Comprehensive Assessment and Monitoring Program (CAMP)

Annual Report 1999

Prepared for

United States Department of Interior

U.S. Fish and Wildlife Service (Lead)
Central Valley Project Improvement Act
2800 Cottage Way
Sacramento, California 95825

U.S. Bureau of Reclamation
2800 Cottage Way
Sacramento, California 95825

Prepared by

CH2M HILL
2485 Natomas Park Drive, Suite 600
Sacramento, California 95833-2937

February 2001

Contents

Section **Page**

Appendices

Tables

Figures

Summary

The Comprehensive Assessment and Monitoring Program (CAMP), established by Section 3406(b)(16) of the Central Valley Project Improvement Act (CVPIA), has two distinct goals:

- Goal 1: To assess the overall effectiveness of actions implemented pursuant to CVPIA Section 3406(b) in meeting restoration production targets.
- Goal 2: To assess the relative effectiveness of four categories of Section 3406(b) actions (water management modifications, structural modifications [excluding fish screens], habitat restoration, and fish screens) in meeting production targets.

This annual report of the CAMP documents the 1999 monitoring results and presents summary information for the first five years of anadromous fish population monitoring under the requirements of the CVPIA. This is the third report produced by the CAMP. The first report covered monitoring from 1995 –1997 (USFWS, 1998) and the second covered 1998 monitoring results (USFWS, 1999). As measures of progress toward meeting restoration goals, adult anadromous fish monitoring results since 1995 have shown variable population estimates between years. Results of population estimates from the 1999 monitoring (Goal 1) are as follows:

- Fall-run chinook salmon estimates of overall natural production are higher than those for 1998 but below estimates for 1995 through 1997. However, in the Battle Creek, Butte Creek, and Clear Creek watersheds, adult salmon return estimates are at or above watershed-specific production targets.
- Winter-run and spring-run chinook salmon estimates of natural production are generally below estimates of natural production for 1998, but comparable to the 1995-1997 period.
- American shad population estimates decreased substantially in 1999, compared to estimates in all previously monitored years.
- Abundance estimates for steelhead, striped bass, and sturgeon are unavailable for 1999 because the fish were not sampled or sampling results are unavailable.

CAMP Goal 2 uses a variety of monitoring and analysis techniques to distinguish among the effects of the four categories of restoration actions. The primary assessment tool of Goal 2 is the measurement of juvenile fall-run chinook salmon production using rotary screw traps (RSTs). Because implementation of restoration actions contributes to natal stream conditions, the Goal 2 effort also requires that the results of site-specific restoration actions be monitored and reported. The total juvenile production in the watershed then can be apportioned among the various categories of actions based on results from site-specific monitoring. The results of assessing Goal 2 will remain unresolved until juvenile production, site-specific monitoring for restoration actions, environmental, and adult natural production data are available for a sufficient number of years to conduct a weight of evidence analysis. Based on limited juvenile and adult natural production data,

observations on the cumulative effectiveness of restoration actions in the Mokelumne and Stanislaus rivers show statistically significant improvements in juvenile production and in the index of juveniles/females for fall-run chinook salmon. Additionally, the Mokelumne River and Battle, Butte, and Clear creeks now exceed restoration targets for adult natural production. No comparison of categories of actions currently is possible, however.

The population estimates in this report were developed with the best available data and present a good estimate of recent population trends among salmon in the Central Valley. The data, however, have limits. While adult carcass counts have been used to estimate spawning escapements for over 50 years and have served scientists and decision makers well, carcass counts and other estimating techniques (e.g. ladder counts, aerial redd surveys, etc.) tend to produce variable population estimates. For example, carcass counts can be difficult to obtain when storms occur early in the spawning season. However, over time, carcass counts and other methods provide trends of relative abundance and are a valuable tool for fishery scientists.

Rotary screw traps (RSTs) are another important tool by which trends in juvenile fish abundance may be evaluated. Used over a significant numbers of years, RST's can provide useful estimate of juvenile production. Standardized protocols, such as those recommended in CAMP, can overcome most sampling errors. However, the use of RST's is not without error. Rotary screw traps sample a discrete elevation in the water column and are not always calibrated in a manner needed to produce consistent results. Significant progress has been made to standardize CAMP data. These data will become more valuable as predictive and descriptive tools over time.

Early results of the CAMP monitoring are encouraging and suggest that streams where restoration actions have been implemented show positive trends. However, more data and more refined methods and analysis are needed to assess progress toward doubling the populations and assessing the relative effectiveness of categories of actions.

01052000101052000101052000101052000 1SECTION 1

Introduction

This third annual report of the Comprehensive Assessment and Monitoring Program (CAMP) has been prepared for the U.S. Fish and Wildlife Service (USFWS) and the Bureau of Reclamation (Reclamation) pursuant to the Central Valley Project Improvement Act (CVPIA). The report summarizes anadromous fish population estimates for Central Valley watersheds in the context of progress toward achieving CVPIA restoration goals. Additionally, the report addresses the status of assessing the relative effectiveness of four categories of actions for restoring anadromous fish populations.

Background

The CVPIA (Public Law 102-575, Title 34) of October 1992 amends the authority of the Central Valley Project (CVP) to include fish and wildlife protection, restoration, and mitigation as having equal priority with other CVP functions. Section 3406 (b) of the CVPIA directs the Secretary of Interior 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, with help from other agencies and groups, 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 data 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:

- **Goal 1:** To assess the overall effectiveness of actions implemented pursuant to CVPIA Section 3406(b) in meeting production targets.
- **Goal 2:** To assess the relative effectiveness of four categories of Section 3406(b) actions (water management modifications, structural modifications [excluding fish screens], habitat restoration, and fish screens) in meeting production targets.

The 1999 CAMP Annual Report includes the results of monitoring performed to estimate the natural production of anadromous fish in target watersheds.

The recommended methods by which data are collected and analyzed to evaluate progress toward these goals are outlined in the CAMP Conceptual Plan (USFWS 1996). The CAMP Implementation Plan (USFWS 1997) further refines recommendations for adult and juvenile production monitoring programs necessary to achieve CAMP's two primary goals and provides detailed data management protocols and data analysis methods.

The CAMP Goals

Monitoring Measures

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. Progress toward natural production goals for each species and race is determined by comparing the annual adult production estimates to the 1967 through 1991 baseline period estimates for each targeted watershed. The adult monitoring program relies largely on existing monitoring programs in place prior to CAMP's implementation and is planned to be conducted annually and on a long-term (25 to 50 years) basis.

Juvenile chinook salmon production estimates, which are determined by monitoring selected watersheds, are used as part of an effort to evaluate the relative effectiveness of the four categories of restoration actions (CAMP's second goal). 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. The relative effectiveness of the four categories of restoration actions is assessed using three measures: 1) juvenile production estimates on tributaries provided by RST; 2) site-specific monitoring results that assess the effects of individual restoration actions; and 3) measurement of environmental variables that could affect juvenile production. 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. Discussions regarding the most effective actions to restore anadromous fish populations will remain unresolved until sufficient information is available to address the differences among these categories.

Reporting Assumptions

The adult and juvenile fish abundance estimates presented in the CAMP Annual Reports represent a compilation of the best estimates available at the time of report production. Typically, we present abundance estimates provided by agency resource managers and field staff in the spring and summer that represent estimates of the previous year's populations. Other fish abundance compilations, such as the CDFG spreadsheet of Central Valley chinook salmon numbers known as "Grandtab", may be used for comparison, if available. All such estimates are taken from the same original agency data sources.

Most fish annual population estimates developed by resource agencies change throughout the year or over several years as data and estimating techniques are refined. For the abundance estimates compiled by CAMP, estimates may be assumed final when reported as part of the CDFG Stock Recruitment Reports. Reports now are being prepared for individual watersheds for 1997 by CDFG. In addition, as noted in the Methods section, below, Pacific Fishery Management Council ocean harvest data are used every year in the CAMP Annual Report but are only available as preliminary data at the time of report production. Changes in ocean harvest data that have occurred following CAMP report production are noted in the Results section of the report.

Other assumptions are noted in the Methods and Results Sections. It should be noted that the CDFG (1994) method of estimating the percentage of naturally spawning Chinook Salmon for each watershed is a central component of the salmon estimating methods for CAMP.

SECTION 2

Methods

CAMP Goal 1

Adult Fish Monitoring Programs

Recommended monitoring programs to assess adult anadromous fish natural production targets to satisfy CAMP's first goal are included in Table 1. Not all recommended monitoring programs have been implemented, affecting the accuracy and precision of population estimates and reported results. This report presents the results of monitoring programs conducted in 1999, consistent with protocols included in the CAMP Implementation Plan (USFWS 1997). The 1999 data are presented for all target species. Data from the 1995-1997 and 1998 annual reports are provided for comparison.

TABLE 1
CAMP: Recommended Adult Fish Monitoring Programs

Watershed	Species/Race	Adult Fish Monitoring Programs
Chinook Salmon		
American River	Fall-run Chinook Salmon	Carcass counts, hatchery marking, hatchery returns, in-river harvest
Battle Creek	Fall-run Chinook Salmon	Carcass counts, hatchery marking, hatchery returns
	Late Fall-run Chinook Salmon	Hatchery marking, hatchery returns
	Winter-run Chinook Salmon	Hatchery marking, hatchery returns
Butte Creek	Fall-run Chinook Salmon	Carcass counts
	Spring-run Chinook Salmon	Snorkel survey
Clear Creek	Fall-run Chinook Salmon	Carcass counts
Deer Creek	Fall-run Chinook Salmon	Carcass counts
	Spring-run Chinook Salmon	Snorkel survey
Feather River	Fall-run Chinook Salmon	Carcass counts, hatchery marking, hatchery returns, in-river harvest
Merced River	Fall-run Chinook Salmon	Carcass counts, hatchery marking, hatchery returns
Mill Creek	Fall-run Chinook Salmon	Carcass counts
	Spring-run Chinook Salmon	Redd 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]

TABLE 1
CAMP: Recommended Adult Fish Monitoring Programs

Watershed	Species/Race	Adult Fish Monitoring Programs
Sacramento River	Fall-run Chinook Salmon	Ladder counts, carcass counts, aerial redd counts, in-river harvest
	Late Fall-run Chinook Salmon	Aerial redd counts, in-river harvest, carcass counts [1]
	Winter-run Chinook Salmon	Ladder counts, carcass counts, aerial redd counts
	Spring-run Chinook Salmon	Ladder counts, in-river harvest, carcass counts
San Joaquin River	Fall-run Chinook Salmon	In-river harvest [1]
Stanislaus River	Fall-run Chinook Salmon	Carcass counts, in-river harvest [1]
Tuolumne River	Fall-run Chinook Salmon	Carcass counts
Yuba River	Fall-run Chinook Salmon	Carcass counts, 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		
American	Steelhead	Hatchery returns
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
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.

As in previous years, the estimates of total production are calculated by summing in-river estimates (e.g., carcass survey estimates or ladder counts), hatchery returns, and in-river and ocean harvest estimates. Total production is multiplied by the proportion of natural production in each watershed (estimated by CDFG [1994]) to yield the watershed race-specific natural production estimates.

On the Mokelumne River, returning adults are counted at a downstream ladder and counted again as they enter the hatchery upstream of the ladder. For this report, hatchery counts are subtracted from the ladder counts to avoid double counting.

The watershed-specific component of the ocean harvest of fall-run chinook salmon is 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 is 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 are added to other components of adult production to yield total production by watershed and race.

Note that the ability to estimate numbers of naturally-spawning adult steelhead is limited. It has been suggested that a steelhead smolt out migrant index may provide an improved long-term monitoring method for the abundance of steelhead (CDFG staff, pers comm. 2001).

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

Estimates of adult chinook salmon production for the mainstem Sacramento River are calculated using the same methods employed by CDFG:

1. The number of adult fish spawning in the mainstem upstream of the RBDD is 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).

2. The resulting estimate of fish spawning in the mainstem upstream of RBDD is 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 surveys below versus above RBDD to yield the below-RBDD estimate.

3. To calculate the CAMP estimate of total production, the in-river harvest and ocean harvest estimates are added to both the upstream and downstream mainstem spawning escapement estimates to produce an estimate of total mainstem production for the year.

4. The estimate of total production is multiplied by the expected percentage of natural fish (63 percent) to produce an estimate of the total natural production for the year.

As described in the 1998 Annual Report (USFWS 1999), 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 numbers of 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.

In early 2000, CDFG and CAMP representatives reviewed the methods for estimating escapement in the mainstem Sacramento River. Several options were reviewed, and it was determined that the expanded ladder count at RBDD and information from the ongoing angler surveys will serve as the basis for calculating escapement in the mainstem Sacramento River. CAMP will continue to use the estimate of chinook salmon escapement in the mainstem Sacramento River developed by CDFG to generate estimates of natural production. However, this method is still under review by CDFG.

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 is assumed to represent only fish returning to the mainstem, even though a substantial number of the fish caught in the Sacramento River likely are destined for Battle and Clear creeks and other tributaries. Subtracting the entire in-river harvest estimate above RBDD 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. A negative estimate may also occur with the assumption that the entire in-river harvest spawns in the mainstem results in an underestimate of the production in Battle and Clear creeks and other tributaries because many of these fish likely were spawned in those tributaries and so should be included in the in-river production estimates.

Hatchery Marking Report Recommendations

As indicated in Table 1, hatchery marking is important to accurately assess natural production, thus reliable methods to distinguish hatchery and naturally produced fish are needed. CAMP thus undertook an effort to determine a program for hatchery marking that would satisfy CAMP needs while being consistent with the needs of other programs for marking hatchery fish. A final report on Hatchery marking was completed in 2000 with recommendations for marking of a 20–40 percent fraction of all hatchery fish (USFWS 2000). A pilot marking program is planned for 2001.

Population Trend Assessments

Progress toward stream by stream production targets is currently assessed using a modification of the Pacific Salmon Commission's (PSC 1996) rebuilding assessment methods (USFWS 1997). The basic methods of analysis involve comparing population estimates over time to trend lines between baselines and watershed-specific targets.

First, natural abundance estimates that are above targets are identified as those with at least four of the last five estimates that are at or above their target and with the 5-year average abundance estimate of adult spawning fish equal to or greater than the target. Population data from those watersheds did not undergo further analysis.

Second, the remaining estimates that were below target but rebuilding are identified using three tests:

- *Mean criterion.* A test value is calculated as the mean value of the 1995–1999 estimates of abundance from the 1992–2002 baseline to goal line for each target. This test value is then compared to the corresponding 1995–1999 average abundance estimate. An average greater than or equal to the test value is assigned a +1 score. Otherwise, a score of –1 is assigned.

- *Line criterion*. The observed abundance of naturally-spawning adults was compared to the baseline to target trend line for each species by watershed. If three or more of the five monitored years of data were on or above the trend line, a score of +1 is assigned. Otherwise a score of –1 is assigned.
- *Short term trend criterion*. If in at least four of the five monitoring years an estimate of abundance exceeded the previous year's estimate, a score of +1 is assigned. The baseline value for each species by watershed is used as the "Year 0" value. If four of the five years showed a decline from the previous year, a score of –1 is assigned. Others are given a score of 0.

The scores from all three tests are added and classified into categories of:

+2, + 3 = Rebuilding

-1, 0, +1 = Indeterminate

-2, -3 = Not rebuilding

Populations classified as indeterminate or not rebuilding are further characterized as being greater, less, or within one standard error of the mean from the baseline mean. Also, the five-year average is expressed as a percentage of the watershed-specific AFRP target for all groups.

CAMP Goal 2

Rotary screw trapping is the primary method by which juvenile salmon abundance is sampled to provide data to assess the relative effectiveness of the four categories of actions. Standard CAMP protocols, including the frequent estimate of trap efficiency are required for these data to be valid (USFWS 1997). It is recognized that trap efficiencies and subsequent estimates of total outmigrating juvenile fish may be highly variable. For example, estimates of total outmigrating fish in the lower Sacramento River have an 80 percent confidence interval of about 55 percent of the mean estimate (Snider and Titus 2000).

To evaluate the relative effectiveness of categories of restoration actions, it is important to distinguish the effects of key environmental variables that may affect juvenile abundance independent of restoration actions. Two of these variables, stream flow and temperature, are monitored for most of streams of interest (Table 2). Flow and temperature data are obtained from the U.S. Geological Survey (USGS) and Department of Water Resources (DWR) flow monitoring gages.

The implementation of a standardized, site-specific monitoring program is also important to address CAMP's second goal. The Service began planning this monitoring program and CAMP currently is working with Service staff to standardize monitoring methods and reporting practices. Implementation of this program will provide valuable information in the overall evaluation of the relative effectiveness of restoration actions analyzed as part of the CAMP juvenile monitoring program.

TABLE 2
CAMP: Recommended Juvenile Salmon Monitoring Programs

Recommended Watershed	Recommended Chinook Salmon Race	Watersheds/Years Sampled [a]
American River	Fall-run	1996, 1997, 1998, **1999**
Battle Creek	Fall-, winter-, and spring–run	**1999**
Butte Creek	Fall- and spring-run	
Clear Creek	Fall-run	**1999**
Deer Creek	Fall- and spring-run	
Feather River	Fall-run	1996, 1998, **1999**
Merced River	Fall-run	**1999**
Mill Creek	Fall- and spring-run	
Mokelumne River	Fall-run	1995, 1996, 1997, 1998, **1999**
Stanislaus River	Fall-run	1996, 1997, 1998, **1999**
Tuolumne River	Fall-run	**1999**
Upper Sacramento River	Fall-, spring-, and winter-run	

[a] Years included in this report shown in **bold**

SECTION 3

Adult Fish Monitoring Program Results: 1995 - 1999

Adult Abundance Estimates: 1999

Chinook Salmon

Estimates of Natural Production

Estimates of the abundance of naturally produced adult chinook salmon in each watershed for monitoring year 1999 are presented in Table 3. These estimates are based on monitoring methods described in the CAMP Implementation Plan (USFWS 1997).

The 1999 production estimates assume that all spring-run and winter-run chinook salmon are naturally produced. Because late fall-run chinook salmon were not distinguished from fall-run fish in the in-river counts, no attempt is made to estimate the number of naturally produced late fall-run chinook salmon in previous CAMP reports. Beginning in 1998, late fall-run salmon carcass surveys were available for the Sacramento River. The estimated percent natural production was applied to the Sacramento River total late fall-run production estimate as for all other runs depicted in Table 3. Hatchery return fish identified as late fall-run in Battle Creek are presented in this report, but they do not contribute to the natural production totals.

In-river monitoring for fall-run chinook salmon in Butte, Deer, and Mill creeks was not completed in 1999. High and variable flows in the fall of 1999 precluded accurate carcass count estimates for fall-run chinook salmon spawners in these streams. In lieu of these data, the information in Table 3 represents averages of the 1995-1998 CAMP abundance estimates for those watersheds.

Revised Ocean Harvest Data

The ocean harvest estimates used to calculate adult chinook salmon production in 1999 are taken from the *Review of 1999 Ocean Salmon Fisheries* (Pacific Fishery Management Council 2000). In this document, values for 1999 are published as "preliminary data subject to revision." Final data for the years prior to 1999 are also presented in the 1999 review. The final values differ by as much as 3.4 percent from the preliminary values used in the 1995 through 1997 and 1998 CAMP Annual Reports (USFWS 1998, USFWS and USBR 1999). This translates into changes in total adult production of up to 1.8 percent. The updated final ocean harvest values for 1995, 1996, 1997, and 1998 and the revised total production estimates are presented in Table 4. Similar changes in the calculated 1999 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, CAMP annual reports will continue to develop production estimates using preliminary ocean harvest data.

TABLE 3
1999 Adult Chinook Salmon Production Estimates

Watershed	In-River Estimates: Total	In-River Estimates: Hatchery Component	Hatchery Returns: Total	Hatchery Returns: Hatchery Component	In-River Harvest	Ocean Harvest[a]	Total Production	% Natural[b]	Natural Production
Fall-Run Chinook Salmon									
American River	53,619[c]		9,760		21,053	58,272	142,704	62%	88,476
Battle Creek	92,949[c]		26,970			82,763	202,682	10%	20,268
Butte Creek	2,000[d]					1,380	3,380	80%	2,704
Clear Creek	8,003[c]					5,523	13,526	80%	10,821
Deer Creek	644[d]					444	1,088	80%	871
Feather River	35,903[c]		12,384		25,684	51,052	125,023	61%	76,264
Merced River	4,000[c]		1,626			3,883	9,509	91%	8,653
Mill Creek	1,022[d]					705	1,727	81%	1,399
Mokelumne River	2,177[e]		3,156		401	3,957	9,691	81%	7,850
Sacramento River	76,413[f]				45,238	83,959	205,610	63%	129,534
Stanislaus River	4,500[c]					3,106	7,606	100%	7,606
Tuolumne River	9,000[c]					6,211	15,211	100%	15,211
Yuba River	23,049[c]				774	16,442	40,265	100%	40,265
Total	**313,279**		**53,896**		**93,150**	**317,697**	**778,022**		**409,922**
Late-Fall Run Chinook Salmon									
Battle Creek			4,083	4,083		2,895	7,089	**0%**	**0**
Sacramento River	8,552[c]		0	0	4,013	8,672	21,237	**59%**	**12,530**
Total	8,552[c]		**4,083**	**4,083**	**4,013**	**11,567**	**28,326**		**12,530**
Winter-Run Chinook Salmon									
Sacramento River	**3,208[e]**					**2,214**	**5,422**	**100%**	**5,422**
Spring-Run Chinook Salmon									
Butte Creek	3,679 [g]					2,539	6,218	100%	6,218
Deer Creek	1,591 [g]					1,098	2,689	100%	2,689
Mill Creek	560 [h]					386	946	100%	946
Sacramento River	431 [e]					297	728	100%	728
Total	**6,261**					**4,321**	**10,582**	**100%**	**10,582**
Total 1999 Natural Production of Adult Chinook Salmon									**438,456**

[a] Individual watershed totals based on in-river count proportions.
[b] Watershed-specific % natural component from CDFG (1994).
[c] Carcass survey.
[d] Average of 1995-1998.
[e] Ladder count.
[f] Estimate based on RBDD ladder counts, subtracting carcass counts and hatchery returns for Battle and Clear creeks and in-river harvest.
[g] Snorkel survey.
[h] Aerial redd count.

TABLE 4
Chinook Salmon Production Calculations with Preliminary and Final Ocean Harvest Values

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**	705,011	705,011	**0.00**
1996	462,900	478,200	**3.20**	427,341	435,713	**1.95**
1997	690,500	689,200	**0.19**	601,422	600,726	**0.12**
1998	324,900	336,000	**3.4**	376,563	302,651	**1.6**

Ocean Harvest Values from Review of 1998 Ocean Salmon Fisheries (PFMC 1999).

Other Species

Natural production targets are also established for steelhead, striped bass, American shad, white sturgeon, and green sturgeon. In 1999, production estimates are available only for American shad (Table 5).

TABLE 5
Steelhead, American Shad, Striped Bass, White Sturgeon, and Green Sturgeon Adult Spawner Estimates

Species	Restoration Target	Adult Spawner Abundance Estimate				
		1995	1996	1997	1998	1999
Steelhead	13,000	NA	NA	NA	NA	NA
American Shad	4,300	6,859	4,312	2,594	4,142	715
Striped Bass	2,500,000	NA	1,400,131	NA	NA	NA
White Sturgeon	11,000	NA	NA	149,000[a]	NA	NA
Green Sturgeon	2,000	NA	NA	2,041[b]	NA	NA

[a] Mark-recapture estimate changed from original report.
[b] 1.37% of white sturgeon total.

Trends in Population Abundance

Fall-Run Chinook Salmon

The 1999 natural production of fall-run chinook salmon in CAMP watersheds (Figure 1) is summarized as:

- Total 1999 naturally spawning fall-run chinook numbered 409,922 (all CAMP watersheds).
- The 1999 fall-run counts were higher than in 1998 but still below all previously monitored years (1995–1997).
- Watershed specific natural production targets were exceeded in Battle Creek, and Clear Creek.

- Estimates of 1999 natural production in the Feather, Mokelumne, and Yuba watersheds are below all previous years (1995-1998). (See Table 6.)

TABLE 6
Fall-Run Chinook Salmon Baseline Production Estimates, Production Targets and Estimates of Natural Production

Watershed	Baseline Production Estimates	CAMP Production Targets	Estimate of Natural Production				
			1995	1996	1997	1998	1999
American River	81,000	160,000	211,123	121,278	107,559	86,184	88,476
Battle Creek	5,000	10,000	34,315	18,047	26,340	18,664	20,268
Butte Creek	760	1,500	1,468	981	1,662	3,797	2,704
Clear Creek	3,600	7,100	30,682	11,619	17,805	6,467	10,821
Deer Creek	760	1,500	1,861	1,056	2,500	410	871
Feather River	86,000	170,000	189,214	87,132	89,963	92,195	76,264
Merced River	9,000	18,000	9,609	12,811	7,771	5,378	8,653
Mill Creek	2,100	4,200	5,062	2,871	1,220	840	1,399
Mokelumne River	4,700	9,300	18,099	15,446	25,955	11,065	7,850
Sacramento River	120,000	230,000	116,176	70,235	219,729	18,234	129,534
Stanislaus River	11,000	22,000	2,520	412	4,265	3,966	7,606
Tuolumne River	19,000	38,000	3,065	8,834	15,833	14,494	15,211
Yuba River	33,000	66,000	62,255	69,752	69,631	59,797	40,265
Total	**370,000**	**737,600**	**685,450**	**420,474**	**590,233**	**321,491**	**409,922**

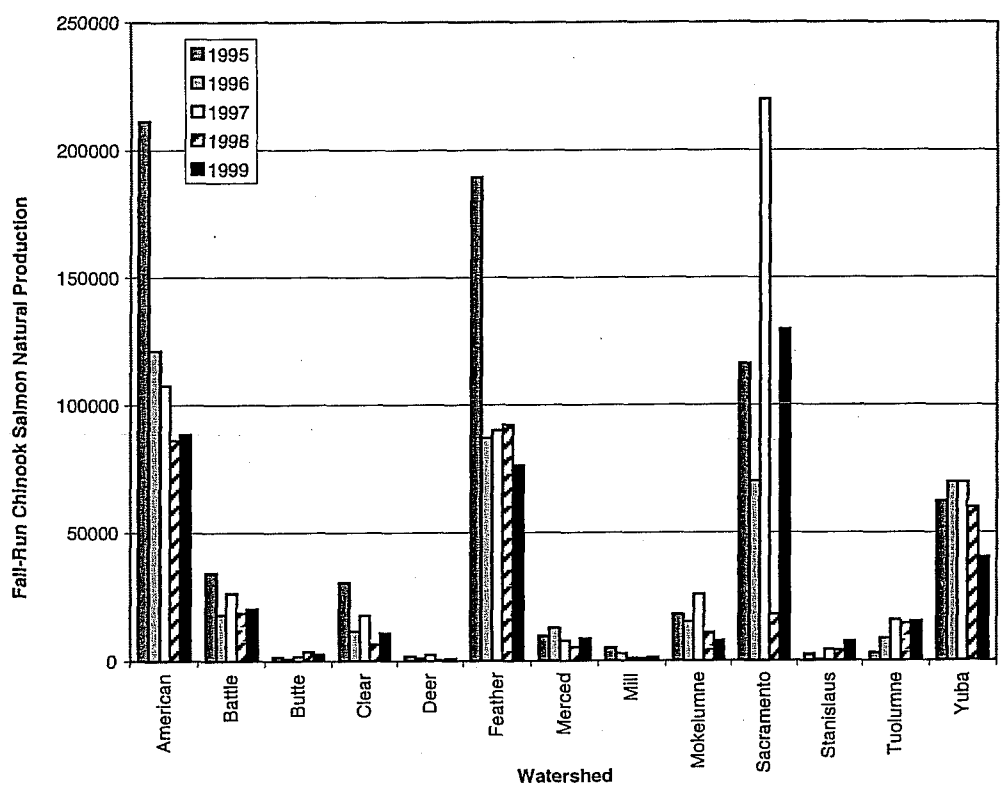

FIGURE 1
Fall-Run Chinook Estimates by Watershed for 1995-1999

The annual in-river escapement estimates (e.g., carcass surveys) and hatchery return data reflect year-to-year variation from climatic conditions and the variety of unknown causes affecting survival and reproduction (Tables 7 and 8). The 1999 estimate of in-river escapement is substantially higher than in 1998 and is one of the highest escapement estimates since 1995 (Table 7). The 1998 and 1999 estimates of in-river harvest (Table 9) showed a substantial deviation (up to a six-fold increase) from previous years, particularly for the American, Feather, and Sacramento rivers. These increases in the in-river harvest estimates represent a sampling artifact; they are the first angler surveys conducted since the initiation of CAMP monitoring in 1998 and 1999. CAMP's previous in-river harvest estimates for 1995-1997 are 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 estimates in 1998 and 1999 could be the result of the combination of both increased angler pressure and harvest and a possible underestimation of in-river harvest in previous years.

TABLE 7
Fall-Run Chinook Salmon In-River Escapement Estimates

Watershed	1995	1996	1997	1998	1999
American River	70,096	65,915	56,000	43,000	53,619
Battle Creek	56,515	52,404	50,743	53,957	92,949
Butte Creek	445	500	800	2,500[a]	2,000[b]
Clear Creek	9,298	5,922	8,569	4,258	8,003
Deer Creek	564	538	1,203	270	644[b]
Feather River	59,893	46,301	38,193	43,000	35,903
Merced River	1,958	4,599	2,342	2,314	4,000
Mill Creek	1,515	1,445	580	546	1,022[b]
Mokelumne River	2,094	3,892	10,161	4,091	2,177
Sacramento River	39,665	40,870	125,218	5,865	76,413
Stanislaus River	611	168	1,642	2,089	4,500
Tuolumne River	743	3,602	6,096	7,634	9,000
Yuba River	14,561	27,520	25,778	30,802	23,044
Total	**261,281**	**257,559**	**327,327**	**203,187**	**313,279**

[a] Estimate based on professional judgement of biologist working on Butte Creek during adult fall-run chinook salmon migration/spawning in 1998.
[b] Estimate is an average of 1995-1998 data.

TABLE 8
Fall-Run Chinook Salmon Hatchery Returns

Watershed	1995	1996	1997	1998	1999
American River	6,498	7,838	6,142	10,581	9,760
Battle Creek	26,677	21,178	50,670	44,350	26,970
Feather River	11,719	8,710	15,066	18,699	12,384
Merced River	602	1,141	946	799	1,626
Mokelumne River	3,323	3,883	6,494	3,090	3,156
Total	**48,819**	**42,750**	**79,318**	**77,680**	**53,896**

TABLE 9
Fall-Run Chinook Salmon In-River Harvest

Watershed	1995	1996	1997	1998	1999
American River	5,961	6,003	4,651	19,636	21,053
Feather River	3,589	3,229	3,523	17,908	25,684
Mokelumne River	-	-	-	14	401
Sacramento River	5,042[a]	4,585	9,066	9,380[b]	45,238[c]
Stanislaus River	-	-	-	0	0
Yuba River	532	920	1,031	694	774
Total	**15,124**	**14,737**	**18,271**	**47,632**	**93,150**

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

Late Fall-Run Chinook

For all CAMP reports prior to 1999, adult late fall-run chinook salmon were assumed accounted as part of the fall-run totals. For 1999, for the first time, separate in-river harvest and carcass count information for late fall-run was available, limited to the mainstem Sacramento River. The estimate of late fall-run abundance for the Sacramento River was 12,530 naturally-spawning adults (Table 3) as compared to the Sacramento River target of 44,000 and the system-wide target of 68,000 returning fish. As in previous years, the Battle Creek count of late fall-run hatchery returns do not contribute to the natural production total.

Winter-Run Chinook

The watershed-specific target for winter-run chinook salmon and estimates of natural production for 1995 through 1999 are presented in Table 10. In all five years, estimates of natural production of winter-run chinook salmon in the upper Sacramento River are substantially below the production target. While the 1998 estimate is nearly double the next highest estimate, the 1999 estimate is comparable to 1995 and 1997.

TABLE 10
Winter-Run Chinook Salmon Baseline Production Estimate, Production Target and Estimates of Natural Production

Watershed	Baseline Production Estimate	Production Target	Estimate of Natural Production				
			1995	1996	1997	1998	1999
Upper Sacramento River	54,000	110,000	5,614	2,317	5,332	10,444	5,422

Spring-Run Chinook Salmon

The watershed-specific targets for spring-run chinook salmon and the estimates of natural production by watershed for 1995 through 1999 are presented in Table 11. The total estimate of natural production was substantially below the production target for all streams in all years except for Butte Creek. The total 1999 estimate is substantially less than in 1998 but still higher than in previous years. The increase in 1998 is attributable almost entirely to the extremely high estimate for Butte Creek (Table 11).

TABLE 11
Spring-Run Chinook Salmon Baseline Production Estimates, Production Targets and Estimates of Natural Production

Watershed	Baseline Production Estimate	Production Targets	Estimate of Natural Production				
			1995	1996[a]	1997[a]	1998	1999
Butte Creek	1,000	2,000	5,321	1,557	3,636	38,351	6,218
Deer Creek	3,300	6,500	5,342	1,506	1,210	3,567	2,689
Mill Creek	2,200	4,400	1,787	687	519	805	946
Sacramento River	29,000	59,000	1,497	800	491	1,904	728
Total	**35,500**	**71,900**	**13,947**	**4,550**	**5,856**	**44,628**	**10,581**

Progress Toward Meeting Production Targets

Background

Watershed-specific restoration targets were established for chinook salmon and system-wide targets were set for all five species of anadromous fish monitored by CAMP. The CAMP watersheds represent 97 percent of the total fall-run chinook production (CAMP Implementation Plan). The CAMP production target for fall-run chinook, therefore, is slightly lower than the overall target. As specified in the CAMP Implementation Plan, progress toward production targets will be assessed using a modification of the Pacific Salmon Commission's (PSC 1996) rebuilding assessment methods when a minimum of five years of monitoring data are available (USFWS 1997). The PSC assessment methods classify indicator races or species into three categories: (1) those at or above their production target; (2) those meeting their rebuilding schedule; and (3) those not rebuilding. The analysis is based on the comparison of a continuous five-year database to baseline and restoration target levels.

Several CAMP-monitored species were analyzed for evidence of rebuilding stocks; also analyzed was the progress made towards meeting population goals using the methods of the Pacific Salmon Commission (PSC 1996). The analysis included all five years of CAMP monitoring data (1995 – 1999) for four races of chinook salmon and for American shad. Other CAMP-monitored species possess a less complete record and could not be included in the analysis.

Results

Graphs of the adult salmon and American shad population estimates and the baseline to target trend lines are shown in Figure 2. The results of the population analyses are summarized in Table 12. Battle Creek, Clear Creek, and Mokelumne River populations of fall-run chinook salmon and Butte Creek spring-run salmon are classified as meeting restoration goals. Fall-run salmon from the Yuba watershed are classified as Rebuilding. All other races and watershed-specific runs of chinook salmon are classified as Not Rebuilding, except for American River fall-run salmon classified as Indeterminate. Production estimates from the Butte, Deer, and Mill creeks for fall-run chinook salmon are not analyzed using Pacific Salmon Commission methods because several years of data are based on historic returns or averages from prior years, rather than on accepted survey methods (e.g., carcass surveys), or they are underestimates of the total production.

TABLE 12
Assessment Scores and Status of CAMP-Monitored Central Valley Stocks of Chinook Salmon Races Using Pacific Salmon Commission Methodology (PSC 1996).

		Assessment Scores						
Watershed	**Race**	**Mean**	**Line**	**Trend**	**Total**	**Baseline Comparisons (for totals of 0-2, only)**	**1995-1999 Mean as % of Goal**	**Status**
American	Fall-run	1	-1	0	0	Mean exceeds baseline + 1 stnd. Error	77%	Indeterminate, declines halted
Battle	Fall-run						235%	Above Goal
Butte	Spring-run						551%	Above Goal
Clear	Fall-run						218%	Above Goal
Deer	Spring-run	-1	-1	0	-2		44%	Not Rebuilding
Feather	Fall-run	-1	-1	0	-2		63%	Not Rebuilding
Merced	Fall-run	-1	-1	0	-2		49%	Not Rebuilding
Mill	Spring-run	-1	-1	0	-2		22%	Not Rebuilding
Mokelumne	Fall-run						169%	Above Goal
Sacramento	Fall-run	-1	-1	0	-2		48%	Not Rebuilding
	Spring-run	-1	-1	-1	-3		2%	Not Rebuilding
	Winter-run	-1	-1	0	-2		5%	Not Rebuilding
Stanislaus	Fall-run	-1	-1	0	-2		17%	Not Rebuilding
Tuolumne	Fall-run	-1	-1	0	-2		30%	Not Rebuilding
Yuba	Fall-run	1	1	0	2	Mean exceeds baseline + 1 stnd. Error	91%	Rebuilding, declines halted
Total (all CAMP streams)	Fall-run	-1	-1	0	-2		66%	Not Rebuilding
	Spring-run	-1	-1	0	-2		22%	Not Rebuilding
	Winter-run	-1	-1	0	-2		5%	Not Rebuilding

Shaded lines indicate groups assessed as above restoration goals.

Watershed-specific evidence of progress towards attainment of restoration goals is variable across races and location (Table 12). The Battle Creek, Clear Creek, and Mokelumne River fall-run chinook salmon and the Butte Creek spring-run chinook salmon exceed their baseline to goal trend line for all five monitoring years. In contrast, the Merced, Stanislaus, and Tuolumne River fall-run chinook salmon, the Mill Creek spring-run and the Sacramento River spring- and winter-run populations all are below the baseline to goal trend line for all five monitoring years. When summed across watersheds, the CAMP-monitored races of fall-run, spring-run, and winter-run chinook salmon are all classified as Not Rebuilding towards restoration goals. Late fall-run salmon estimates are incorporated in the fall-run totals by CAMP (Figure 2).

American shad, although classified as Rebuilding by this salmon-based method (as a result of higher than goal production estimates for three of the five monitoring years), exhibited a marked decline in abundance estimates over the course of the five-year monitoring record (from significantly above to moving far below the goal line) (Figure 2).

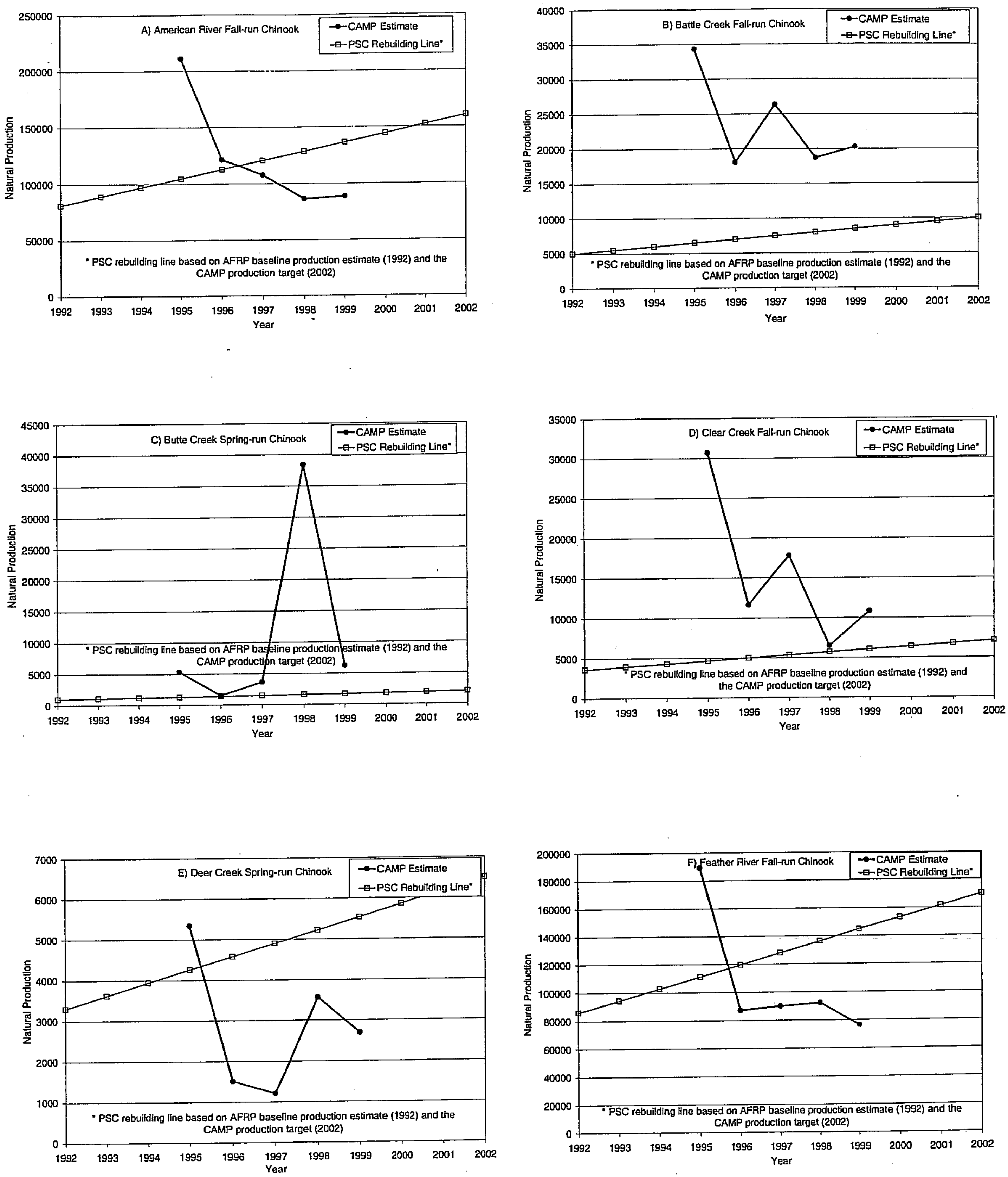

FIGURE 2

CAMP Adult Anadromous Fish Abundance Estimates, 1995-1999 versus AFRP Baseline to Target Levels. Pacific Salmon Commission Assessment Methodology

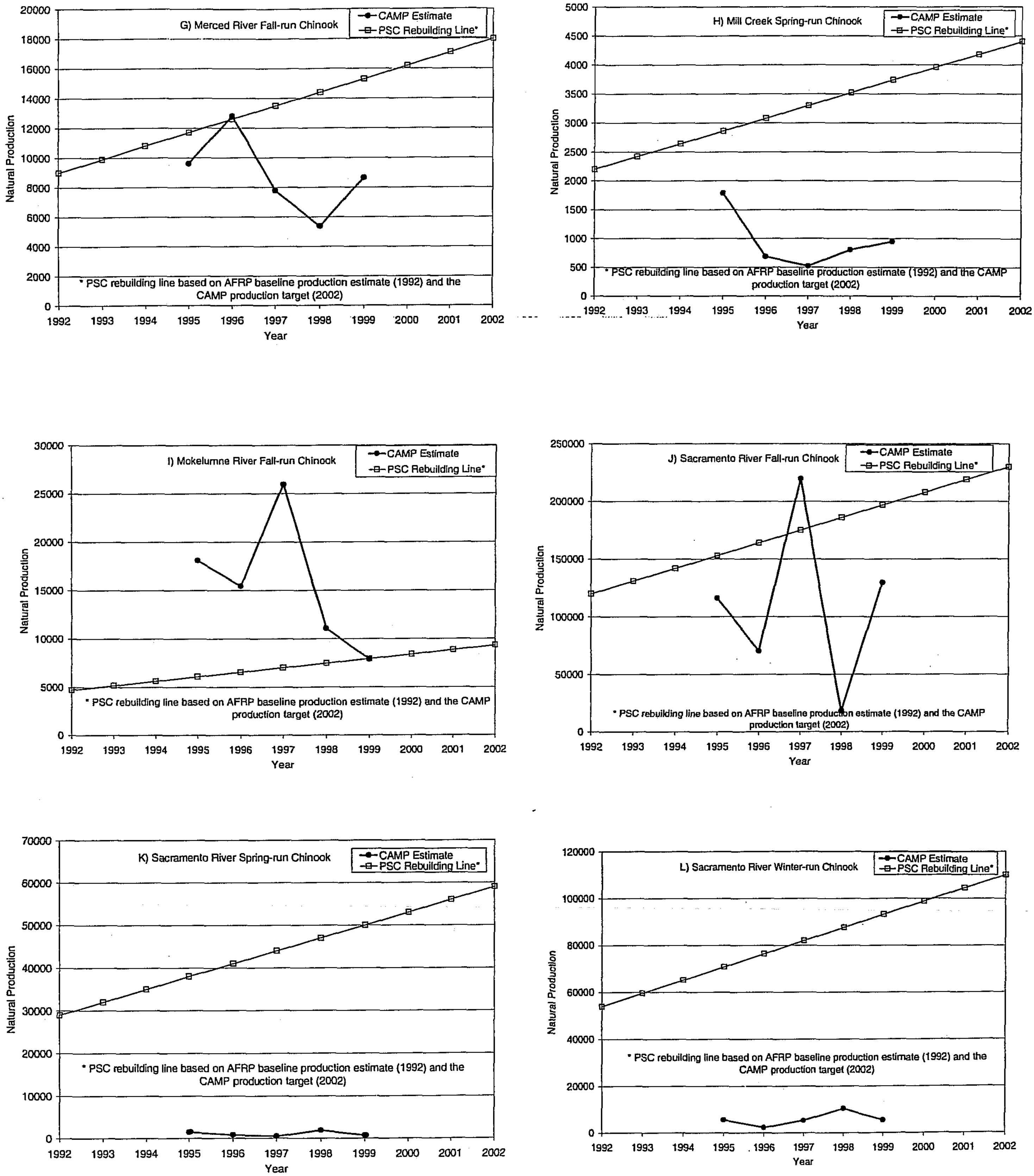

FIGURE 2
(Continued)

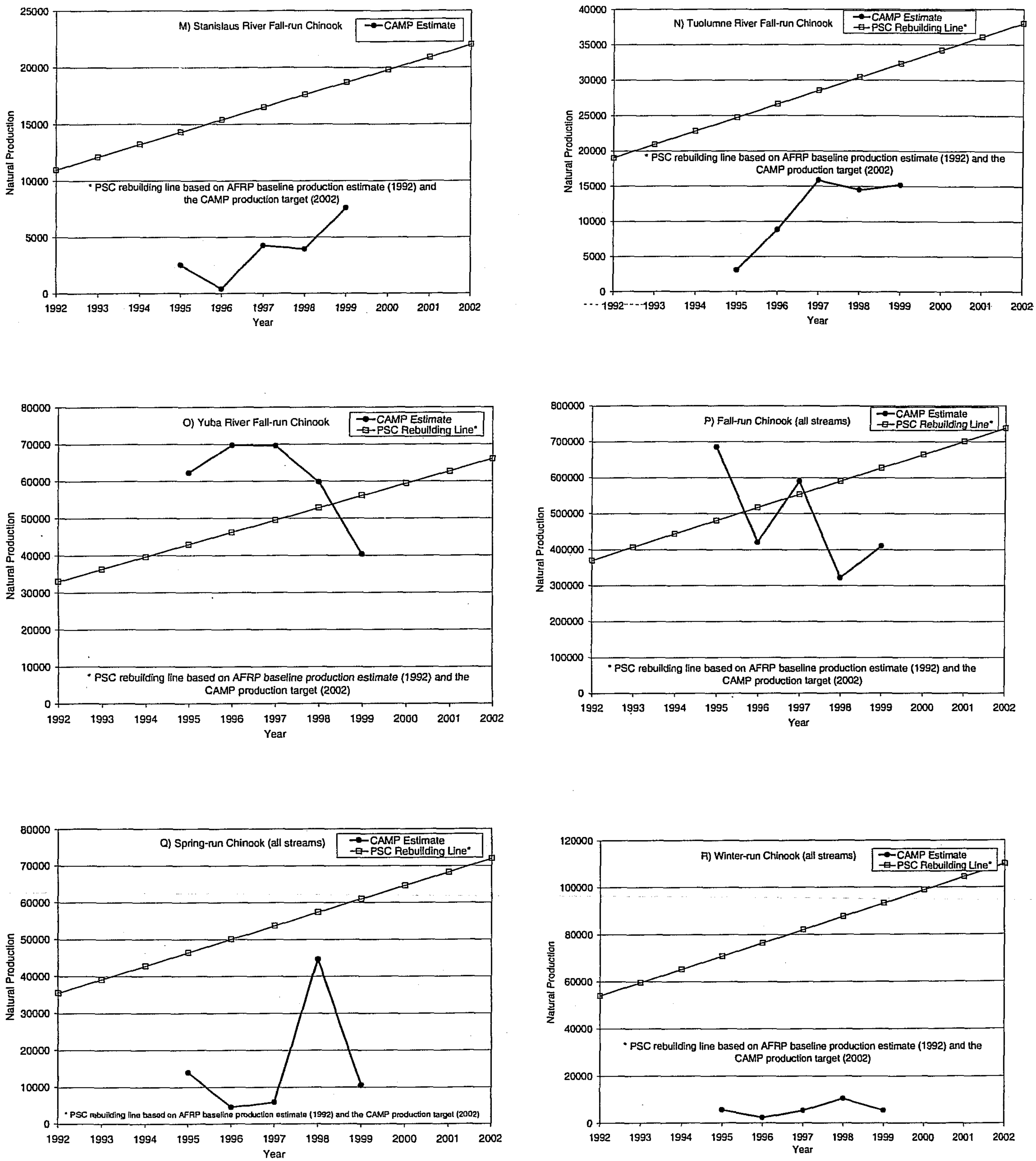

FIGURE 2
(Continued)

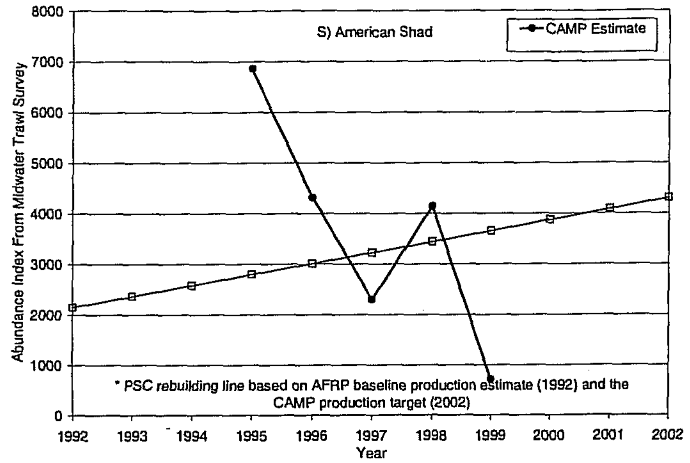

FIGURE 2
(Continued)

SECTION 4

Relative Effectiveness of Categories of Actions: 1995 – 1999

Goal 2 Monitoring Data

The CAMP juvenile monitoring program was established to assess the relative effectiveness of four categories of restoration actions toward meeting 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 and years:

- American River – 1996 - 1999
- Feather River – 1996 - 1999
- Mokelumne River– 1995 - 1999
- Stanislaus River– 1996 - 1999
- Battle Creek - 1999
- Clear Creek – 1999

The target species/race for analysis in these streams was fall-run chinook salmon. Table 13 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 1999 are summarized in Table 14. Detailed analysis of juvenile abundance in these and other streams is provided in Appendix B.

The watersheds monitored to date are similar with respect to completed restoration actions (Table 13). 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 in 1996. No fish screening projects have been completed in these streams.

TABLE 13
Summary of Restoration Actions Completed In Recent Years in the Watersheds with CAMP Goal 2 Assessments

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
	1999	Habitat Restoration	Spawning gravel restoration at several sites
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

TABLE 13
Summary of Restoration Actions Completed In Recent Years in the Watersheds with CAMP Goal 2 Assessments

Watershed	Year Implemented	Restoration Action Type	Action
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
Battle Creek	Since 1995	Water Management	Flow improvements for fish passage
	1999-2001	Habitat Restoration	Various project including dam removals
	Since 1998	Screening	Coleman Hatchery screening
Clear Creek	1996 - Ongoing	Habitat Restoration	Erosion control, spawning gravel restoration, channel bypass improvements, eventual dam removal

TABLE 14
Summary of Estimated Numbers of Juvenile Fall-Run Chinook Salmon Emigrating from the American, Feather, Mokelumne, and Stanislaus Rivers and Battle and Clear Creeks, 1999

Watershed	Estimated total number of YOY emigrating	Estimated number of fry < 50 mm	Estimated number of juveniles >50 mm
American River	9,984,790	9,986,540	119,250
Feather River	6,283,940	N/A	N/A
Mokelumne River	1,535,439	1,228,351	307,088
Stanislaus River	1,321,042	NA	NA
Lower Battle Creek[1]	14,446,682	NA	NA
Clear Creek[1]	7,585,023	NA	NA

NA = data not available
[1] Jan-Dec 1999 data, possibly including early 2000 migrants

Weight of Evidence Analysis

It is probable that restoration actions completed to date have increased the success of chinook salmon spawning and rearing in these streams and have resulted in a higher abundance of juveniles emigrating each winter and spring. The most recent years show the highest values of the index of juvenile to adult females over the period of record (Table 15).

With limited juvenile abundance data, natural environmental variations, such as extremely high flows in early 1997 and other climatic events, reduce the ability to discern differences due to action types. In all cases, pre-project monitoring was either not available or not conducted with methods identified in CAMP. In addition, in some streams and years, sampling was not conducted over the entire fall-run emigration period.

TABLE 15
Index of Emigrating YOY to the Abundance of Adult Females*

Watershed	1996	1997	1998	1999
American River	130	56	1,156	464
Feather River	22		2,362	292
Mokelumne River	174	276	211	751
Stanislaus River	344	558	793	1,265
Battle Creek				535
Clear Creek				3,563

*Females estimated as 50% of spawning escapement

As an initial evaluation of CAMP Goal 2, data are shown below (Table 16). For the current subset of CAMP watersheds, comparisons among watersheds are limited. Although there appears to be differences among watersheds in total juvenile outmigrants, adult returns, and index values, the watersheds examined are not different in terms of types of restoration actions implemented (Table 13). In estimating juvenile salmon abundance, the index of juveniles to adult females must be used to standardize population size and allow comparisons between watersheds. However, the juvenile index values are not statistically different among watersheds (Analysis of Variance, P> 0.10). Therefore, no between-watershed indices are possible.

TABLE 16
Analysis of CAMP Juvenile Salmon Monitoring Data for Watersheds with Multiple Year Records

Watershed	Abundance Estimate	CAMP Mean	Standard Error of Mean	Significance of Change over Time (Linear regression)
American River	Total Outmigrants	12,190,742	6,933,461	NS
	Index of YOY/female	452	251	NS
Feather River	Total Outmigrants	17,340,647	13,973,451	NS
	Index of YOY/female	892	739	NS
Mokelumne River	Total Outmigrants	752,017	243,632	P<0.05(1)
	Index of YOY/female	353	134	NS
Stanislaus River	Total Outmigrants	530,990	296,406	NS
	Index of YOY/female	740	198	P<0.05(1)

(1) = Statistically significant increase over time for linear or Log_e-transformed variable.
NS = no statistically significant trend over time.

Within watersheds, it is apparent that the Mokelumne and Stanislaus Rivers have shown improvements in the yield of juvenile fall-run salmon over the CAMP monitoring record. Estimated total number of juveniles has increased significantly over time for the

Mokelumne, and the index of juveniles/female has increased in the Stanislaus (Table 16). These results suggest the effect of cumulative restoration actions in the watersheds. However, the error of these RST estimates is unknown and these preliminary trends should be viewed with caution. In addition to the RST data, the Battle, Butte, Clear, and Mokelumne watersheds have exceeded the restoration target values for naturally spawning adults (Section 2). Together, these pieces of evidence suggest the cumulative success of all types of restoration actions in the Mokelumne River watershed. However, without site-specific monitoring information and more complete RST data, it will not be possible to assess the relative success of categories of restoration actions in restoring anadromous fish populations over the CVPIA system.

The CAMP juvenile RST program is intended to provide long-term watershed-specific monitoring of juvenile production as part of the larger Goal 2 effort. Screw trap monitoring data alone are not sufficient to distinguish the relative effectiveness of the four categories of actions to restore anadromous fish populations. Data from site-specific monitoring and long-term adult monitoring are also needed to help provide the critical link between the types of restoration actions implemented within a watershed and juvenile production and population growth. Without site-specific monitoring, CAMP's goal of assessing which categories of restoration actions are most effective in restoring fish populations cannot be effectively addressed.

SECTION 5

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.

______________, 2001. Personal Communication. Bill Snider and Rob Titus, CDFG, to Larry Puckett and Earl Byron.

Pacific Fisheries Management Council (PFMC), 1999. Review of 1998 Ocean Salmon Fisheries. Report of the Pacific Fishery Management Council pursuant to National Oceanic and Atmospheric Administration Award Number NA97FC0031.

Snider, B. And R. Titus, 2000. Timing, composition, and abundance of juvenile anadromous salmonid emigration in the Sacramento River near Knights Landing, October 1996 – September 1997. California Department of Fish and Game, Habitat Conservation Division. July 2000.

U.S. Fish and Wildlife Service (USFWS), 1995. Working Paper on Restoration Needs. Habitat Restoration Actions to Double Natural Production of Anadromous Fish in the Central Valley of California, Vol. 2. Section 9, May, 1995. Prepared for the U.S. Fish and Wildlife Service under the direction of the Anadromous Fish Restoration Program Core Group. Stockton, California.

______________, 1996. Comprehensive Assessment and Monitoring Program (CAMP) Final Conceptual Plan, February, 1996. 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.

______________, 1997. Comprehensive Assessment and Monitoring Program (CAMP). Standard Protocol for Rotary Screw Trap Sampling. Prepared by CH2M HILL, Sacramento, California.

______________, 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.

______________, 1998. Comprehensive Assessment and Monitoring Program (CAMP) Annual Report 1995-1997. Prepared by CH2M HILL, Montgomery Watson, Jones & Stokes Associates, Inc., Sacramento, California.

______________, 1999. Comprehensive Assessment and Monitoring Program (CAMP) Annual Report 1998. Prepared by CH2M HILL, Sacramento, California.

_______________, 2000. Comprehensive Assessment and Monitoring Program (CAMP) Final Hatchery Marking Program Report. Prepared by CH2M HILL, Sacramento, California.

Appendix A

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

Appendix A

This Appendix provides the detailed methods and results summarized in Section 3 of the 1999 CAMP Annual Report. The Appendix includes documentation of the actions implemented in each watershed 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 all four categories have been implemented in this report. Data for only a limited number of restoration actions precludes definitive conclusions regarding the effectiveness of action categories. As more actions are monitored over a greater number of years, it is likely that likely that links between juvenile success and restoration actions will become apparent. In addition, comprehensive site-specific monitoring of individual actions will greatly enhance the ability to evaluate the effectiveness of actions.

Water Management Modifications

CVPIA-related and other water management modifications have been made in recent years in the 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. The AFRP program has adopted these release schedules into annual flow recommendations for the use of dedicated water.

Since 1994, higher flow releases have been made in the fall to benefit salmonid spawning and egg incubation. Higher fall flows 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 on the lower American River in the fall, winter, and early spring 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 techniques comparable 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 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, were 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 in the low flow channel. Juvenile data for 1996 and 1998 on the lower Feather River show large variation among years. Further monitoring of adult and juvenile abundance will be needed to evaluate the effectiveness of flow augmentations for this watershed.

Mokelumne River

In water year 1992, East Bay Municipal Utility District (EBMUD) voluntarily implemented the basic provisions of the FERC Principles of Agreement (EBMUD, DFG, USFWS 1996), which included increased year-round flow releases for the benefit of fall-run chinook salmon and steelhead spawning, rearing, and outmigration.

These increased flow releases should result in long-term benefits to chinook salmon production. Consistent baseline data on juvenile abundance prior to implementation of the new flow schedule is not available; therefore, direct comparison of juvenile production before and after implementation of the new schedule is not possible. Evaluations of flow changes should be based on long-term monitoring of adult returns to the river.

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 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, 1998, and 1999, 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. In addition, releases are made to the lower river to meet many other needs. Flow augmentations since 1995 have 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.

Battle Creek

Existing FERC minimum flows within the anadromous portion of the Battle Creek will be increased under a Memorandum of Understanding between NMFS, USBR, USFWS, CDFG, and PG&E signed in 1999.

Habitat Restoration

Habitat restoration projects have been implemented on some of the analyzed streams, including the Mokelumne, Stanislaus, American, Tuolumne and Merced Rivers.

Mokelumne River

In recent years, several salmon spawning gravel restoration projects have been implemented by EBMUD. In 1992, EBMUD placed approximately 300 cubic yards of salmon-spawning gravel in the Mokelumne River in 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 have probably 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 complete gravel projects. 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, intragravel permeability, dissolved oxygen, temperature, and macroinvertebrate production have also 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 River

Two gravel restoration projects have been implemented in recent years. In 1994, three spawning riffles at River Mile (RM) 47.4, RM 50.4, and RM 50.9 near Horseshoe Park were reconstructed, funded by the 4-Pumps Agreement. In 1995, these sites were revegetated using 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, and 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. The projects have resulted in salmon using the newly deposited gravel for spawning.

American River

One gravel restoration project has been implemented in recent years. The gravel restoration project was funded by CVPIA 3406(b)(13). Restoration consisted of loosening and redistributing layers of coarse, compacted gravel using a bulldozer to scarify the substrate. Subsequent to scarification, approximately 6,000 tons of spawning size gravel was added to six locations along a five mile stretch of the lower American River between RM 18.5 and RM 23. Salmon now use the newly restored areas for spawning. These spawning gravel restoration projects may have increased the success of chinook salmon spawning, egg incubation, and early rearing in project areas. Continued monitoring of adult and juvenile production will allow increases to be verified and quantified.

Tuolumne and Merced Rivers

Efforts were undertaken to restore the Tuolumne River Mining Reach and to restore the channel at Special Run Pools 9 and 10. On the Merced River, in-channel habitat was recently restored in the Ratzlaff Reach.

Clear Creek

Several actions to restore aquatic and riparian habitats in Clear Creek have been proposed and/or undertaken in recent years. One project that is ongoing consists of placement of spawning-sized gravel into lower Clear Creek below McCormick-Saeltzer Dam. Efforts are underway to remove McCormick-Saeltzer Dam and gravel placement will likely occur farther upstream if the dam is removed.

Structural Modifications

Only two structural modifications has been completed on the streams included in this analysis. Several projects to improve fish passage on Butte Creek have been implemented, but no juvenile monitoring data were available for inclusion in this report.

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 fall 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 fall 1997, temperatures were relatively high as a result of the prior depletion of the cool water pool in the reservoir. Improved water availability and management of the cold water pool in 1998 and 1999 resulted in cooler water temperatures during the salmon spawning and egg incubation period.

It is possible that the cooler water temperatures increased egg incubation during the spawning period in 1996, 1998, and 1999. Direct evaluation of the effects of the project on

APPENDIX B

CAMP Juvenile Monitoring Program: Summary of Juvenile Chinook Salmon Monitoring, 1999. Detailed Methods and Results

Introduction

Streams were selected based on the presence of 1) target races, 2) opportunities to spatially isolate the effects of actions, 3) an implementation schedule for restoration actions, and 4) the presence of existing juvenile and adult monitoring programs. Target streams for juvenile monitoring included 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.

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 in eight streams during 1999. 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 for 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, have not been available 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 or weekly
- 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 actions 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 1996-1999	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, 1999	Feather River Outmigration Study	Fall-run Chinook	One Trap at Live Oak	1 Jan. - 30 Jun.	DWR	1996
Mokelumne River 1995-1999	Mokelumne River Chinook Salmon and Steelhead Monitoring Program	Fall-run Chinook	Two traps at Woodbridge Dam	1 Jan. - 30 Jun.	EBMUD	1993
Stanislaus River 1996-1999	Stanislaus River Juvenile (smolt) Production Indices and Estimates	Fall-run Chinook	Two traps near Caswell State Park	1 Jan. - 30 Jun.	USFWS	1994
Battle Creek 1999	Battle Creek Outmigration Study	Chinook/All Races	One trap 2.8 mi upstream of mouth; One trap above CNFH weir	1 Jan. - 31 Dec.	USFWS	1999
Clear Creek 1999	Clear Creek Outmigration Study	Chinook/All Races	One trap 1.7 mi upstream of mouth	1 Jan. - 31 Dec.	USFWS	1999
Tuolumne River 1999	Tuolumne River Outmigration Study	Fall-run Chinook	Two traps near Grayson Fishing Access	1 Jan. - 30 Jun.	CDFG	1999
Merced River 1999	Merced River Outmigration Study	Fall-run Chinook	One trap near Hagaman County Park	1 Jan. - 30 Jun.	CDFG	1999

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 were generally consistent with CAMP protocol.

From 1996 to 1999, 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, from mid-November 1997 through July 1998, and late December 1998 through June 1999.

The trap was 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 and 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. If 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. An average trap efficiency of 0.0119 was used in 1999. The average trap efficiency was applied to raw catch data by size class (estimated number = raw catch/trap efficiency) on each date to estimate the number of juvenile chinook salmon emigrating on that day.

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 1999 is shown in Figure B-1.

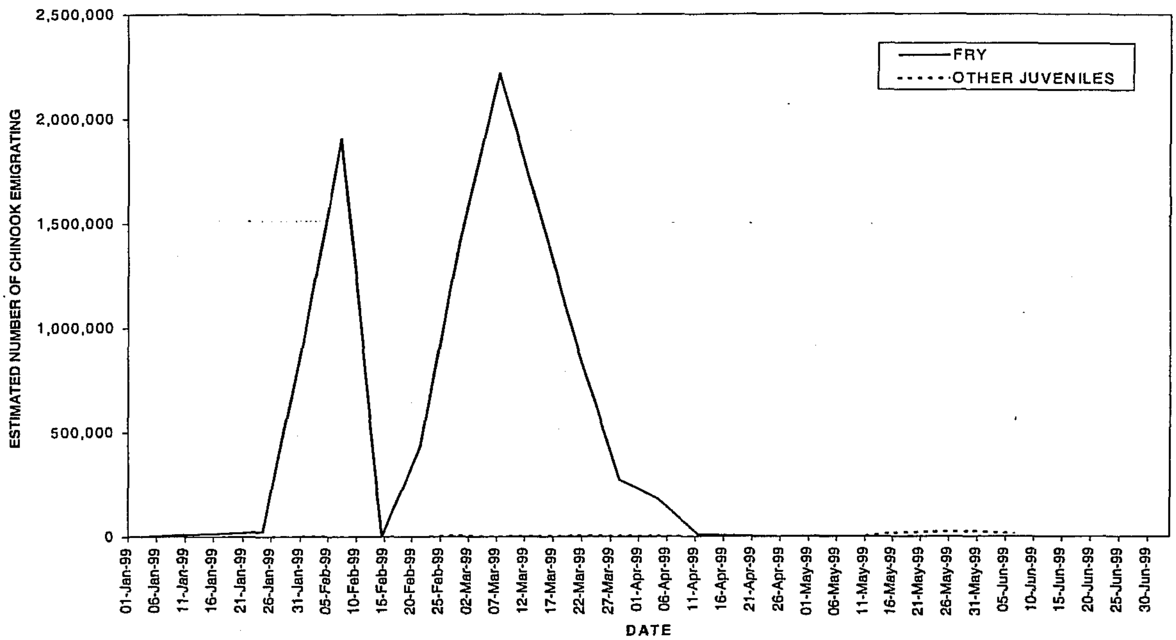

FIGURE B-1
Estimated Number of YOY Chinook Salmon Emigrating from the Lower American River During 1999

In 1999, 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 1999, fry emigration was bi-modal with a peak in early February and a second peak in mid-March. Few fry were caught after the last week of March. The emigration of larger juveniles was highest in May. This is similar to the pattern of emigration seen in 1996 through 1998.

TABLE B-2
Estimated Number of Fry (< 50 mm) and Juveniles (50mm to 125 mm) Emigrating from the Lower American River, 1996 - 1999

	Estimated Number of Outmigrants			
Life Stage	**1996**	**1997**	**1998**	**1999**
Fry (less than 50 mm)	4,461,729	1,772,842	31,822,165	9,865540
Juvenile (50-125 mm)	125,487	57,532	539,011	119,250
TOTAL	4,587,216	1,830,374	32,361,176	9,984,790

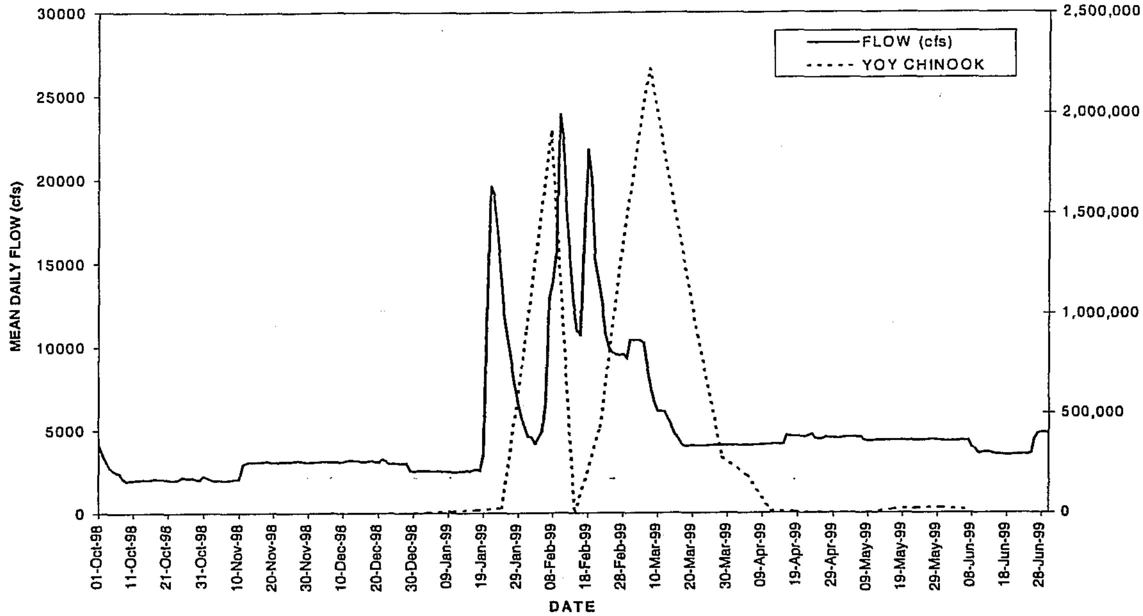

FIGURE B-2.
Mean Daily Flow (cfs) at Fair Oaks, October 1998 Through June 1999 and Estimated Abundance of YOY Chinook Salmon Emigrating Weekly from the Lower American River During 1999.

Effect of Streamflow on 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 1998 – 1999 (October 1998 through June 1999) and the abundance of YOY chinook salmon emigrating from the lower American River.

Flows were relatively low and constant at about 2,500 to 3,000 cfs from the beginning of October 1998 to the middle of January 1999. Fry emigration was observed as early as December. From mid-January through February 1999, flows were high and variable, peaking at over 20,000 cfs. The period of high fry outmigration appeared to lag the peaks in flow by one to three weeks. Flows from mid-March through June were relatively constant, averaging around 4,500 cfs. Fry continued to emigrate in high numbers through March. Relatively low numbers of chinook salmon emigrated in April and May.

Although the period of high outmigration in 1999 followed a period of relatively high flows in late-January and February, it is unclear whether the high flows stimulated outmigration. Outmigration occurred at a higher rate and earlier in 1999 than in either 1996 or 1997.

Effect of Water Temperature on Spawning and Egg Incubation

Water temperatures were measured by the USGS at Fair Oaks in 1998-1999. The Fair Oaks gage (No. 11446500) is located just downstream of Nimbus Fish Hatchery. Mean daily water temperatures from November 1998 through June 1999 are shown in Figure B-3. The temperature recorder was not operating before November 2, 1998.

Temperatures declined steadily during the fall in 1999 from near 62° F in November to around 47° F in December. Temperatures in November and December 1998 were similar to temperatures recorded during the same period in 1996 and 1997, following structural modifications at Folsom Dam to allow for cooler water releases in the fall of the year. It is

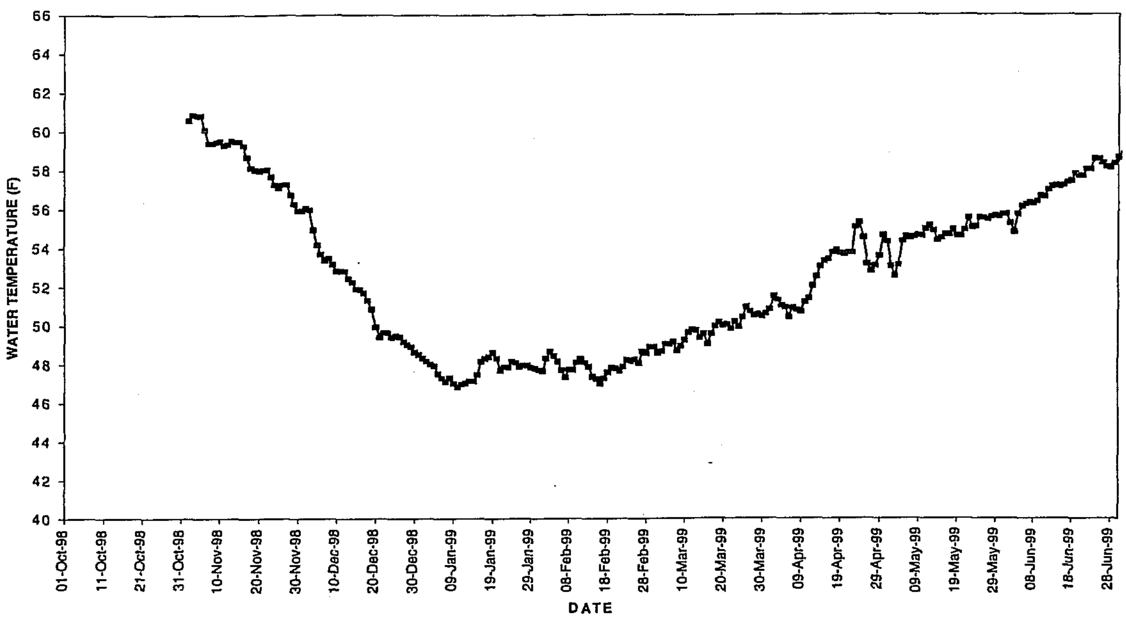

FIGURE B-3
Mean Daily Water Temperature (°F). Below Nimbus Dam on the Lower American River, October 1998 – June 1999.

probable that the cooler water temperatures in the fall increased spawning and egg incubation success in the early part of the spawning and incubation period compared to previous years.

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 and 1999, from January 1 through June 30. In general, methods used for rotary screw trap sampling on the Feather River in 1996, 1998, and 1999 were consistent with the CAMP standard protocol.

In 1996, 1998, and 1999, 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 one to five days prior to release approximately one km upstream of the trap. The reported trap efficiency in 1998 was as 0.002. The average efficiency from tests conducted during the 1999/2000 sampling period (0.0342) was applied to catches during the 1999 sampling period. This efficiency was applied to raw catch data for 1999 to estimate the number of juvenile chinook salmon emigrating (estimated number = raw catch/trap efficiency).

Results

Estimated Abundance

The estimated number of fry and juvenile chinook salmon emigrating from the Feather River each year is presented in Table B-3. The extremely high estimate of total juvenile production for the Feather River in 1998 may be an artifact of the application of a single low trap efficiency, rather than multiple trap efficiencies from several 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, 1998 and 1999

	Estimated Number of Outmigrants		
Life Stage	**1996**	**1998**	**1999**
Fry (less than 50 mm)	550,500	43,908,500	NA
Juvenile (50-125 mm)	90,500	1,188,500	NA
Total	**641,000**	**45,097,000**	**NA**

Mokelumne River

Methods

Since 1993, Natural Resource Scientists Inc., under contract with EBMUD, has used rotary screw traps to monitor juvenile emigration on the lower Mokelumne River. In general, methods used for rotary screw trap sampling on the lower Mokelumne River have been consistent with the CAMP standard protocol.

Two rotary screw traps (8 foot diameter) were fished side-by-side each year immediately downstream from Woodbridge Dam. Sampling was conducted continuously from December 16, 1998 to July 31, 1999. The sampling was initiated earlier and concluded later in 1999 compared to previous years. Data from the entire sampling period from December through July are included in this report.

Traps were fished 24 hrs/day, 7 days/week, and checked at least twice daily, early in the morning and late in the afternoon. During periods of high debris loads and/or large fish catches, traps were checked two or three additional times each day. During each trap check, fish were removed from the trap, sorted, and counted by species. Up to 30 individuals of each salmonid species captured in each trapping period were randomly subsampled, measured (total length and fork length in mm), and weighed (in grams).

Paired day and night trap efficiency tests have been conducted frequently throughout the sampling periods. Fish were obtained from the Mokelumne River Fish Hatchery. Fish were marked by excision of the pelvic fin or clipping the caudal fin and were allowed to recover for 8 to 24 hours prior to release. Releases were made approximately 20 to 30 meters upstream of the trap site in two or three replicate groups. During each efficiency test, all fish measured were also checked for marks. If all fish were not checked, the number of recovered fish was expanded by the proportion of fish checked to the total number captured. Calculated efficiency rates (number of recaptures/number of marked fish in release group) varied from 0.002 - 0.331 in 1999. Appropriate trap efficiency test results were applied to catch data on each date to estimate the number of juvenile chinook salmon emigrating by size class (estimated number = raw catch / trap efficiency).

Results

Estimated Abundance

The estimated daily number of YOY chinook salmon emigrating weekly from the Mokelumne River at Woodbridge in 1999 is shown in Figure B-4.

In 1999, estimates of fry and juvenile emigration were not reported separately, on a daily basis as in previous years. Instead, an overall total of 80 percent fry, 20 percent smolt was reported. In 1999, emigration was high from late January through mid-March, peaking in mid-February. The rate of emigration was much lower in late March and early April. Emigration was prolonged, with some fish outmigrating through July. The estimated number of outmigrants was highest in 1999; estimated numbers were lowest in 1996 (Table B-4). The timing of emigration was similar in all four years.

Effect of Streamflow on Timing of Outmigration

Flow data for the Mokelumne River were obtained from USGS gage 11323500, located below Camanche Dam. Figure B-5 shows the mean daily flow (cfs) at the gage site during the egg incubation, juvenile rearing and emigration period in 1998-1999 (October 1998 through June 1999) and the abundance of YOY chinook salmon emigrating from the Mokelumne River from late January through June, 1999.

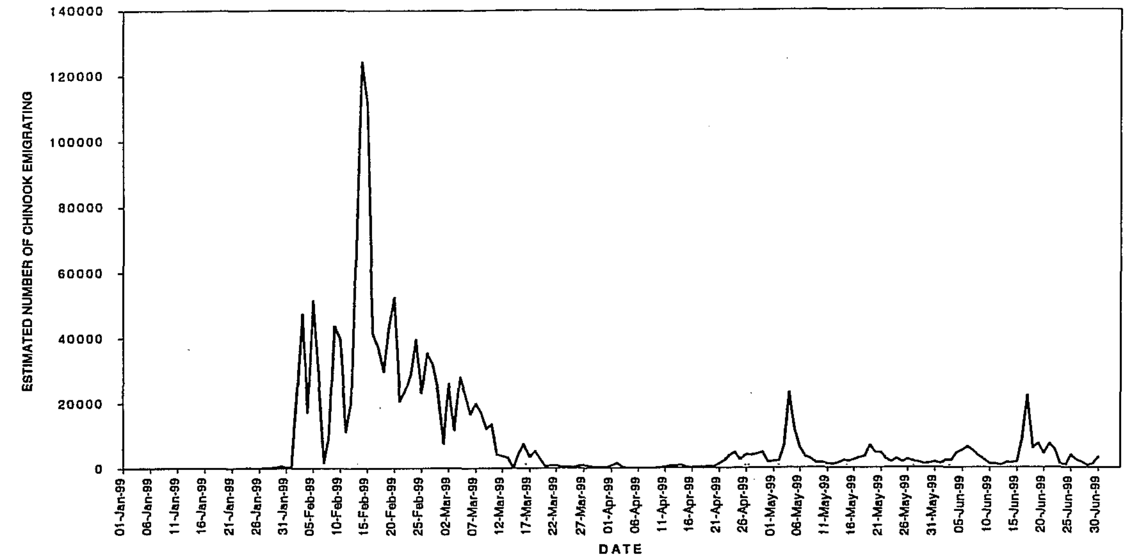

FIGURE B-4

Estimated Number of YOY Chinook Salmon Emigrating from the Mokelumne River Each Day During 1999

TABLE B-4

Estimated Number of Fry (< 50 mm) and Juveniles (50mm to 125 mm) Emigrating from the Mokelumne River

	Estimated Number of Outmigrants				
Life Stage	**1995**	**1996**	**1997**	**1998**	**1999**
Fry (less than 50 mm)	230,582	101,788	393,341	976,692	N/A
Juvenile (50-125 mm)	203,513	80,672	144,372	93,953	N/A
Total	**434,095**	**182,460**	**537,713**	**1,070,645**	**1,535,439**

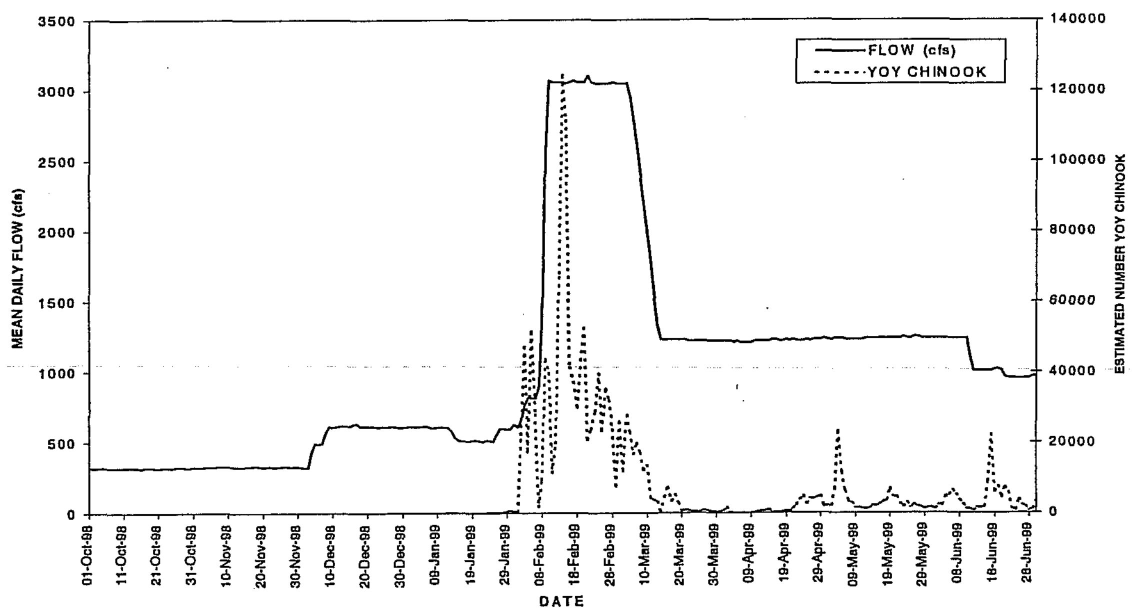

FIGURE B-5

Mean Daily Flow (cfs) at Camanche Dam, October 1998 through June 1999 and Estimated Abundance of YOY Chinook Salmon Emigrating from the Mokelumne River During 1999.

Flows from October through November 1998 were relatively low and were stable at around 325 cfs. Flows increased in mid to late November to around 600 cfs and remained near this level until late January 1999. Flows dramatically increased in early February to around 3,100 cfs. Flows remained high until early March when they declined to around 1,200 cfs. Peak emigration occurred in mid-February during the peak flows. Emigration continued during the period of relatively stable flows in May, June, and July.

Effect of Water Temperature on Spawning and Egg Incubation

Mean daily water temperatures collected by EBMUD at Mackville Road within the spawning and rearing reach from October 1998 through June 1999 are shown in Figure B-6. Temperatures during October through mid-November, 1998, when chinook salmon spawning and egg incubation were occurring in the river, ranged from 56° to 64°F. These temperatures slightly exceeded the optimal temperature range reported in the literature for chinook salmon spawning and incubation of 41° to 56.0°F (Rich 1987; Reiser and Bjornn 1987) and were within the range reported as resulting in low chronic stress for these life stages (Leidy and Li 1987). From late November on, temperatures remained below 56°F.

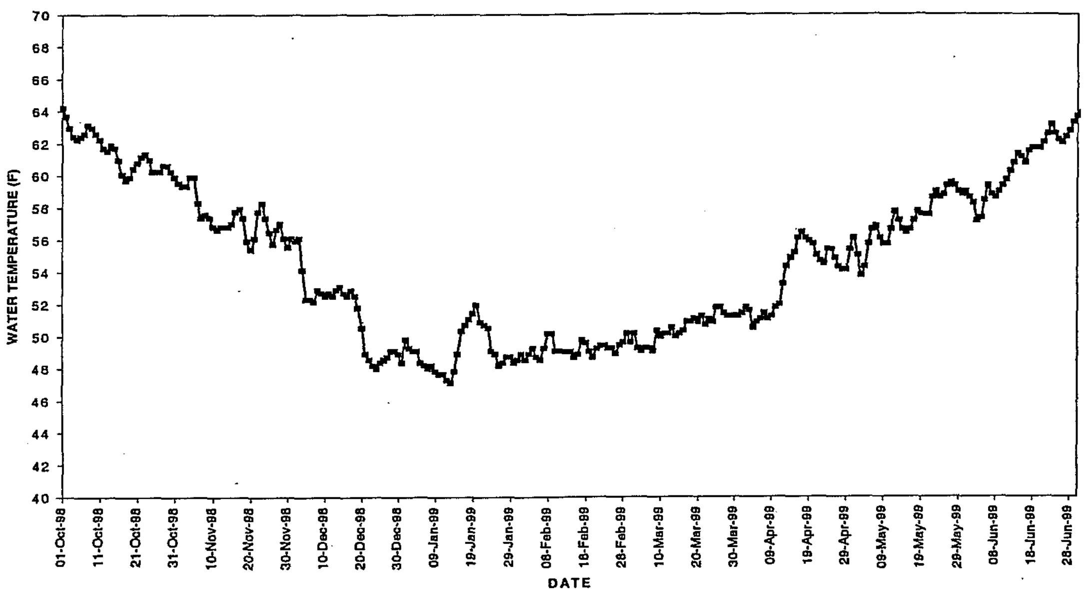

FIGURE B-6
Mean Daily Water Temperature (°F) at Mackville Road on the Lower Mokelumne River, October 1998 - June 1999

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. In 1999, sampling was conducted from January 18 through June 30. 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 1999 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 one to four days in a net pen and then released ¼ mile upstream of the trap site. During each efficiency test, all fish 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 in 1998, using the efficiency data from the 1998 sampling. In 1999, 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-7. The outmigrants were not separated into fry and juvenile size classes. In 1999, there was a period of relatively high emigration during January and February with a distinct peak of emigration in mid-February. Numerous

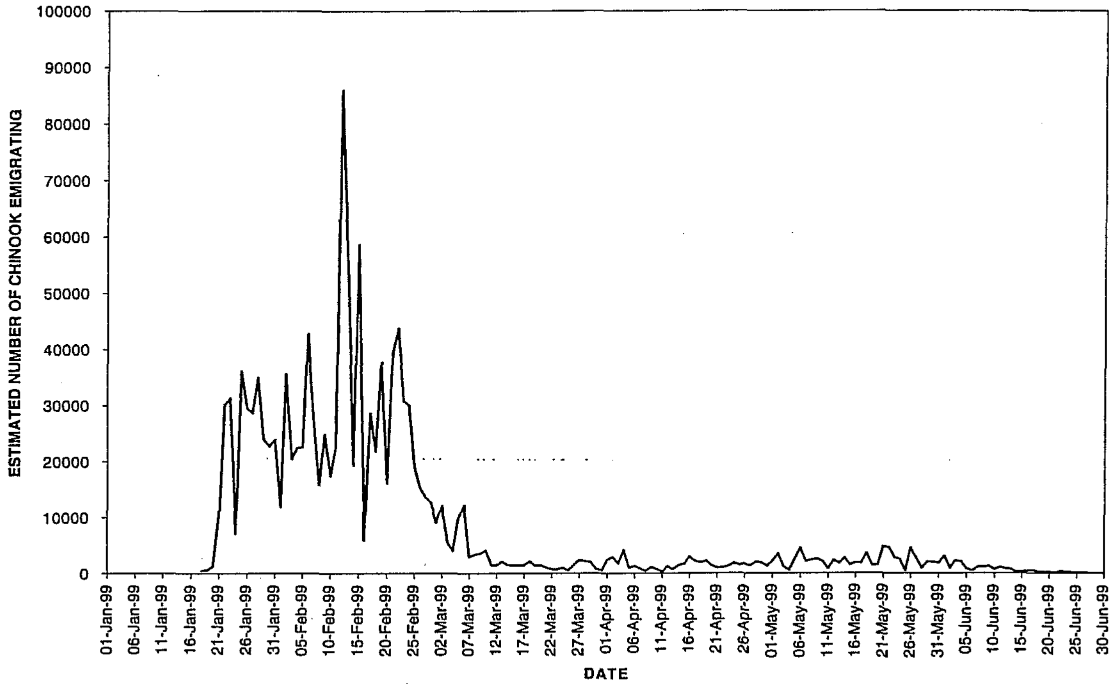

FIGURE B-7
Estimated Number of YOY Chinook Salmon Emigrating from the Lower Stanislaus River Each Day During 1999

smaller peaks occurred throughout January. This is consistent with the pattern of fry emigration that occurred in 1998; however, emigration rates were higher in January 1999 than in January 1998.

Table B-5 presents the estimated number of fall-run chinook salmon emigrating from the lower Stanislaus River from 1996 through 1999. In 1999, estimates of fry and juvenile emigration were not reported separately as in previous years. 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

	Estimated Number of Outmigrants			
Life Stage	1996	1997	1998	1999
Fry (less than 50 mm)	41,026	85	N/A	N/A
Juvenile (50-125 mm)	64,187	46,835	N/A	N/A
TOTAL	**105,213**	**46,920**	**650,917**	**1,321,042**

Effect of Streamflow on 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-8 shows the mean daily flow (cfs) at the gage site during the egg incubation, juvenile rearing and emigration period from

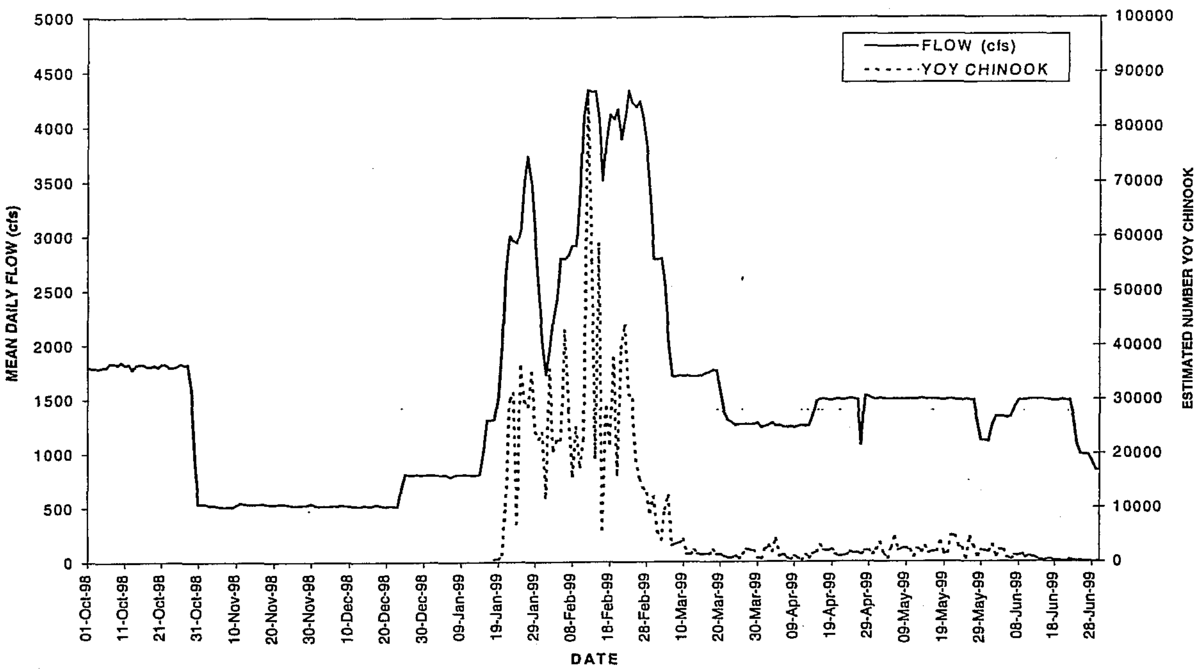

FIGURE B-8
Mean Daily Flow (cfs) at Goodwin Dam, October 1998 Through June 1999 and Estimated Abundance of YOY Chinook Salmon Emigrating from the Stanislaus River During 1999

October 1998 through June 1999 and the abundance of YOY chinook salmon emigrating from the lower Stanislaus River.

During October 1998, flows were near 1,800 cfs. From November 1998 through December 1998 flows were relatively low and stable at around 500 cfs. Flows increased during January 1999 to around 3,700 cfs, but declined to around 1,700 cfs by the end of the month. Flows increased again in early February 1999 to around 4,300 cfs. Flows remained high through February and then declined during March. Flow remained relatively constant during April, May, and June 1999 at around 1,500 cfs. Peak emigration occurred in January and February during the period of highest flows. Emigration also continued during the period of relatively stable flows in April, May, and June.

Effect of Water Temperature on Spawning and Egg Incubation

Mean daily water temperatures obtained from USGS gage 11302000, located at Goodwin Dam near Knight's Ferry, California, from October 1998 through June 1999 are shown in Figure B-9. 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 those measured at the gage site.

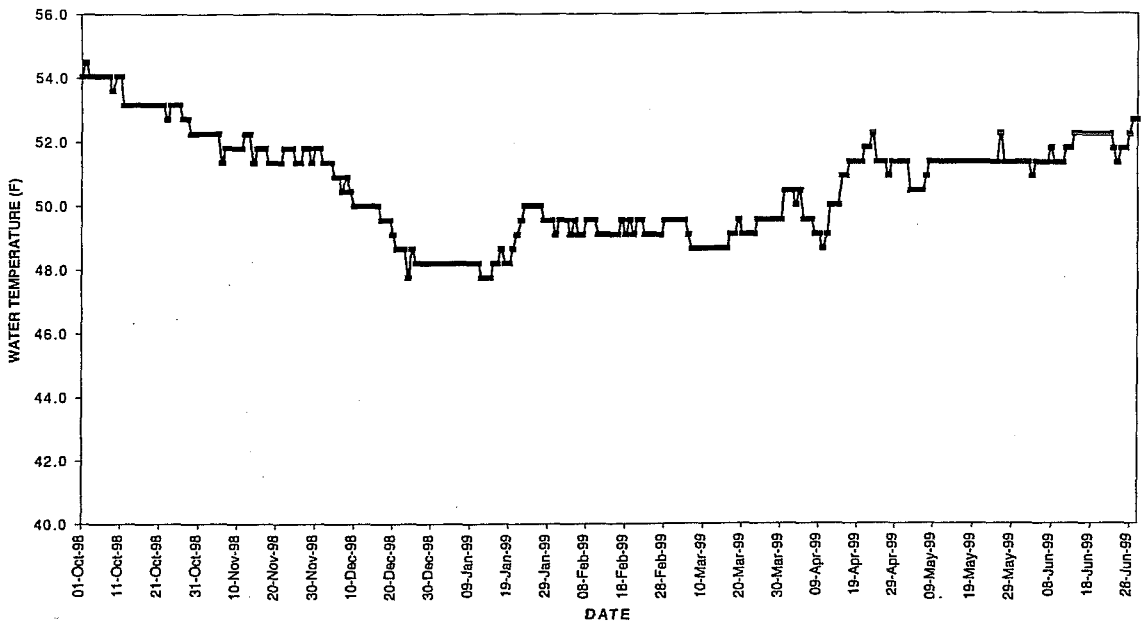

FIGURE B-9
Mean Daily Water Temperature (°F) at Goodwin Dam on the Lower Stanislaus River, October 1998 - June 1999 (USGS)

Battle Creek

Methods

In 1999, sampling was conducted by the USFWS. Two 5 foot diameter rotary-screw traps were placed in Battle Creek. One trap was placed approximately 2.8 miles (4.5 kilometers) above its confluence with the Sacramento River. The second trap was placed just above the Coleman NFH barrier weir at river mile 5.8 (RK 9.3). In 1999, traps were fished from January 1 through December 31, covering the outmigration period for all races of chinook salmon. 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 Battle Creek in 1999 were consistent with the CAMP standard protocol. Flow data used in this report were obtained from USGS gage 11376550 located below Coleman National Fish Hatchery.

Traps were fished continuously seven days per week year round, except when high flows or debris loads would jeopardize equipment or the safety of personnel. Routine trap access was by wading, but during high flows traps were pulled into shallow water for boarding and then returned to the thalweg to collect environmental data. Traps were checked and cleared of debris and fish once daily, unless high flows and heavy debris loads necessitated that they be cleared twice daily to reduce mortality of captured fish or sinking of the trap. Information such as fishing dates, times, cone depth, water depth, amount and types of debris, weather conditions and trap condition were gathered at each checking.

All fish were identified, enumerated and fork lengths (FL) measured (nearest 1.0 mm). At the time of measurement, all salmonids were classified as fry, parr, silvery parr or smolt. To investigate the relative condition of juvenile salmonids, approximately 150 individuals (when present) were weighed to the nearest 0.01 g twice weekly using a battery-operated Ohaus Scout digital scale. Also, three times per week 200 juvenile salmon were held and marked with bismark brown (a chemical stain) for use in mark/recapture trials.

When large numbers of fish (>250) were captured, fish were transported from the trap and placed off-shore in a 121-L fish retention container. A random sample was taken and all fish in the sample were identified and enumerated. All juvenile chinook and up to 50 steelhead trout and 20 individuals from non-salmonid species were measured (FL). However, when extremely large catches (>1000) of juvenile salmon occurred, counts were estimated based on the weight and enumeration of individuals from two random subsamples and the weight of the total catch.

Trap efficiency tests were conducted in 1999. Only naturally produced juvenile salmon captured by rotary-screw traps were used for mark/recapture trials. Initially, 100 juvenile salmon were marked and released each day from Monday through Friday. Fish were held in a Bismark brown solution and then transported 0.8 km above the upper trap and released in the center of the stream. By early spring, approximately 200 fish per day were marked, three times per week. Marked fish recaptured by rotary-screw traps after release were enumerated and measured (FL), and allowed to recover before being released down-stream of the trap.

Calculated efficiency rates (number of recaptures/number of marked fish in release group) were not reported, but were used to expand captures to overall estimates of juvenile emigration (estimated number = raw catch/predicted trap efficiency rate). Emigration estimates were reported weekly throughout the sampling period.

Results

Estimated Abundance

The estimated number of fall-run chinook salmon emigrating weekly from the upper and lower Battle Creek sampling locations in 1999 is shown in Figure B-10. The outmigrants were not separated into fry and juvenile size classes. In 1999, there was a period of relatively high emigration during January and February with a distinct peak of emigration in mid-February. Numerous smaller peaks occurred throughout January. Table B-6 presents the estimated number of chinook salmon emigrating from Battle Creek during 1999. This total includes all fish captured in 1999, not just those captured during the CAMP standard monitoring period of January 1–June 30. A small number of fall-run chinook salmon emigrated after June 30 and captures in November and December indicate that some fall-run chinook begin emigrating prior to January 1.

TABLE B-6
Estimated Number of YOY Chinook Salmon Emigrating from Battle Creek during 1999

	Estimated Number of Outmigrants[a]			
Location	**Fall-run**	**Late Fall-run**	**Winter-run**	**Spring-run**
Upper Battle Creek	1,493,585	193	18	4,546
Lower Battle Creek	14,446,682	128,818	26,893	10,032

[a] Estimates include all captures from Jan 1, 1999 through Dec 31, 1999.

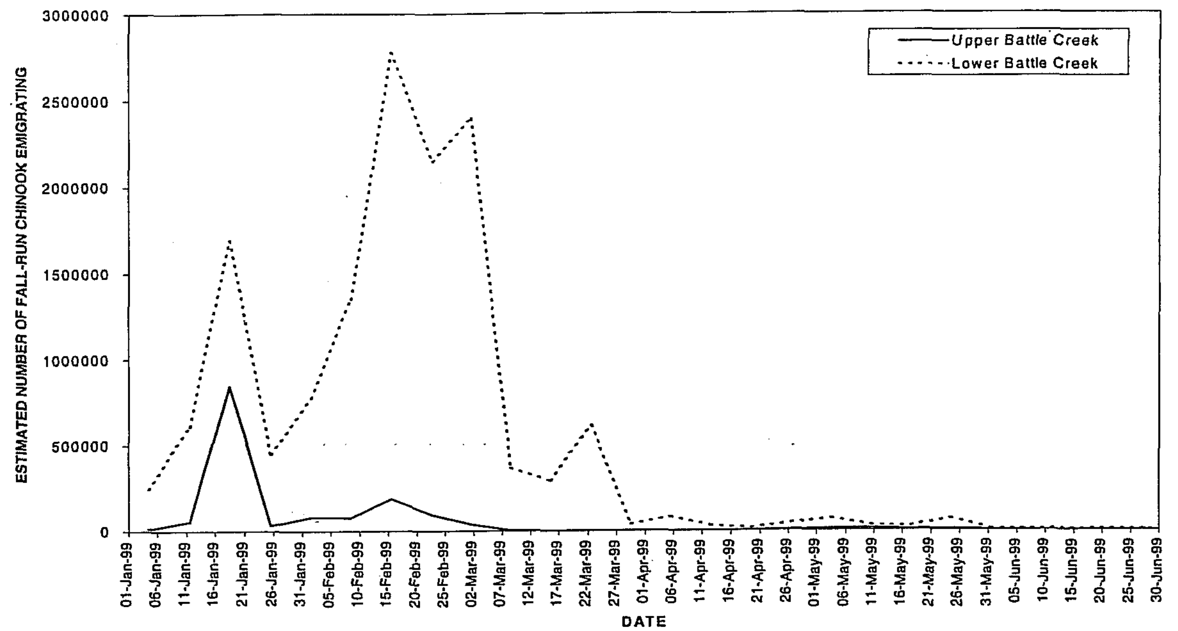

FIGURE B-10
Estimated Number of YOY Fall-run Chinook Salmon Emigrating from Battle Creek Each Week During 1999

Effect of Streamflow on Timing of Outmigration

Flow data for Battle Creek were obtained from USGS gage 11376550 located below Coleman National Fish Hatchery. Figure B-11 shows the mean daily flow (cfs) at the gage site during the egg incubation, juvenile rearing and emigration period from October 1998 through June 1999 and the weekly estimates of fall-run chinook salmon emigrating from Battle Creek.

Flows from October through mid-November 1998 were relatively low and were stable at around 450 cfs. During late November 1998, flows rose sharply, peaking near 2,200 cfs before returning to about 500 cfs by mid-December. Flows rose sharply again in early February, 1999 to around 3,200 cfs. Flows remained variable through February and March with several smaller peaks, then remained relatively stable from mid-March through June at 600-800 cfs. The timing of peak emigration coincided with the high and variable flows during February and March. However, emigration continued during periods of lower and more stable flows.

Clear Creek

Methods

In 1999, sampling was conducted by the USFWS. One trap was placed in Clear Creek (latitude 40° 30′ 23" north and longitude 122° 23′ 45" west), 1.7 miles (2.7 km) above its confluence with the Sacramento River. The trap was situated directly below a channel constriction where stream gradient ranged from 1.0° to 1.5°. The trap was

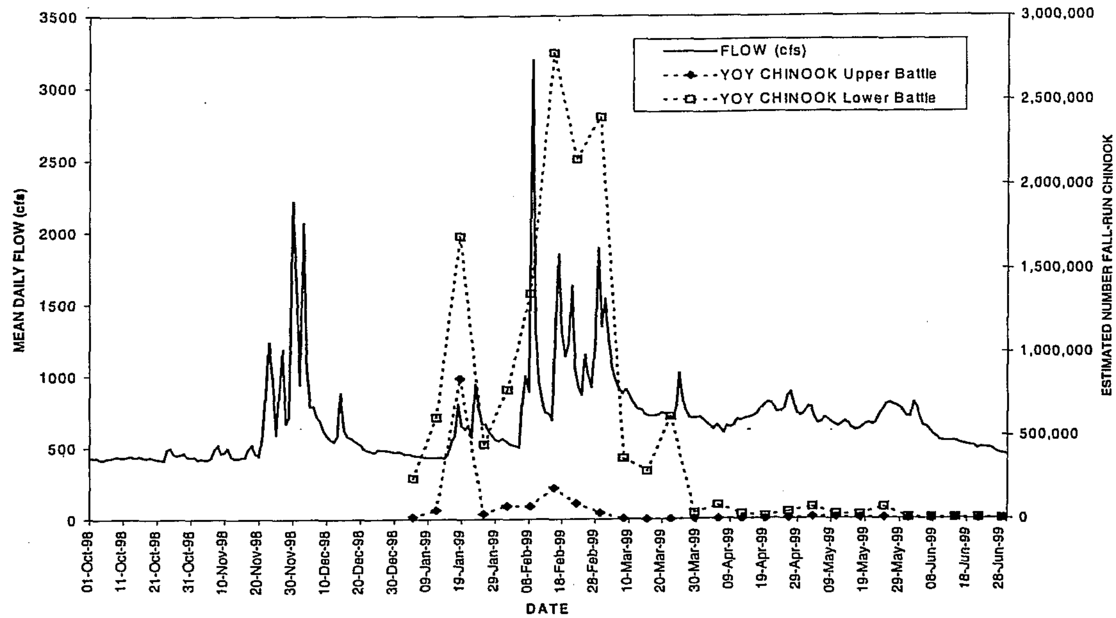

FIGURE B-11
Mean Daily Flow (cfs) below Coleman NFH, October 1998 Through June 1999 and Estimated Emigration of YOY Fall-run Chinook Salmon from Battle Creek During 1999

fished from January 1 through December 31, covering the outmigration period for all races of chinook salmon. 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 Clear Creek in 1999 were consistent with the CAMP standard protocol.

The trap was fished continuously seven days per week year round, except when high flows or debris loads would jeopardize equipment or the safety of personnel. Routine trap access was by wading, but during high flows traps were pulled into shallow water for boarding and then returned to the thalweg to collect environmental data. The trap was checked and cleared of debris and fish once daily, unless high flows and heavy debris loads necessitated that they be cleared twice daily to reduce mortality of captured fish or sinking of the trap. Information such as fishing dates, times, cone depth, water depth, amount and types of debris, weather conditions and trap condition were gathered at each checking.

All fish were identified, enumerated and fork lengths (FL) measured (nearest 1.0 mm). At the time of measurement, all salmonids were classified as fry, parr, silvery parr or smolt. To investigate the relative condition of juvenile salmonids, approximately 150 individuals (when present) were weighed to the nearest 0.01 g twice weekly using a battery-operated Ohaus Scout digital scale. Also, three times per week 200 juvenile salmon were held and marked with bismark brown (a chemical stain) for use in mark/recapture trials.

When large numbers of fish (>250) were captured, fish were transported from the trap and placed off-shore in a 121-L fish retention container. A random sample was taken and all fish in the sample were identified and enumerated. All juvenile chinook and up to 50 steelhead trout and 20 individuals from non-salmonid species were measured (FL). However, when extremely large catches (>1000) of juvenile salmon occurred, counts were estimated based on the weight and enumeration of individuals from two random subsamples and the weight of the total catch.

Trap efficiency tests were conducted in 1999. Only naturally produced juvenile salmon captured by rotary-screw traps were used for mark/recapture trials. Initially, 100 juvenile salmon were marked and released each day from Monday through Friday. Fish were held in a Bismark brown solution and then transported 0.8 km above the upper trap and released in the center of the stream. By early spring, approximately 200 fish per day were marked, three times per week. Marked fish recaptured by rotary-screw traps after release were enumerated and measured (FL), and allowed to recover before being released down-stream of the trap.

Calculated efficiency rates (number of recaptures/number of marked fish in release group) were not reported, but were used to expand captures to overall estimates of juvenile emigration (estimated number = raw catch/predicted trap efficiency rate). Emigration estimates were reported weekly throughout the sampling period.

Results

Estimated Abundance

The estimated number of fall-run chinook salmon emigrating from the Clear Creek sampling location in 1999 is shown in Figure B-12. The outmigrants were not separated into fry and juvenile size classes. In 1999, there was a period of relatively high emigration during January and February with a distinct peak of emigration in mid-February. Numerous smaller peaks occurred throughout January. Table B-7 presents the estimated number of chinook salmon emigrating from Clear Creek during 1999. This total includes all fish

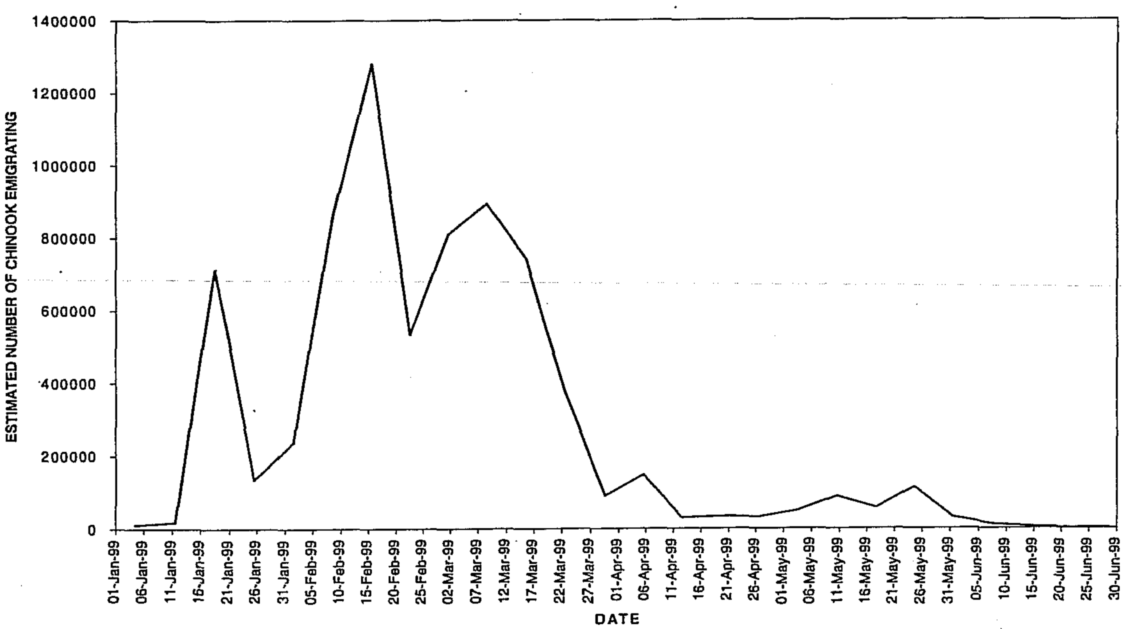

FIGURE B-12
Estimated Number of YOY Fall-run Chinook Salmon Emigrating from Clear Creek Each Week During 1999

TABLE B-7
Estimated Number of YOY Chinook Salmon Emigrating from Clear Creek during 1999

	Estimated Number of Outmigrants[a]			
Location	Fall-run	Late Fall-run	Winter-run	Spring-run
Clear Creek	7,585,023	272,940	868	52,436

[a] Estimates include all captures from Jan 1, 1999 through Dec 31, 1999.

captured in 1999, not just those captured during the CAMP standard monitoring period of January 1–June 30 as shown in Figures B-12 and B-13. A small number of fall-run chinook salmon emigrated after June 30 and captures in November and December of 1999 indicate that some fall-run chinook begin emigrating prior to January 1, 2000.

Effect of Streamflow on Timing of Outmigration

Flow data for Clear Creek were obtained from USGS gage 11372000 located near Igo, California. Figure B-13 shows the mean daily flow (cfs) at the gage site during the egg incubation, juvenile rearing, and emigration period in 1998 - 1999 (October 1998 through June 1999) and the weekly estimates of fall-run chinook salmon emigrating from Clear Creek.

Flows from October 1998 through mid-January 1999 were relatively low and stable at around 200 cfs with the exception of two peaks of short duration that exceeded 700 cfs. During mid-February 1999, flows rose sharply, peaking near 1,500 cfs and dropping rapidly with numerous smaller peaks continuing through mid-April. Flows remained relatively stable from mid-April through June with a gradual decline from around 300 cfs to approximately 200 cfs. The timing of peak emigration coincided with the high and variable flows during February and March. However, emigration continued during periods of lower and more stable flows.

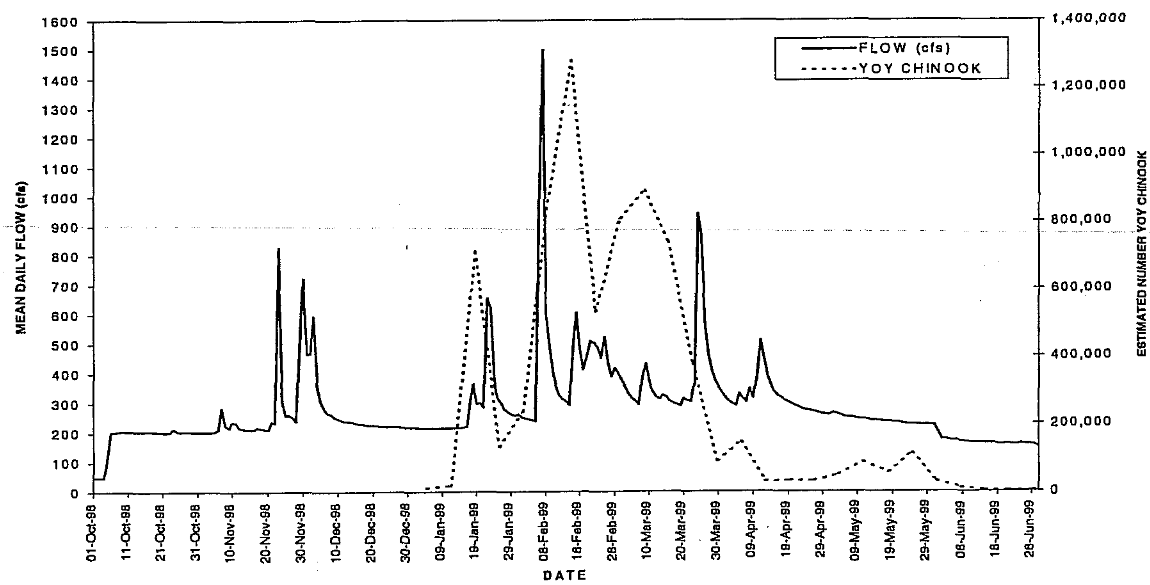

FIGURE B-13
Mean Daily Flow (cfs) in Clear Creek near Igo, California, October 1998 Through June 1999 and Estimated Emigration of YOY Fall-Run Chinook Salmon from Clear Creek During 1999

Effect of Water Temperature on Spawning and Egg Incubation

Mean daily water temperatures reported to the California Data Exchange (CDEC) from the gage located near Igo, California from October 1998 through June 1999 are shown in Figure B-14. Temperatures measured at this station throughout the fall-run chinook salmon spawning, egg incubation, rearing, and emigration periods were generally within optimum levels (less than 54° F).

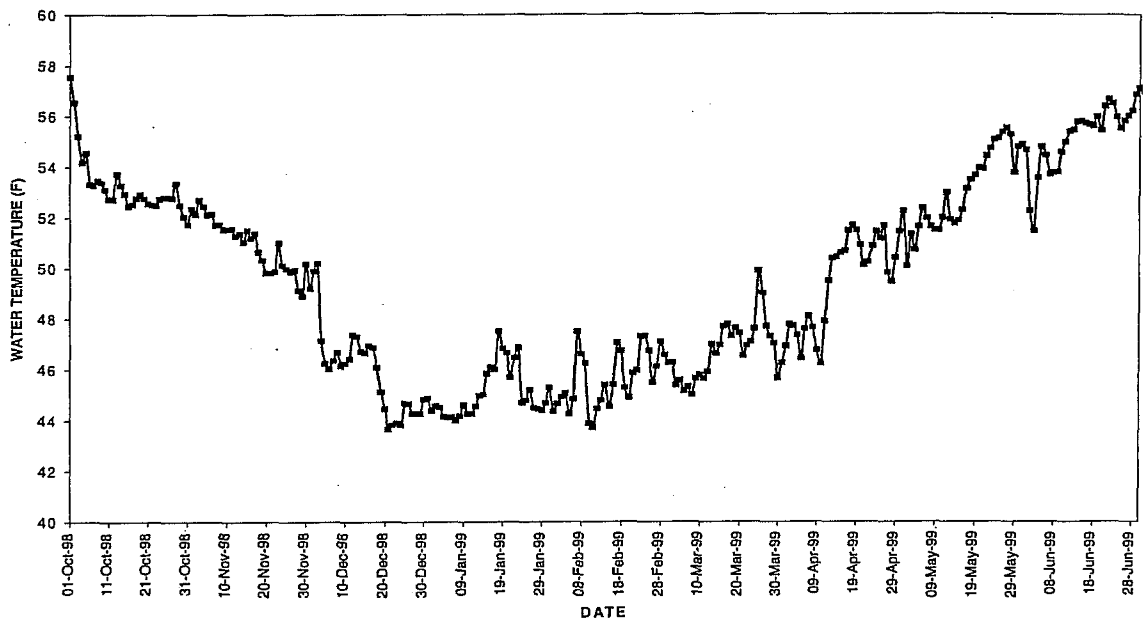

FIGURE B-14
Mean Daily Water Temperature (°F) near Igo, California on Clear Creek, October 1998 - June 1999 (USGS)

Merced River

Methods

In 1999, one trap was operated in the lower watershed of the Merced River near Hagaman County Park (RM 13.5) from January 13 through June 12, covering most of the outmigration period for fall-run chinook salmon. In general, methods used for rotary screw trap sampling on the Merced River in 1999 were consistent with the CAMP standard protocol.

The trap was 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 more frequently. During each trap check, fish were removed from the trap, sorted, and counted by species. Chinook salmon were classified as fry or juveniles based on size of individuals. Flow data used in this report were obtained from USGS gage 11270900 located below Merced Falls Dam near Snelling, California.

Trap efficiency tests were conducted in 1999. Tests were conducted with naturally produced fish. Fish were marked by dye inoculation using Alcian Red dye. A specific pattern was used to indicate the week of marking. After marking, fish were held one to four days in a net pen and then released upstream of the trap site. During each efficiency test, all fish sampled were checked for marks. An average efficiency rate from all tests was used to expand captures to overall estimates of juvenile emigration (estimated number = raw patch/predicted trap efficiency rate). Emigration estimates were reported daily throughout the sampling period.

Results

Estimated Abundance

The estimated daily number of fry and other juvenile young-of-the-year (YOY) chinook salmon emigrating from the Merced River in 1999 is shown in Figure B-15. In 1999, the majority of YOY emigrated from the Merced River as juveniles (Table B-8). In 1999, fry emigration was bi-modal with a peak in late January and a second peak in mid-February. Few fry were caught after mid-March. The emigration of larger juveniles was highest in late April and May.

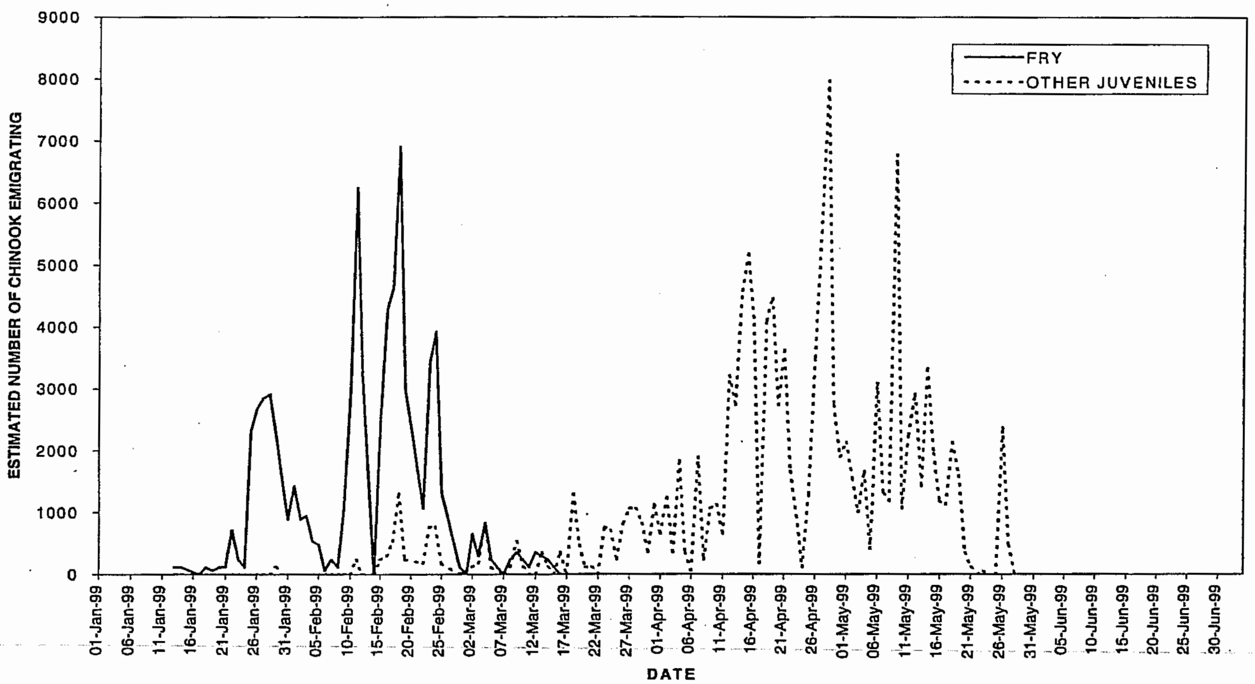

FIGURE B-15
Estimated Number of YOY Chinook Salmon Emigrating from the Merced River During 1999

TABLE B-8
Estimated Number of Fry (< 50 mm) and Juveniles (50mm t0 125 mm) Emigrating from the Merced River in 1999.

	Estimated Number of Outmigrants
Life Stage	**1999**
Fry (less than 50 mm)	70,595
Juvenile (50-125 mm)	128,571
Total	199,166

Effect of Streamflow on Timing of Juvenile Outmigration

Figure B-16 shows the mean daily flow (cfs) at the gage site during the egg incubation, juvenile rearing and emigration period, in 1998 – 1999 (October 1998 through June 1999) and the abundance of YOY chinook salmon emigrating from the Merced River.

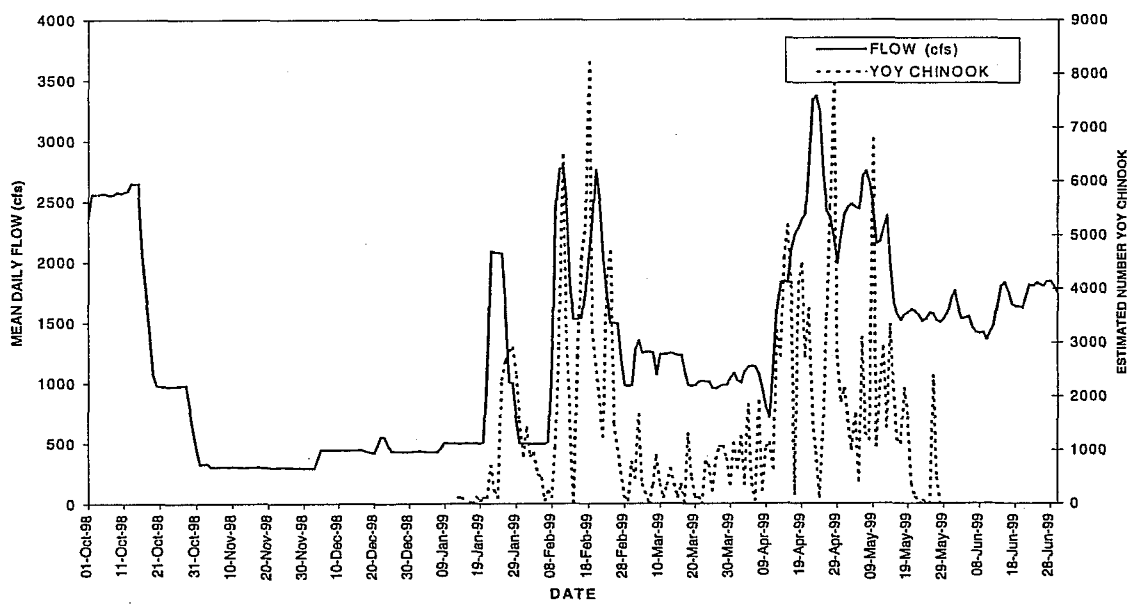

FIGURE B-16
Mean Daily Flow (cfs) below Merced Falls Dam, October 1998 Through June 1999 and Estimated Abundance of YOY Chinook Salmon Emigrating from the Merced River During 1999

Flows were relatively low and constant at about 350 to 500 cfs from late October 1998 to mid-January 1999. From mid-January through February 1999, flows were high and variable, peaking at over 2,500 cfs. The period of high outmigration appeared to lag the peaks in flow by several days. Flows from early March through early April were relatively constant, averaging around 1,000 cfs. YOY chinook salmon continued to emigrate, but at lower numbers during this period. As flows increased in mid-April to over 3,000 cfs, emigration again increased, lagging the peaks in flow by several days. No chinook salmon emigrated in June.

Effect of Water Temperature on Spawning and Egg Incubation

Water temperatures were measured by the USGS at River Road Bridge in 1998-1999. The River Road gage (No. 11273500) is located near Newman, California, several miles downstream of the trap location and the major rearing areas in the Merced River. Mean daily water temperatures from October 1998 through June 1999 are shown in Figure B-17.

Temperatures declined steadily during the fall in 1999 from near 64° F in November to a low of around 40° F in December. 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) through February and exceeded this value by up to 10° through mid-May when temperatures rose sharply and remained relatively high through June. However, temperatures through the spawning and rearing reach were probably somewhat cooler than temperatures measured at the gage site.

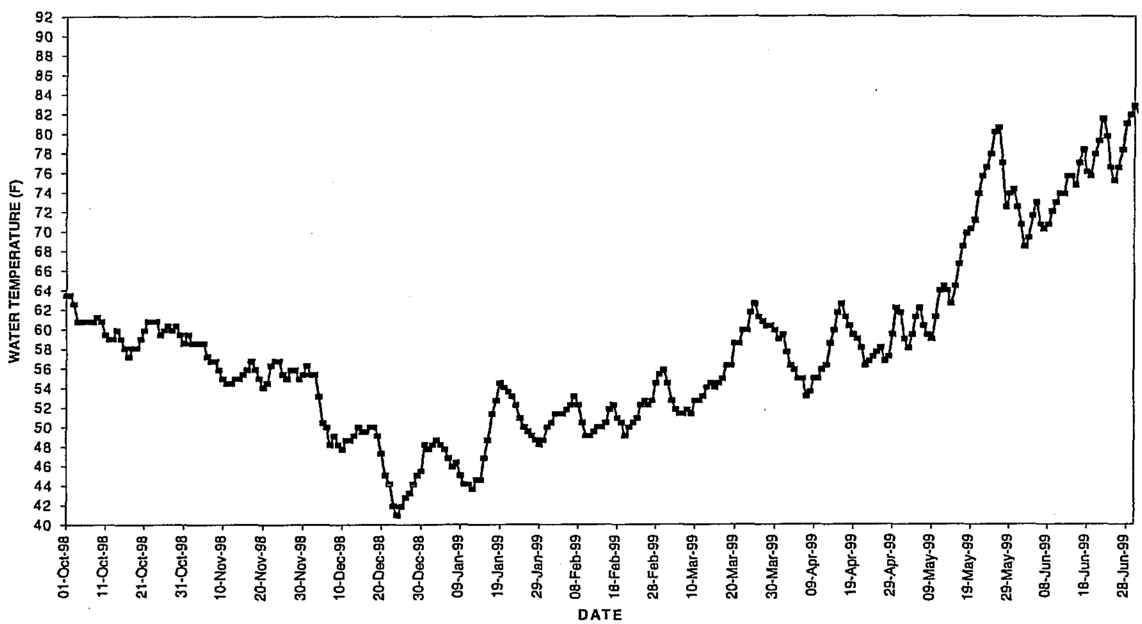

FIGURE B-17
Mean Daily Water Temperature (°F) near Newman, California on the Merced River, October 1998 - June 1999

Tuolumne River

Methods

In 1999, two traps were operated in the lower watershed near Grayson Fishing Access (RM 6) from January 13 through June 17, covering most of the outmigration period for fall-run chinook salmon. In general, methods used for rotary screw trap sampling on the Tuolumne River in 1999 were consistent with the CAMP standard protocol.

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 more frequently. During each trap check, fish were removed from the trap, sorted, and counted by species. Chinook salmon were classified as fry or juveniles based on size of individuals. Flow data used in this report were obtained from USGS gage 11289650 located below LaGrange Dam near LaGrange, California.

Trap efficiency tests were conducted in 1999 with naturally produced fish. Fish were marked by dye inoculation using Alcian Blue dye. A specific pattern was used to indicate the week of marking. After marking, fish were held one to four days in a net pen and then released upstream of the trap site. During each efficiency test, all fish sampled were checked for marks. An average efficiency rate from all tests was used to expand captures to overall estimates of juvenile emigration (estimated number = raw catch /predicted trap efficiency rate). Emigration estimates were reported daily throughout the sampling period.

Results

Estimated Abundance

The estimated daily number of fry and other juvenile young-of-the-year (YOY) chinook salmon emigrating from the Tuolumne River in 1999 is shown in Figure B-18. In 1999, the majority of YOY emigrated from the Tuolumne River as fry (Table B-9). In 1999, fry emigration was variable, peaking in mid-February. Few fry were caught after mid-March. The emigration of larger juveniles was highest in late April and May.

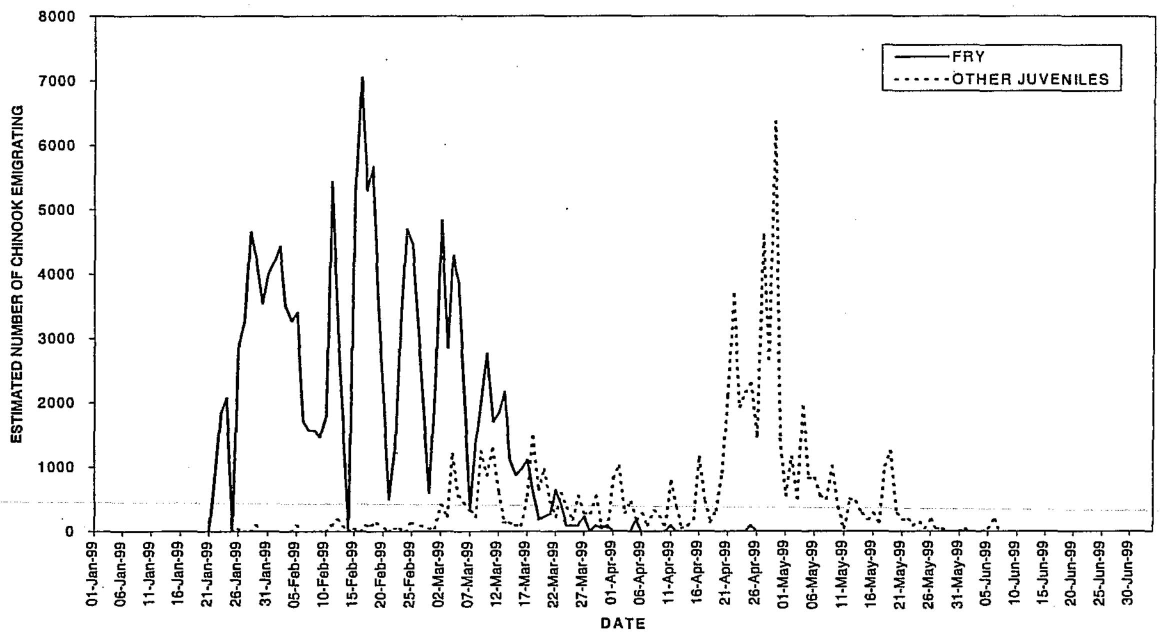

FIGURE B-18
Estimated Number of YOY Chinook Salmon Emigrating from the Tuolumne River During 1999

TABLE B-9
Estimated Number of Fry (< 50 mm) and Juveniles (50mm t0 125 mm) Emigrating from the Tuolumne River in 1999.

	Estimated Number of Outmigrants
Life Stage	**1999**
Fry (less than 50 mm)	141,705
Juvenile (50-125 mm)	66,774
Total	208,479

Effect of Streamflow on Timing of Juvenile Outmigration

Figure B-19 shows the mean daily flow (cfs) at the USGS gage site below LaGrange Dam (11289650) during the egg incubation, juvenile rearing and emigration period in 1998 – 1999 (October 1998 through June 1999) and the abundance of YOY chinook salmon emigrating from the Tuolumne River.

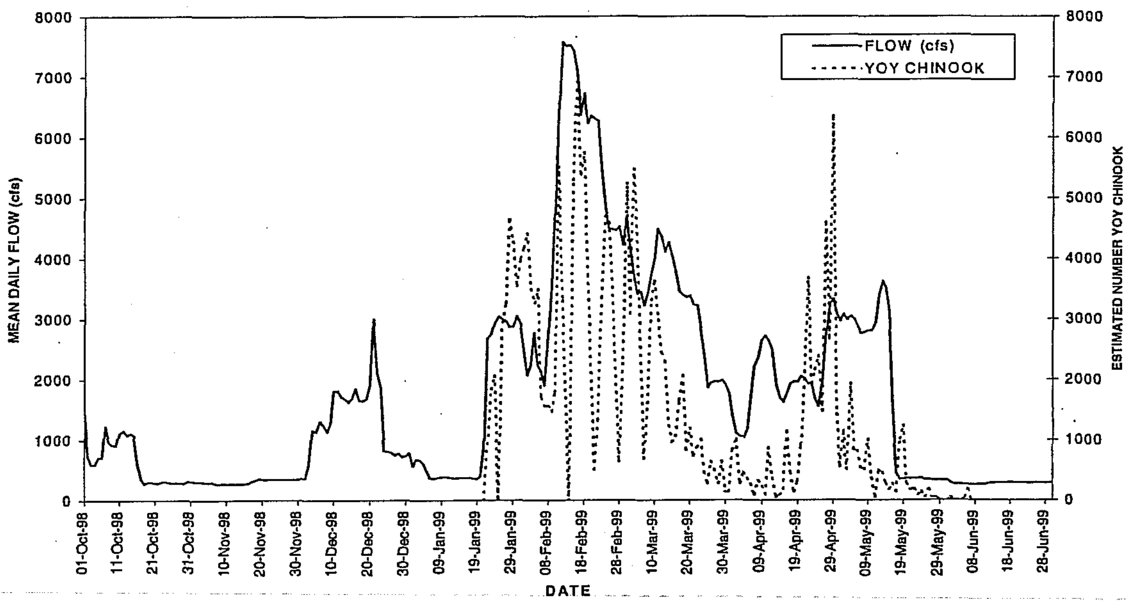

FIGURE B-19
Mean Daily Flow (cfs) below LaGrange Dam, October 1998 Through June 1999 and Estimated Abundance of YOY Chinook Salmon Emigrating from the Tuolumne River During 1999

Flows were relatively low and constant at about 350 cfs from late October 1998 to mid-January 1999 except for a period in December when flows peaked at around 3,000 cfs. From mid-January through March 1999, flows were high and variable, peaking at over 7,000 cfs. The period of high outmigration appeared to lag the peaks in flow by several days. Flows from late March through late April were variable between 1,500 and 2,500 cfs. YOY chinook salmon continued to emigrate, but at lower numbers during this period. Emigration increased again in mid- to late April, preceding an increase in flows to over 3,500 cfs. Flows were reduced sharply in late May to around 400 cfs.

Effect of Water Temperature on Spawning and Egg Incubation

Water temperatures were measured by the USGS below LaGrange Dam in 1998-1999. Mean daily water temperatures from October 1998 through June 1999 are shown in Figure B-20. Temperatures measured at this station throughout the fall-run chinook salmon spawning, egg incubation, rearing, and emigration periods were generally within optimum levels (less than 54° F).

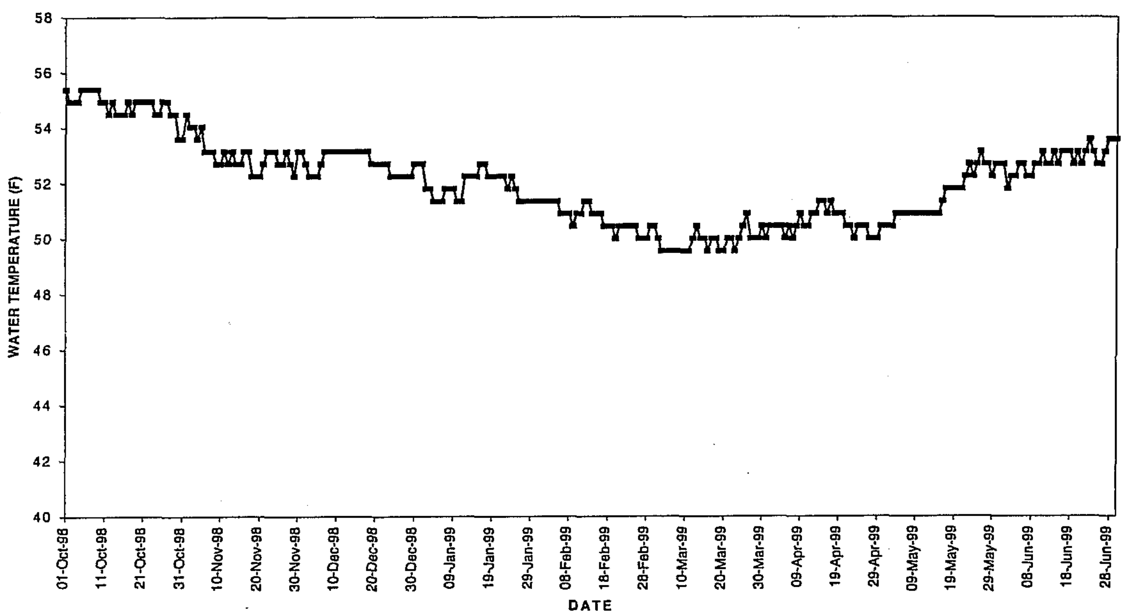

FIGURE B-20
Mean Daily Water Temperature (°F) in the Tuolumne River below LaGrange Dam, October 1998 - June 1999

References

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.

Leidy, G.F., and S.K. Li. 1987. Analysis of river flows necessary to provide water temperature requirements of anadromous fishery resources of the American River. Lower American River Court reference (EDF et al. v EBMUD). Prepared for McDonough, Holland, and Allen, Sacramento, CA.

Reiser, D.W., and T.C. Bjornn. 1987. Habitat requirements of anadromous salmonids. Influence of forest and rangeland management on anadromous fish habitat in the western United States and Canada. (General Technical Report PNW-96). U.S. Department of Agriculture, Forest Service. Portland, OR.

Rich, A.A. 1987. Water temperatures which optimize growth and survival of the anadromous fishery resources of the lower American River. A.A. Rich and Associates. San Rafael, CA.