluations of flow changes will need to be based on long-term monitoring of adult returns to the river.

## Stanislaus River

On the Stanislaus River, an existing 1987 instream flow agreement between USBR and CDFG requires allocation of 98,300 to 302,000 acre-feet per year for fishery resources, depending on carryover storage levels in New Melones Reservoir. CDFG submits recommended flow schedules to the USBR on an annual basis.

In 1995, the fishery flow allocation was 98,300 acre-feet; in 1996 and 1997, the allocation was 302,000 acre-feet. In April and May of 1995 and 1996, flow augmentations for fishery purposes were made through allocation of CVPIA 3406(b)(2) and (b)(3) water and voluntary water releases by Oakdale and South San Joaquin Irrigation Districts. In 1997 and 1998, additional flood releases were made.

Evaluation of the effects of flow changes in recent years is difficult, because flow allocations for fishery purposes vary between years based on variations in hydrology, and releases are made to the lower river to meet many other needs. Flow augmentations in the spring of 1995 and 1996 probably increased survival of outmigrating juvenile chinook, but because outmigrant data for the Stanislaus River have only been collected using standardized techniques beginning in 1996, it is not possible to directly evaluate the effectiveness of water management modifications in increasing juvenile production.

# Habitat Restoration

Habitat restoration projects were implemented on three of the streams included in the analysis, the Mokelumne, Stanislaus, and American rivers.

## Mokelumne River

On the Mokelumne River, several salmon spawning gravel restoration projects have been implemented by EBMUD in recent years. In 1992, EBMUD placed approximately 300 cubic yards of salmon spawning gravel in the Mokelumne River in the vicinity of Murphy Creek. The project was continued over subsequent years in cooperation with CDFG and the California Department of Parks and Recreation Habitat Conservation Fund Program. Projects have typically consisted of placing clean river gravel (1 - 4 inch diameter) in known spawning areas.

In the fall of 1993, 500 cubic yards of gravel were placed at the Mokelumne River Day Use Area (MRDUA). The following year, the substrate was ripped and another 100 cubic yards of gravel were placed at the MRDUA. In the fall of 1996, EBMUD placed over 650 cubic yards of clean river gravel at three sites, two at the MRDUA and one near Mackville Road. In 1997, 1,500 cubic yards of gravel (1 - 8 inch diameter) were placed at three sites (one at the MRDUA, one near Mackville Road, and one site about one mile below Mackville Road.

Spawning gravel restoration projects in recent years probably have increased the success of chinook salmon spawning, egg incubation, and early rearing in project areas. However, comparable juvenile outmigrant data is not available at the watershed scale for years prior to project implementation, making pre- and post-project comparisons difficult. Biological staff at EBMUD have been conducting site-specific monitoring at each of the gravel projects completed thus far. The number of salmon spawning redds in each restored riffle area have been monitored pre- and post-project, and compared as a proportion of the total number of spawning redds in the lower river each year. Substrate size, intergravel permeability, dissolved oxygen, temperature, and macroinvertebrate production also have been measured at project sites pre- and post-restoration. Results of these studies are in draft form and were not available for inclusion in this report.

## Stanislaus and American Rivers

On the lower Stanislaus River, two gravel restoration projects have been implemented in recent years. In 1994, three spawning riffles at River Mile (RM) 47.4, 50.4, and 50.9 near Horseshoe Park were reconstructed, funded by the 4-Pumps Agreement. In 1995, these sites were revegetated using vegetation stock from the site. In 1997, 1,000 tons of salmon spawning gravel were added at each of two sites in Goodwin Canyon below Goodwin Dam (one project funded by CDFG, one by CVPIA 3406(b)(13)). Phase I of the project added gravel at three sites located approximately ½ mile below the dam; Phase II added gravel at a site approximately 1/8 mile below the dam.

These spawning gravel restoration projects have probably increased the success of chinook salmon spawning, egg incubation, and early rearing in project areas. However, comparable juvenile outmigrant data are not available at the watershed scale for an adequate number of years prior to and following project implementation, making pre- and post-project comparisons difficult. On the Stanislaus River, post-project monitoring of spawning use has been conducted by CDFG, but comparable pre-project data were not collected at all sites. *Implementation of a comprehensive standardized site-specific monitoring program throughout the Central Valley will greatly enhance the ability to evaluate the benefits of habitat restoration actions.*

Gravel restoration projects were funded on the lower American River by CVPIA 3406(b)(13). A gravel restoration project was recently completed six sites on the lower American River. This project, which includes pre and post-construction monitoring, is expected to improve chinook salmon spawning success. Steelhead also are expected to benefit.

# Structural Modifications

Only one structural modification has been completed on the streams included in this analysis.

## American River

In 1996, the shutters at Folsom Dam were reconfigured to allow better water temperature management in the lower American River. The shutters can now be operated to allow release of cooler water in the fall months to benefit salmon spawning and egg incubation. In the fall of 1996, cooler water was released from the reservoir than would have been feasible without the project. In 1997, the shutters were not operated to reduce fall water temperatures. Cooler water temperatures were released in the summer. As a consequence, during the early spawning period in the fall of 1997, temperatures were relatively high as a result of the prior depletion of the cool water pool in the reservoir.

It is possible that the cooler water temperatures increased spawning and egg incubation success in the early part of the spawning period in fall, 1996. Direct evaluation of the effects of the project on juvenile abundance was not possible, however, because no comparable juvenile monitoring data were collected before the project was implemented. Comparisons of the effects of fall temperature conditions on juvenile abundance between the1996 and 1997 sampling years cannot be made, since extreme high flows in the winter of 1997 had an overriding adverse effect on juvenile outmigrant abundance in 1997.

# Fish Screens

No fish screening projects have been completed in recent years on streams included in this analysis. In future years, effects of installation of new screens or upgrading existing screens on juvenile abundance will be evaluated. The current data serves as pre-screen information (as appropriate) for juvenile salmon production on the watersheds evaluated in this report.

As more watersheds are brought into the CAMP juvenile salmon monitoring program, both pre-and post-screen conditions will be assessed. CAMP is currently reviewing existing and planned fish screen facilities to select representative locations for conducting focused evaluations of the effectiveness of fish screens in meeting AFRP goals. A pilot program to evaluate fish screen effectiveness is expected to be initiated in 2000.

# Appendix B

## CAMP Juvenile Monitoring Program: Summary of Juvenile Chinook Salmon Monitoring, 1995-1997 Detailed Methods and Results

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## Tables

# Figures

APPENDIX B

# CAMP Juvenile Monitoring Program: Summary of Juvenile Chinook Salmon Monitoring, 1998. Detailed Methods and Results

## Introduction

Target streams were selected based on the presence of target races, opportunities to spatially isolate the effects of actions, the implementation schedule for restoration actions, and the presence of existing juvenile and adult monitoring programs. Target streams for juvenile monitoring include the American River, Battle Creek, Butte Creek, Clear Creek, Deer Creek, Feather River, Merced River, Mill Creek, Mokelumne River, Sacramento River (upper mainstem), Stanislaus River, Tuolumne River, and the Yuba River.

To monitor the entire period of juvenile outmigration for each target race, the following sampling periods were selected. In streams with fall-run chinook salmon only, as were sampled in 1998, sampling will be conducted from January 1 - June 30.

Rotary screw traps were selected as the standard gear to sample juvenile chinook salmon abundance in the CAMP program. Although rotary screw traps have been used in some Central Valley streams since 1991 to monitor juvenile salmon, sampling programs have often been under-funded, sporadic, or short-term. Implementation of the CAMP juvenile program in 1998 provided funding for new rotary screw trap programs and established a consistent, long-term data management and retrieval system.

A standardized protocol for rotary screw trap sampling was developed for the CAMP based on the protocols used in existing studies on the upper Sacramento River at Red Bluff (by the USFWS), the upper Sacramento River at Balls Ferry (by the CDFG), the lower Sacramento River at Knights Landing (by the CDFG), the lower American River (by the CDFG), and the lower Stanislaus River (by S.P. Cramer and Associates under contract to the USFWS).

This report provides results of rotary screw trap sampling for fall-run chinook salmon during 1998 in four streams where programs have existed since 1995. These programs used methods that conformed, with some exceptions, to the standardized protocol developed for CAMP. The streams and sampling locations are included in Table B-1.

The CAMP Implementation Plan proposed a variety of qualitative and quantitative analytical techniques to evaluate juvenile abundance data, including:

- Assessment of changes in juvenile abundance within watersheds over time, both prior to and following action implementation.
- Comparison of juvenile abundance among watersheds.
- Integration of AFRP and other CVPIA site-specific monitoring results into the CAMP evaluation.
- Use of adult spawner/juvenile abundance relationships to link the impact of actions that increase juvenile abundance to adult production.
- Assessment of the effects on juvenile abundance of changes in abiotic environmental variables.
- Qualitative and quantitative assessment of relative effectiveness of different categories of actions by assessment of results over individual watersheds.

Most of these techniques require several years of data from several streams. Data from a site-specific monitoring program are not yet available. This report analyzes only the results of one to four years of sampling from four Central Valley streams, making comparisons within or among watersheds unreliable. Many of the proposed analyses, therefore, were not conducted for this report.

This report is limited to the following summaries for each stream in each sampling year:

- Estimates of abundance of total young-of-the-year (YOY), fry (≤ 50 mm fork length), and other juveniles (> 50 mm and ≤ 125 mm fork length) emigrating each day.
- Relationship of juvenile abundance to two environmental factors, flow and water temperature, during the rearing period to evaluate the effects of key limiting factors on juvenile production.
- Preliminary analysis of the effects of restoration action implementation on juvenile abundance.

**TABLE B-1**
Rotary Screw Trap Programs Included in the Current CAMP Juvenile Monitoring Program Report.

| Watershed Name and Year of Data | Monitoring Program Name | Target Species/ Race | Location of Screw Trap(s) | Monitoring Period | Lead Agency | Year Began |
|---|---|---|---|---|---|---|
| American River 1996, 1997, 1998 | Lower American River Emigration Survey | Fall-run Chinook | One trap near Watt Avenue in Sacramento | 1 Jan. - 30 Jun. | CDFG | 1994 |
| Feather River 1996, 1998 | Feather River Outmigration Study | Fall-run Chinook | One Trap at Live Oak | 1 Jan. - 30 Jun. | DWR | 1996 |
| Mokelumne River 1995, 1996, 1997, 1998 | Mokelumne River Chinook Salmon and Steelhead Monitoring Program | Fall-run Chinook | Two traps at Woodbridge Dam | 1 Jan. - 30 Jun. | EBMUD | 1993 |
| Stanislaus River 1996, 1997, 1998 | Stanislaus River Juvenile (smolt) Production Indices and Estimates | Fall-run Chinook | Two traps near Caswell State Park | 1 Jan. - 30 Jun. | USFWS | 1994 |

# American River

## Methods

Rotary screw traps have been used by the CDFG Stream Flow and Habitat Evaluation Program, beginning in 1992, to monitor juvenile emigration from the lower American River. The first full sampling season was in 1994. From 1992 to 1995, the study was funded by EBMUD. Since 1995, funding has been provided by the USFWS or the USBR pursuant to the CVPIA.

Methods used for rotary screw trap sampling on the lower American River were incorporated in development of the CAMP standard protocol. Therefore, sampling methods on the lower American River were generally consistent with the CAMP standard protocol.

In 1996, 1997, and 1998, a single rotary screw trap (8 foot diameter) was fished just downstream of the Watt Avenue bridge in Sacramento (RM 9). Sampling was conducted continuously from October 1995 through September 1996, from mid-December 1996 through June 1997, and from mid-November through July 1998. Results from the standard period of fall-run chinook emigration, January 1 - June 30, 1998 are included in this report.

Traps were fished 24 hrs/day, 7 days/week, and checked once or twice daily. During each trap check, fish were removed from the trap, sorted, and counted by species. From 50 to 100 individuals of each species were subsampled from the start, middle, and end of each catch, for a total of 150 to 300 fish per trap catch. Subsampled fish were measured and weighed (fork length to the nearest 0.5 mm, and weight to the nearest 0.1 g). Measured salmonids were visually classified as yolk-sac fry, fry, parr, silvery parr, or smolts. Water transparency (secchi disk depth), water temperature, and effort (hours fished since last trap check) were recorded during each trap check (CDFG 1997). Flow data used in this report were obtained from USGS gage 11446500 at Fair Oaks, California.

Trap efficiency tests were conducted on a weekly basis from January 21 through May 6 in 1996, from January 21 through March 24 in 1997, but were not reported for 1998. Fish captured in the trap were marked and released approximately 2,500 feet upstream. In 1996, fish were marked using Alcian blue dye; a specific pattern was used to indicate the week of marking. In 1997, fish were marked using a Bismark brown bath. Use of this dye enabled much larger release groups to be marked. During each efficiency test, all fish measured were also checked for marks. When all fish were not checked, the number of recovered fish was expanded by the proportion of fish checked to the total number captured. When no fish were recaptured in a test, results of the test were not used. Calculated efficiency rates (number of recaptures/number of marked fish in release group) varied from 0.00101 to 0.01217 in 1996, and 0.00424 to 0.02399 in 1997. An average value for trap efficiency from 1996 through 1997 (0.00595) was used in 1998, due to the unavailability of 1998 trap efficiency data. The average trap efficiency was applied to raw catch data on each date to estimate the number of juvenile chinook salmon emigrating on that day, by size class (estimated number = raw catch / trap efficiency)

# Results

## *Estimated Abundance*

The estimated daily number of fry and other juvenile young-of-the year (YOY) chinook salmon emigrating from the lower American River in 1998 is shown in Figure B-1.

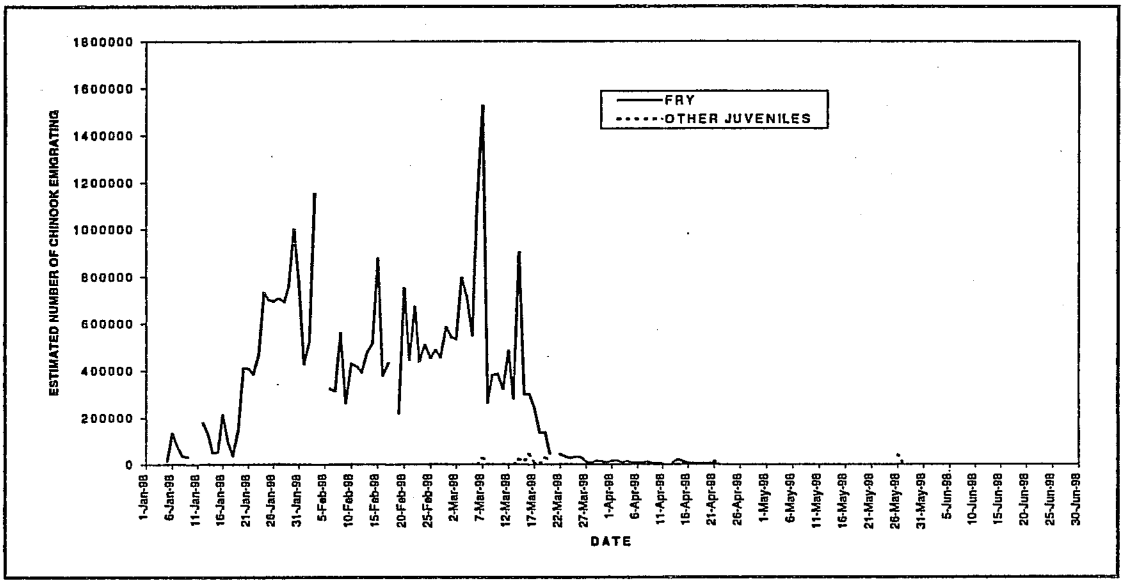


**Figure B-1. Estimated Number of YOY Chinook Salmon Emigrating from the Lower American River Each Day During 1998.**

In 1998, the majority of YOY emigrated from the lower American River as fry. This is consistent with the pattern seen in previous years (Table B-2). In 1998, fry emigration was high from late January through mid-March, peaking in early March. Few fry were caught after the last week of March. The abundance of larger juveniles peaked in mid-March. This is similar to the pattern of emigration seen in 1996 and 1997, except that the number of emigrants was higher during January 1998.

**TABLE B-2**
Estimated Number of Fry (< 50 mm) and Juveniles (50mm t0 125 mm) Emigrating from the Lower American River, 1996 - 1998.

| | Estimated Number of Outmigrants | | |
|---|---|---|---|
| **Life Stage** | **1996** | **1997** | **1998** |
| Fry (less than 50 mm) | 4,461,729 | 1,772,842 | 31,822,165 |
| Juvenile (50-125 mm) | 125,487 | 57,532 | 539,011 |
| **TOTAL** | 4,587,216 | 1,830,374 | 32,361,176 |

### *Relationship of juvenile abundance to environmental factors: Effect of streamflow on survival and timing of juvenile outmigration*

Figure B-2 shows the mean daily flow (cfs) at the gage site during the egg incubation, juvenile rearing and emigration period in 1997 – 1998 (October 1997 through June 1998) and the abundance of YOY chinook salmon emigrating from the lower American River.

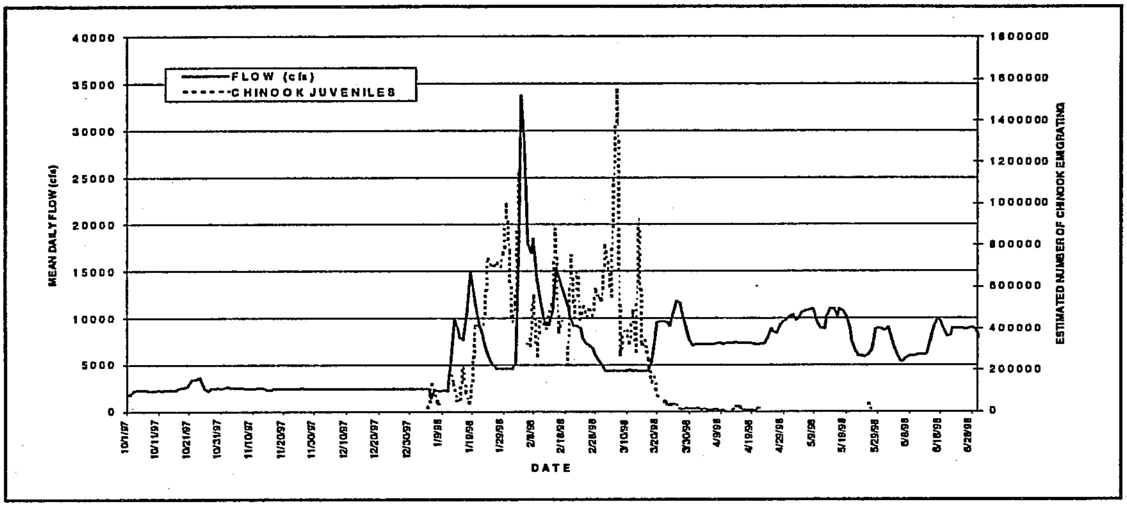


**Figure B-2. Mean Daily Flow (cfs) at Fair Oaks, October 1997 Through June 1998 and Estimated Abundance of YOY Chinook Salmon Emigrating from the Lower American River During 1998.**

Flows were relatively low and constant at about 2,500 cfs from the beginning of October 1997 to the middle of January 1998. These flows were not high enough to stimulate early emigration of emerging fry. From mid-January through February, 1998, flows were high and variable, peaking of over 30,000 cfs. These high flows coincided with the period of high fry outmigration during January and February. Flows during March and April were relatively constant, averaging around 7,000 cfs. Fry continued to emigrate in high numbers throughout March. Relatively low numbers of chinook salmon emigrated in April. Flows were more variable in May and June (5,000 to 11,000 cfs.).

Although the period of high fry outmigration in 1998 coincided with a period of relatively high flows in January and February, it is unclear whether the high flows stimulated outmigration. Outmigration occurred at a higher rate and earlier in 1998 than in either 1996 or 1997.

### Effect of Water Temperature on Juvenile Abundance

Water temperatures were measured by CDFG at Nimbus Dam in 1997-1998. A Stowaway recorder was used to measure water temperature at Nimbus Dam. Mean daily water temperatures from October 1997 through June 1998 are shown in Figure B-3.

Temperatures declined steadily during the fall in 1998 from near 67° F in October to around 50° F in December. Temperatures in November and December 1997 were similar to temperatures recorded during the same period in 1996. It is probable that the cooler water temperatures in the fall of 1996 and 1998 increased spawning and egg incubation success in the early part of the spawning and incubation period compared to other years.

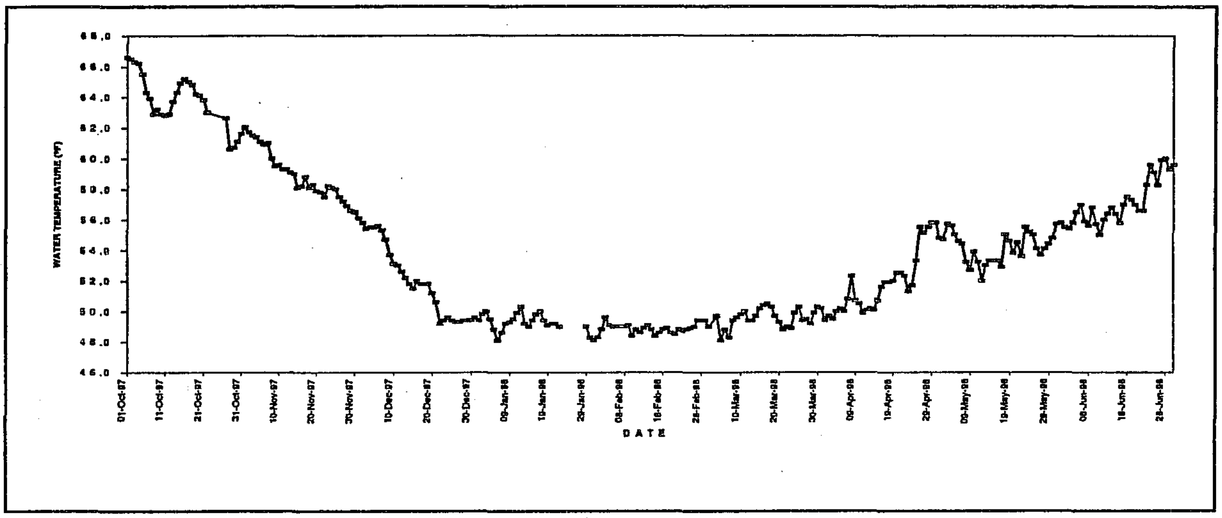


**Figure B-3. Mean Daily Water Temperature (°F) at Watt Avenue or Nimbus Dam on the Lower American River, October 1997 - June 1998.**

# Feather River

## Methods

In cooperation with DFG, DWR has initiated a number of fishery studies on the lower Feather River. Many of the study elements are included in the recent draft CVPIA plan to restore anadromous fish. Juvenile outmigration data are collected by DWR Environmental Services staff based at the Oroville Field Division.

Rotary screw trap sampling was conducted from March 4 to December 27, 1996 at the Live Oak site (station FR042E) on the lower river. In January, 1997, sampling was discontinued when flood flows washed out the trap. Rotary screw trap sampling was again conducted during 1998, from January 1 through June 30. In general, methods used for rotary screw trap sampling on the Feather River in 1996 and 1998 were consistent with the CAMP standard protocol.

In 1996 and 1998, a single rotary screw trap (8 foot diameter) was fished at the Live Oak site. The trap was fished 24 hrs/day, 7 days/week, and checked at least once daily. Traps were serviced more frequently during periods of peak emigration. During each trap check, fish were removed from the trap, sorted, and counted by species. Up to 50 individuals of each species were measured to the nearest 0.5 mm fork length. Water transparency (secchi disk depth), water temperature, and fishing –hour effort were recorded during each trap check. Flow data used in this report were obtained from USGS gage site.

A single trap efficiency test was conducted in 1998 at the Live Oak site. Fish captured in the trap were marked by fin clipping (dorsal or caudal fin) and held in live boxes adjacent to the traps. Fish were kept for 1-5 days prior to release approximately 1 km upstream of the trap. The trap efficiency was as 0.002 in 1998. This efficiency was applied to raw catch data for all 1998 dates to estimate the number of juvenile chinook salmon emigrating on that day, by size class (estimated number = raw catch / trap efficiency).

## Results

### *Estimated Abundance*

The estimated daily number of fry and other juvenile YOY chinook salmon emigrating from the Feather River in 1998 are shown in Figure B-4.

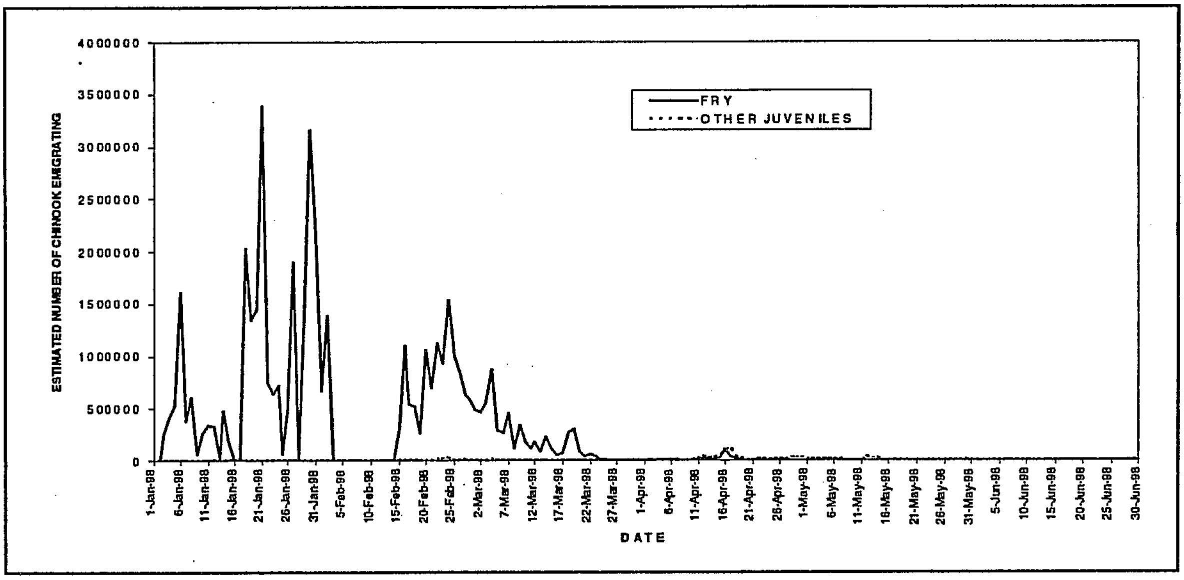


**Figure B-4. Estimated Number of YOY Chinook Salmon Emigrating from the Feather River Each Day During 1998.**

In 1998, the majority of YOY emigrated from the Feather River as fry. This is consistent with the pattern seen in 1996 (Table B-3). Fry emigration during 1998 peaked in mid- to late-January and was high throughout February, declining in March. A small number of fry were caught after the first week of April. The abundance of larger juveniles peaked in mid-April, with emigration continuing through May.

The extremely high estimate of total juvenile production for the Feather River in 1998 may be an artifact of the application of a single trap efficiency, rather than multiple trap efficiency tests as recommended in the CAMP protocols, to the capture data.

**TABLE B-3.**
Estimated Number of Fry (< 50 mm) and Juveniles (50mm t0 125 mm) Emigrating from the Feather River in 1996 and 1998.

| | Estimated Number of Outmigrants | |
|---|---|---|
| **Life Stage** | **1996** | **1998** |
| Fry (less than 50 mm) | 550,500 | 43,908,500 |
| Juvenile (50-125 mm) | 90,500 | 1,188,500 |
| **TOTAL** | 641,000 | 45,097,000 |

### *Relationship of juvenile abundance to environmental factors: Effect of streamflow on survival and timing of outmigration*

Flow data for the Feather River were obtained from the DWR gage located at Gridley, California. Figure B-5 shows the mean daily flow (cfs) at the gage site during the egg incubation, juvenile rearing and emigration period in 1997 - 1998 (October 1997 through June 1998) and the abundance of YOY chinook salmon emigrating from the Feather River from January through June, 1998.

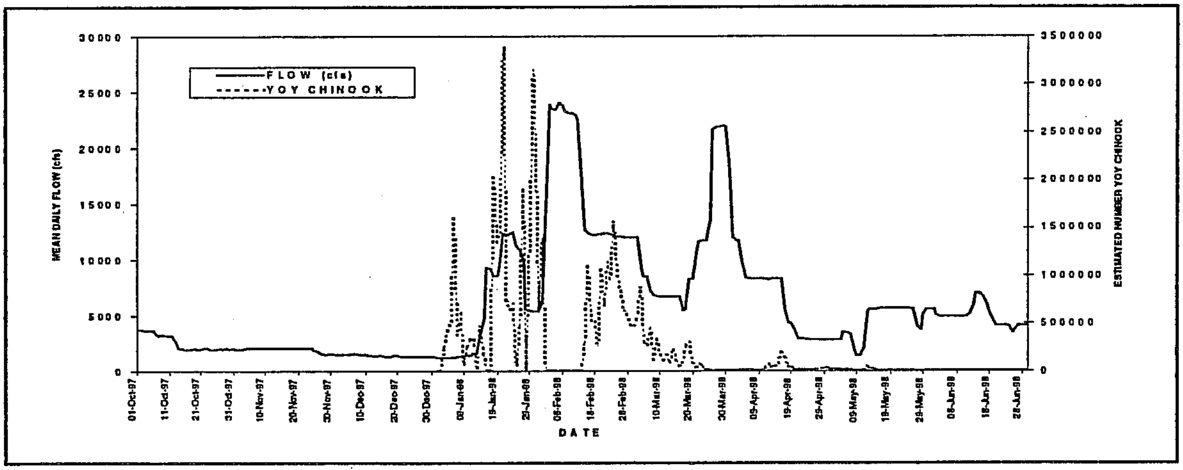


**Figure B-5. Mean Daily Flow (cfs) at Gridley, October 1997 Through June 1998 and Estimated Abundance of YOY Chinook Salmon Emigrating from the Feather River During 1998.**

Flows throughout October, November, and the beginning of December were relatively low. Some fry emigration probably occurred in December, prior to the start of sampling Flows increased during January and remained high throughout February, with a peak occurring in mid- February forcing trapping to be discontinued for a short time. High flows at the end of March again forced trapping to be discontinued for a short time. Emigration began prior to the period of high flows and peaked before the peak in flow. It is unknown if flows had a significant effect on the timing of emigration.

**TABLE B-3.**
Estimated Number of Fry (< 50 mm) and Juveniles (50mm t0 125 mm) Emigrating from the Feather River in 1996 and 1998.

| | **Estimated Number of Outmigrants** | |
|---|---|---|
| **Life Stage** | **1996** | **1998** |
| Fry (less than 50 mm) | 550,500 | 43,908,500 |
| Juvenile (50-125 mm) | 90,500 | 1,188,500 |
| **TOTAL** | 641,000 | 45,097,000 |

### *Relationship of juvenile abundance to environmental factors: Effect of streamflow on survival and timing of outmigration*

Flow data for the Feather River were obtained from the DWR gage located at Gridley, California. Figure B-5 shows the mean daily flow (cfs) at the gage site during the egg incubation, juvenile rearing and emigration period in 1997 - 1998 (October 1997 through June 1998) and the abundance of YOY chinook salmon emigrating from the Feather River from January through June, 1998.

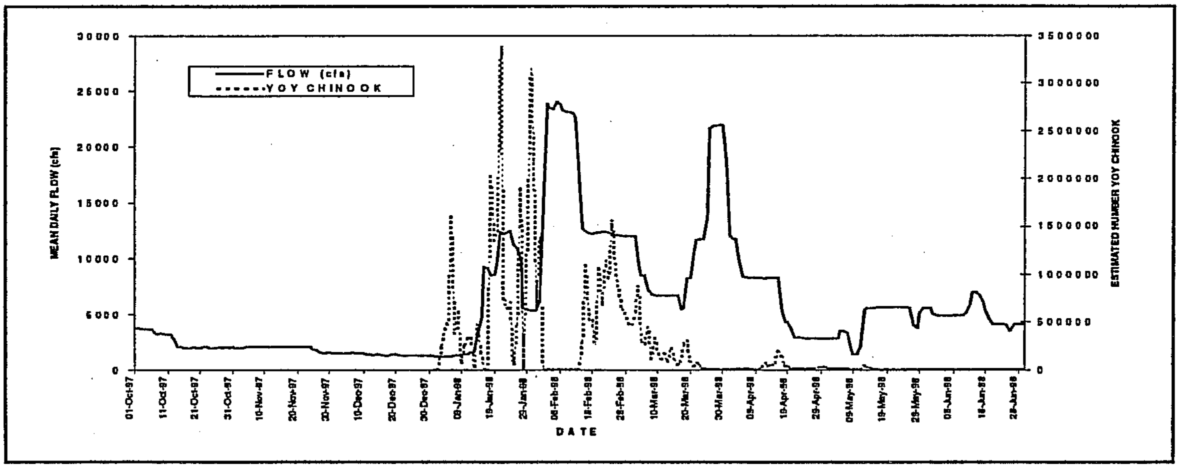


**Figure B-5. Mean Daily Flow (cfs) at Gridley, October 1997 Through June 1998 and Estimated Abundance of YOY Chinook Salmon Emigrating from the Feather River During 1998.**

Flows throughout October, November, and the beginning of December were relatively low. Some fry emigration probably occurred in December, prior to the start of sampling Flows increased during January and remained high throughout February, with a peak occurring in mid- February forcing trapping to be discontinued for a short time. High flows at the end of March again forced trapping to be discontinued for a short time. Emigration began prior to the period of high flows and peaked before the peak in flow. It is unknown if flows had a significant effect on the timing of emigration.

# Results

## *Estimated Abundance*

The estimated daily number of fry and other juvenile YOY chinook salmon emigrating from the Mokelumne River at Woodbridge in 1998 is shown in Figure B-6.

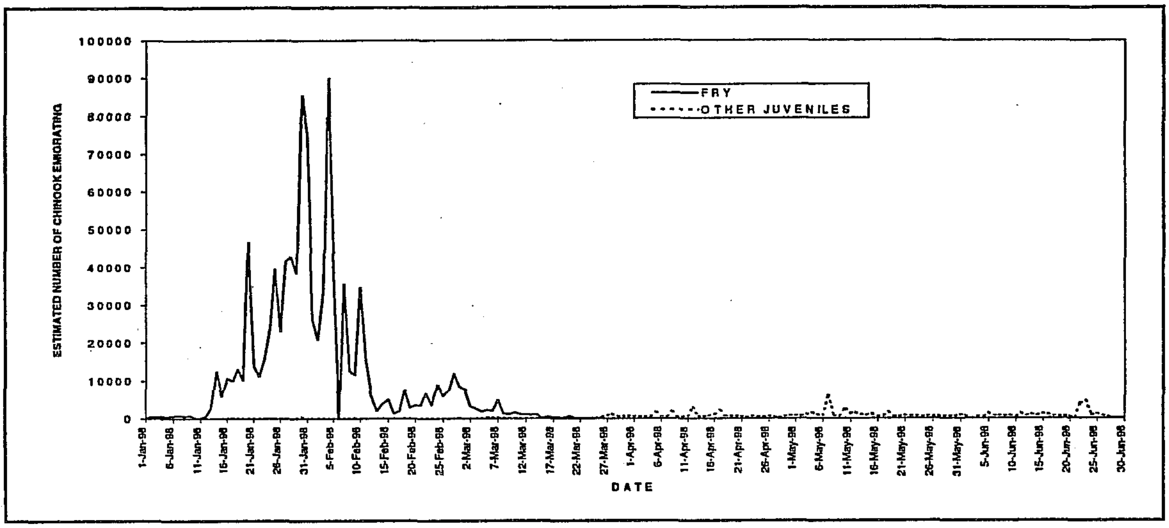


**Figure B-6. Estimated Number of YOY Chinook Salmon Emigrating from the Mokelumne River Each Day During 1998.**

In 1998, the majority of YOY emigrated from the Mokelumne River as fry. This is consistent with the pattern seen in previous years, although the proportion of fry and total juvenile production has increased over time (Table B-4). The timing of emigration was similar in all four years. In 1998, fry emigration was high from mid- January through mid-February, peaking in early February. Fry emigration was much lower in late February and early March. Emigration of larger juveniles was prolonged, occurring from early March and continuing through June, peaking in early May. The estimated number of outmigrants was highest in 1998 and a greater proportion of juveniles emigrated as fry in that year. Estimated numbers were lowest in 1996.

**TABLE B-4.**
Estimated Number of Fry (< 50 mm) and Juveniles (50mm to 125 mm) Emigrating from the Mokelumne River, 1995 - 1998.

| | Estimated Number of Outmigrants | | | |
|---|---|---|---|---|
| **Life Stage** | **1995** | **1996** | **1997** | **1998** |
| Fry (less than 50 mm) | 230,582 | 101,788 | 393,341 | 976,692 |
| Juvenile (50-125 mm) | 203,513 | 80,672 | 144,372 | 93,953 |
| **TOTAL** | **434,096** | 182,461 | 537,713 | 1,070,645 |

### *Relationship of juvenile abundance to environmental factors:*

#### Effect of streamflow on survival and timing of outmigration

Flow data for the Mokelumne River were obtained from USGS gage 11323500, located below Camanche Dam. Figure B-7 shows the mean daily flow (cfs) at the gage site during the egg incubation, juvenile rearing and emigration period in 1997 - 1998 (October 1997 through June 1998) and the abundance of YOY chinook salmon emigrating from the Mokelumne River from late January through June, 1998.

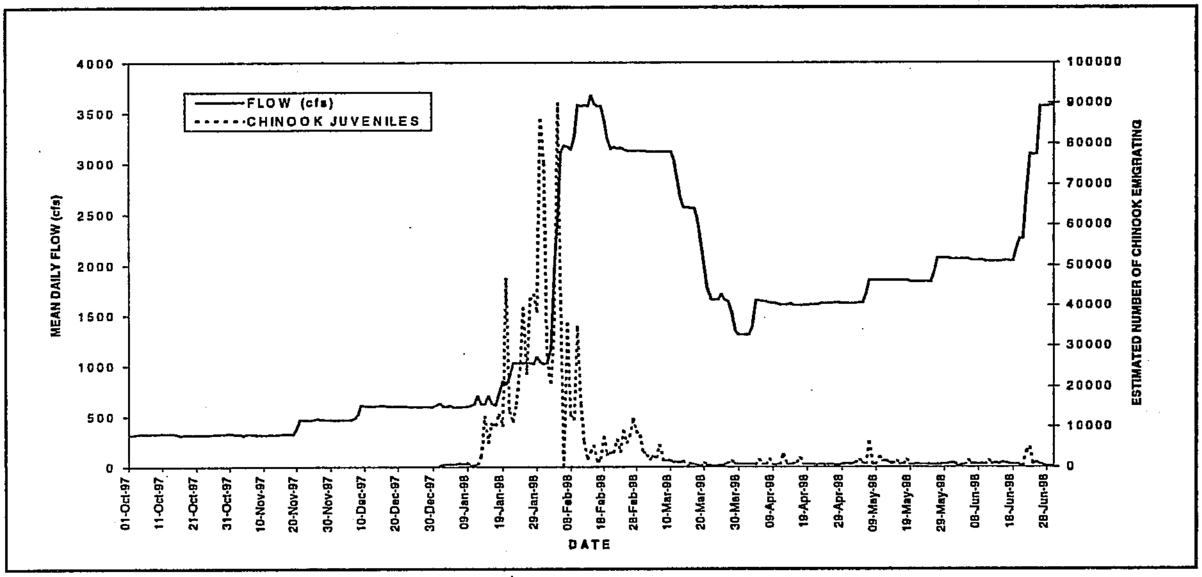


**Figure B-7. Mean Daily Flow (cfs) at Camanche Dam, October 1997 Through June 1998 and Estimated Abundance of YOY Chinook Salmon Emigrating from the Mokelumne River During 1998.**

Flows from October through November 1997 were relatively low and stable at around 300 cfs. Flows increased in mid to late November to around 500 cfs and again in early December to around 600 cfs. Flows continued to increase during January with a dramatic increase in early February, 1998 to around 3,500 cfs. Flows remained high through early March when they declined to around 1,500 cfs. The timing of emigration did not appear to be strongly related to changes in flow. Peak fry emigration occurred in late-January before the peak in flows. Peak emigration of larger juveniles also occurred during a period of relatively high and stable flows in early May.

# Stanislaus River

## Methods

Rotary screw traps have been used since 1994 to monitor juvenile emigration on the lower Stanislaus River at Caswell State Park (RM 8.6) (Demko and Cramer 1997). In 1994, CDFG fished one trap and in 1995, USFWS fished two traps at the site. In these years, traps were not fished throughout the entire fall-run emigration period; catches were relatively low and sampling missed significant portions of the outmigration period.

In 1996 and 1997, sampling was conducted by S.P. Cramer and Associates under contract to the USFWS. Funding was provided by the AFRP CVPIA Restoration Account. In 1996, traps were fished from February 6 through June 30, covering most of the outmigration period. In 1997, traps were installed after the start of outmigration, on March 19, due to high flows in January and February. In 1998, the traps were installed earlier and sampling was conducted from January 1 through July 16, 1998. Results from the standard period for fall-run chinook emigration, (January through June) are included in this report. In general, methods used for rotary screw trap sampling on the lower Stanislaus River in 1996 through 1998 were consistent with the CAMP standard protocol.

In each year, two rotary screw traps (8 foot diameter) were fished side-by-side at Caswell State Park (RM 8.6). Traps were fished 24 hrs/day, 7 days/week, and checked once or twice daily. During peak outmigration periods or when debris loading was heavy, the trap was monitored every 2 to 3 hours. During each trap check, fish were removed from the trap, sorted, and counted by species. Up to 30 individuals of each species were measured (fork length to the nearest 0.5 mm). Measured salmonids were visually classified as fry, parr, or smolts. Turbidity (as NTUs), velocity at trap mouth, water temperature, and effort were recorded each day. Daily water temperatures were also calculated from continuously recording thermographs. Flow data used in this report were obtained from USGS gage 11302000 located at Goodwin Dam near Knight's Ferry, California.

Trap efficiency tests were conducted in 1996, 1997 and 1998. Tests were conducted with naturally produced fish when available in sufficient numbers; fish from the Merced River Fish Facility were also used. Trap efficiency tests were limited in 1997 by the availability of hatchery fish for use in tests. Fish were marked by cold brand or dye inoculation, using Alcian Green and Alcian Blue dyes. A specific pattern was used to indicate the week of marking. After marking, fish were held 1-4 days in a net pen and then released ¼ mile upstream of the trap site. During each efficiency test, all fish measured were also checked for marks.

Calculated efficiency rates (number of recaptures/number of marked fish in release group) varied from 0.0021 to .121 in 1996, and 0.016 to 0.036 in 1997. Following 1997 sampling, a regression was developed relating flow and water turbidity to trap efficiency. This regression was updated following sampling in 1998, using the efficiency data from the 1998 sampling. Predicted values from the updated regression equation were applied to raw catch data on each date to estimate the number of juvenile chinook salmon emigrating by size class (estimated number = raw catch /predicted trap efficiency rate).

## Results

### *Estimated Abundance*

The estimated daily number of YOY chinook salmon emigrating from the lower Stanislaus River in 1998 is shown in Figure B-8. The outmigrants were not separated into fry and juvenile size classes. In 1998, there was a distinct peak of emigration in mid-February. Numerous smaller peaks occurred throughout March and April. This is consistent with the pattern of fry emigration that occurred in 1996.

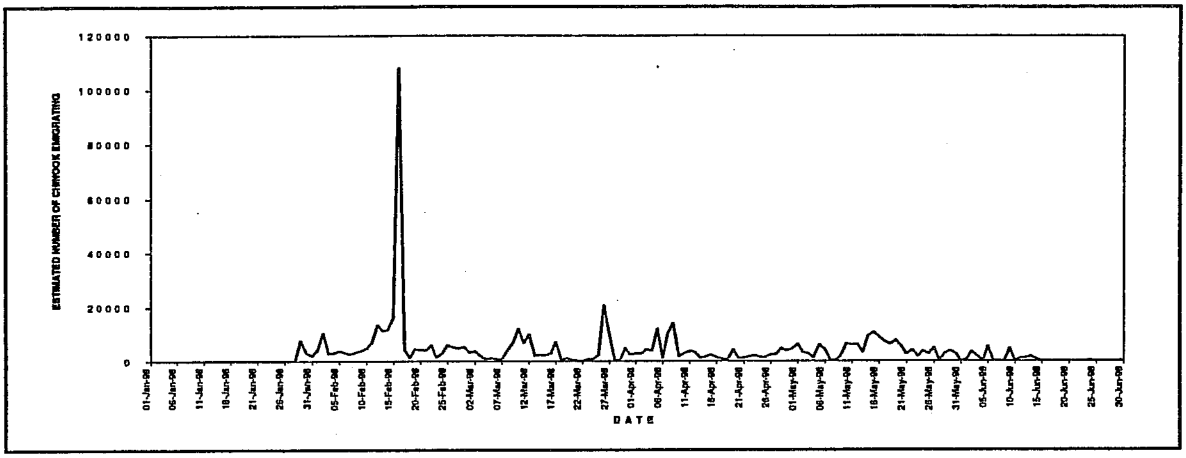


**Figure B-8. Estimated number Number of YOY Chinook Salmon Emigrating from the Lower Lower Stanislaus River Each Day During 1998.**

Table B-5 presents the estimated number of fall-run chinook salmon emigrating from the lower Stanislaus River from 1996 through 1998. Significant numbers of fry probably emigrated prior to the start of sampling in 1998.

**TABLE B-5.**
Estimated Number of Fry (< 50 mm) and Juveniles (50mm to 125 mm) Emigrating from the Lower Stanislaus River, 1996 - 1998.

| | Estimated Number of Outmigrants | | |
|---|---|---|---|
| **Life Stage** | **1996** | **1997** | **1998** |
| Fry (less than 50 mm) | 41,026 | 85 | N/A |
| Juvenile (50-125 mm) | 64,187 | 46,835 | N/A |
| **TOTAL** | 105,207 | 46,920 | 650,917 |

### *Relationship of juvenile abundance to environmental factors: Effect of streamflow on survival and timing of outmigration*

Flow data for the lower Stanislaus River were obtained from USGS gage 11302000 located at Goodwin Dam near Knight's Ferry, California. Figure B-9 shows the mean daily flow (cfs) at the gage site during the egg incubation, juvenile rearing and emigration period in 1997 - 1998 (October 1997 through June 1998) and the abundance of YOY chinook salmon emigrating from the lower Stanislaus River.

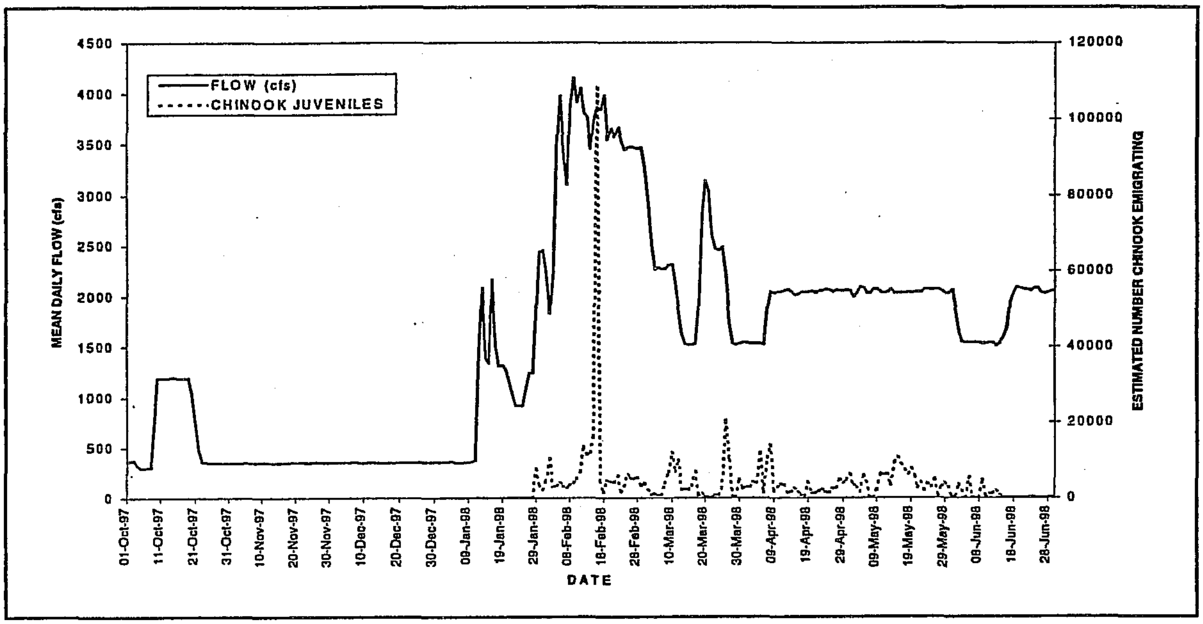


**Figure B-9. Mean Daily Fow (cfs) at Goodwin Dam, October 1997 Through June 1998 and Estimated Abundance of YOY Chinook Salmon Emigrating from the Stanislaus River During 1998.**

Flows from October 1997 through January 1998 were relatively low and stable at around 400 cfs. There was a short period of time in mid-October when flows were near 1,200 cfs. Flows increased during January with a dramatic increase in early February, 1998 to around 4,000 cfs. Flows remained high through February and then declined during March. Flow remained relatively constant during April and May, 1988 at around 2,000 cfs. The timing of emigration did not appear to be strongly related to changes in flow. The strong peak in fry emigration occurred in mid-February after the increase in flows, and was of short duration even though flows remained high.

## Effect of Water Temperature on Juvenile Abundance

Mean daily water temperatures obtained from USGS gage 11302000 located at Goodwin Dam near Knight's Ferry, California from October 1997 through June 1998 are shown in Figure B-10. Temperatures measured at this station throughout the fall-run chinook salmon spawning, egg incubation, rearing, and emigration periods were within optimum levels (less than 54° F). However, temperatures through the spawning and rearing reach were probably somewhat higher than temperatures measured at the gage site.

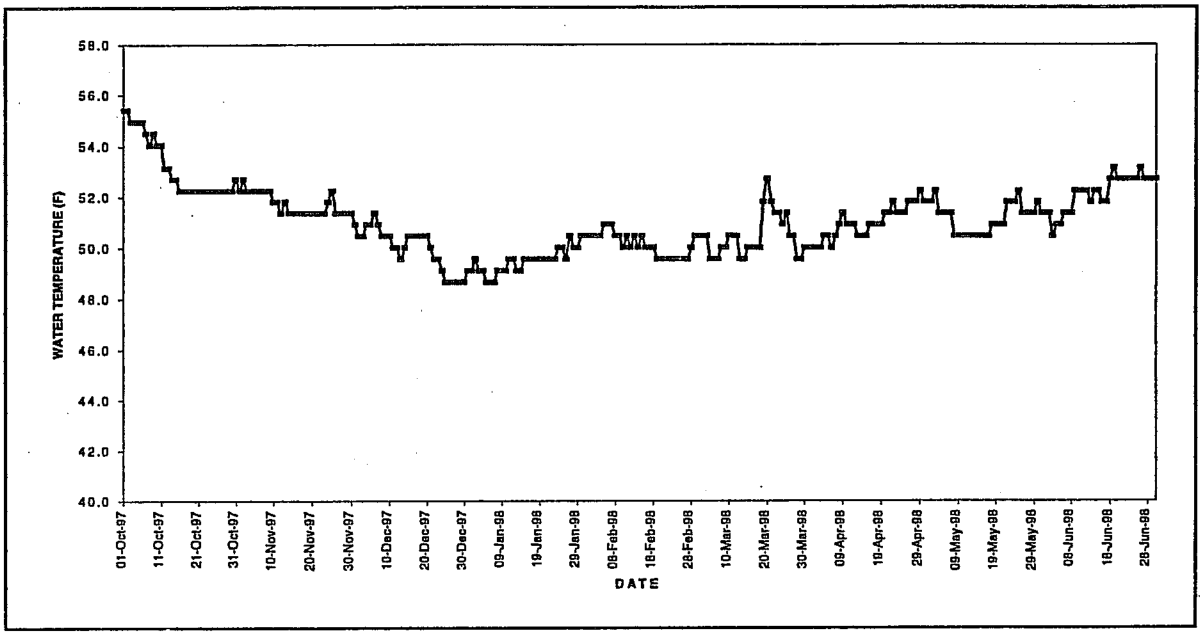


**Figure B-10. Mean Daily Water Temperature (°F) at Goodwin Dam on the Lower Stanislaus River, October 1997 - June 1998 (USGS).**

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California Department of Fish and Game. 1997. Central Valley anadromous fish-habitat evaluations, Sacramento and American River investigations, October 1995 through September 1996. Environmental Services Division, Streamflow and Habitat Evaluation Program. Annual Progress Report prepared for U.S. Fish and Wildlife Service, Central Valley Anadromous Fish Restoration Program, Sacramento, CA. January, 1997.

Demko, D.B. and S.P. Cramer. 1997. Final Report. Outmigrant trapping of juvenile salmonids in the lower Stanislaus River, Caswell State Park site, 1996. Unpublished report to the U.S. Fish and Wildlife Service, Anadromous Fish Restoration Program Office, Stockton, CA.

East Bay Municipal Utility District, Department of Fish and Game, and U.S. Fish and Wildlife Service. 1996. Principles of agreement for a joint settlement agreement concerning the flows and non-flow measures appropriate to the lower Mokelumne River in the matter of FERC Lower Mokelumne River Project No. 2916-004 proceeding.