APPENDIX A

CAMP Juvenile Monitoring Program: Summary of Juvenile Chinook Salmon Monitoring, 2000. Detailed Methods and Results

APPENDIX A

CAMP Juvenile Monitoring Program: Detailed Methods and Results

Introduction

Rotary screw traps (RST) were selected as the standard gear to sample juvenile chinook salmon abundance in the CAMP program. RSTs have been used in Central Valley streams since 1991 to monitor juvenile salmon. A standardized protocol for RST sampling was developed for the CAMP based on the protocols used in existing studies by USFWS on the upper Sacramento River at Red Bluff, by CDFG on the upper Sacramento River at Balls Ferry, the lower Sacramento River at Knights Landing, and the lower American River, and by S.P. Cramer and Associates under contract to the USFWS on the lower Stanislaus River.

This report provides details on the methods used and results of RST sampling for fall-run chinook salmon in seven streams during 2000. 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 A-1.

TABLE A-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 1996-2000	Lower American River Emigration Survey	Fall-run Chinook	One trap near Watt Avenue in Sacramento	1 Jan. - 30 Jun.	CDFG	1994
Feather River 1996, 1998-2000	Feather River Outmigration Study	Fall-run Chinook	One trap at Live Oak One trap at Thermalito	1 Jan. - 30 Jun.	DWR	1996
Mokelumne River 1995-2000	Mokelumne River Chinook Salmon and Steelhead Monitoring Program	Fall-run Chinook	Two traps at Woodbridge Dam	1 Jan. - 30 Jun.	EBMUD	1993
Stanislaus River 1996-2000	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, 2000	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	1998
Clear Creek 1999, 2000	Clear Creek Outmigration Study	Chinook/All Races	One trap 1.7 mi. upstream of mouth	1 Jan. - 31 Dec.	USFWS	1998

TABLE A-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
Tuolumne River 1999, 2000	Tuolumne River Outmigration Study	Fall-run Chinook	Two traps near Grayson Fishing Access	1 Jan. - 30 Jun.	CDFG	1998
Merced River 1999, 2000[a]	Merced River Outmigration Study	Fall-run Chinook	One trap near Hagaman County Park	1 Jan. – 30 Jun.	CDFG	1998

[a] Outmigrant data for 2000 were unavailable for inclusion in this report.

American River

Methods

Since 1992, RSTs have been used by the CDFG Stream Flow and Habitat Evaluation Program to monitor juvenile emigration from the lower American River. The first full sampling season began 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 RST sampling on the lower American River were coordinated with the establishment of the CAMP standard protocol. Therefore, sampling methods generally are consistent with the CAMP protocol.

From 1996 to 1999, one or two RSTs (8 foot diameter) were installed just downstream of the Watt Avenue bridge in Sacramento at river mile (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 through June in 1999 and 2000.

The traps are fished 24 hours a day, 7 days a week, and checked once or twice daily. During each trap check, fish are removed from the trap, sorted by species, and counted. Up to 300 of each species are measured and weighed (length to the nearest 0.5 mm, and weight to the nearest 0.1 g). Water transparency (secchi disk depth), water temperature, and effort (hours fished since last trap check) are recorded during each trap check (CDFG 1997). The raw catch data are expanded by multiplying the weekly catch rate calculated from the observed catches and trapping effort (hours) by the number of hours that would have been fished at 100 percent effort (Snider and Titus, in prep). These expanded catch data are adjusted for trap efficiency as described below.

Trap efficiency tests were conducted on a weekly basis in 1996 and 1997, but were not reported for 1998. Efficiency tests were conducted on a weekly basis in 1999 and 2000. Fish captured in the trap are marked and released approximately 2,500 feet upstream. During each efficiency test, all fish measured are also checked for marks. If all fish are not checked, the number of recovered fish is expanded by the proportion of fish checked to the total number captured. When no fish are recaptured in a test, results of the test are 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. Based on several trap efficiency tests using marked fish, an average trap efficiency of 0.0119 was used in 1999 and an average efficiency of 0.0083 was used in 2000. The average trap efficiency was applied to expanded catch data (estimated number = expanded catch/average trap efficiency) each week to estimate the number of juvenile chinook salmon emigrating that week.

Results

Estimated Abundance

Table A-2 presents the estimated number of fall-run chinook salmon emigrating from the lower American River from 1996 through 2000.

TABLE A-2
Estimated Number of Fry (< 50 mm) and Juvenile (50mm to 125 mm) Fall-run Chinook Salmon Emigrating from the Lower American River

	Estimated Number of Outmigrants				
Life Stage	**1996**	**1997**	**1998**	**1999**	**2000**
Fry (less than 50 mm)	4,461,729	1,772,842	31,822,165	9,865540	9,734,764
Juvenile (50-125 mm)	125,487	57,532	539,011	119,250	219,212
Total	**4,587,216**	**1,830,374**	**32,361,176**	**9,984,790**	**9,953,976** (6.8 to 18.4 million)[a]

[a] 80 percent confidence interval based on trap efficiency.

The estimated number of juvenile fall-run chinook salmon emigrating weekly from the lower American River in 2000 is shown in Figure A-1. In 2000, there was a period of relatively high emigration during January and February with a distinct peak in emigration during early-February.

Feather River

Methods

In cooperation with DFG, DWR has initiated a number of fishery studies on the lower Feather River. Juvenile outmigration data are collected by DWR Environmental Services staff based at the Oroville Field Division.

RST sampling has been conducted at the Live Oak site (high flow channel) and at the Thermalito site (low flow channel) on the Feather River since 1996. In January 1997, sampling was discontinued at the Live Oak site when flood flows washed out the trap. Rotary screw trap sampling was again conducted during 1998 and 1999. During the 2000 outmigration period, sampling was conducted from December 1, 1999 through June 21, 2000. Methods used for RST sampling on the Feather River generally are consistent with the CAMP standard protocol.

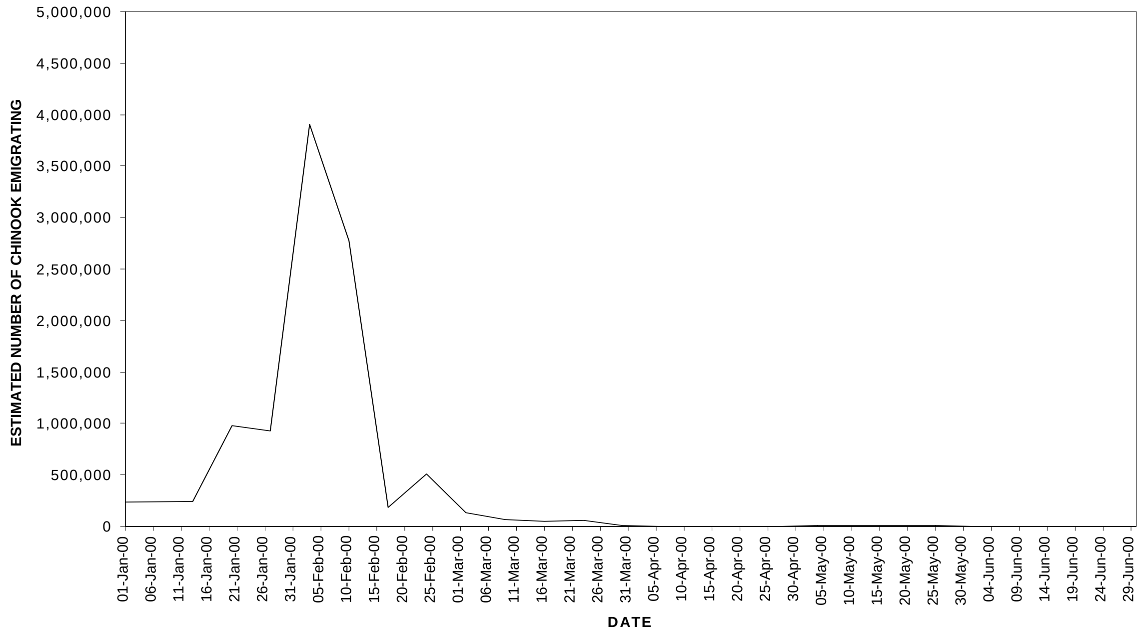

FIGURE A-1
Estimated Number of Juvenile Fall-run Chinook Salmon Emigrating from the Lower American River During 2000

A single RST (8 foot diameter) is used at the Live Oak site and a second RST is used at the Thermalito site. The traps are fished 24 hours a day, 7 days a week, and checked at least once daily. Traps are serviced more frequently during periods of peak emigration. During each trap check, fish are removed, sorted by species, and counted. Up to 50 individuals of each species are measured to the nearest 0.5 mm fork length. Water transparency (secchi disk depth), water temperature, and fishing–hour effort are recorded during each trap check.

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 sampling period (0.0342) was applied to catches for that year. In 2000, trap efficiencies were not reported, but were used to generate estimates of juvenile passage (estimated passage = total number captured / 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 A-3. The apparently 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. The estimate of juvenile outmigration for 2000 past the Live Oak site is low and unreliable because high flows impeded trapping at the site, and the Live Oak trap was not fished for 19 days in February and March of 2000.

TABLE A-3
Estimated Number of Fry (< 50 mm) and Juvenile (50 mm to 125 mm) Fall-run Chinook Salmon Emigrating from the Feather River

	Estimated Number of Outmigrants				
Life Stage	**1996**	**1997**	**1998**	**1999**	**2000**
Thermalito Site					
Total	**NA**	**NA**	**NA**	**6,618,259**	**11,968,861**
Live Oak Site					
Fry (less than 50 mm)	550,500	NA	43,908,500	NA	NA
Juvenile (50-125 mm)	90,500	NA	1,188,500	NA	NA
Total	**641,000**		**45,097,000**	**18,116,006**	**5,946,454**[a]

[a] Estimate is extremely low and unreliable because high flows impeded trapping

The estimated number of juvenile fall-run chinook salmon emigrating weekly from the Feather River in 2000 is shown in Figure A-2.

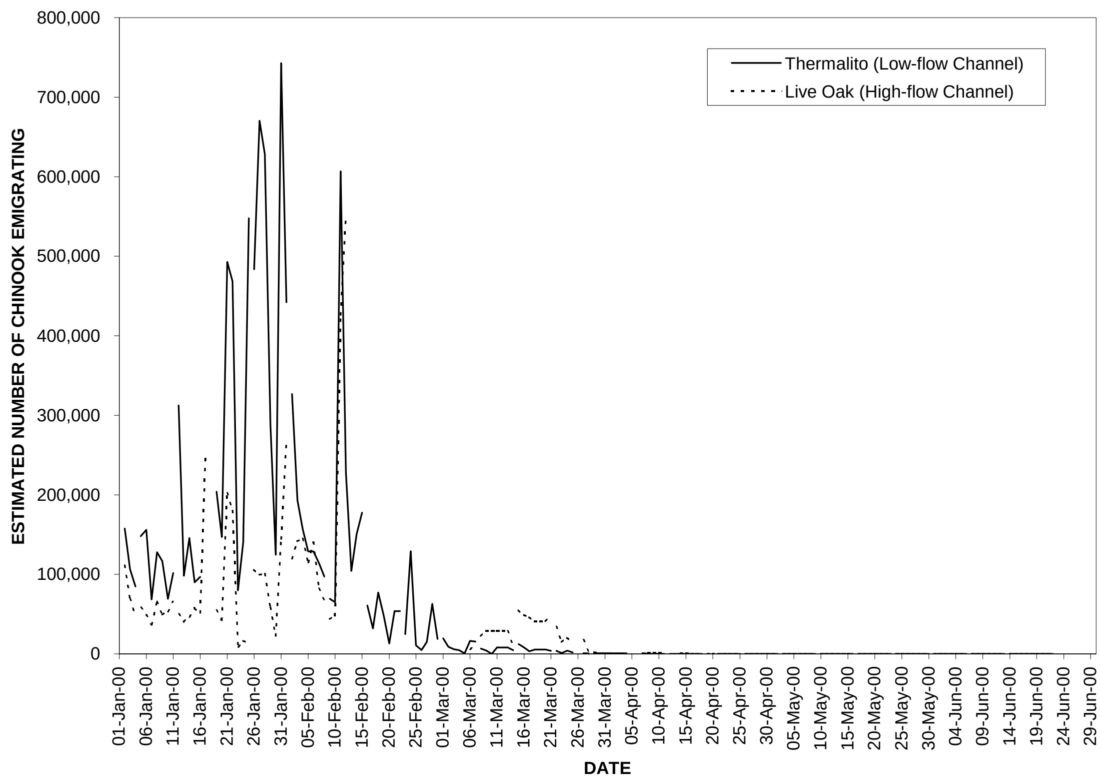

FIGURE A-2
Estimated Number of Juvenile Fall-run Chinook Salmon Emigrating from the Feather River During 2000

Mokelumne River

Methods

Since 1993, Natural Resource Scientists Inc., under contract with EBMUD, has used RSTs 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 RSTs (8 foot diameter) are fished side-by-side each year immediately downstream from Woodbridge Dam. During the 2000 outmigration period, sampling was conducted continuously from December 15, 1999 through July 31, 2000. Data from the entire sampling period are included in this report.

Traps are fished 24 hours a day, 7 days a 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 are checked more frequently. During each trap check, fish are removed from the trap, sorted, and counted by species. Up to 60 individuals of each salmonid species captured in each trapping period are 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 are obtained from the Mokelumne River Fish Hatchery. Fish are marked by fin clip or dye and are allowed to recover for 8 to 24 hours prior to release. Releases are made at the crest of the spill over flashboards at Woodbridge Dam in four to five replicate groups. During each efficiency test, all fish are measured and checked for marks. Calculated efficiency rates (number of recaptures/number of marked fish in release group) in 2000 ranged from 0.020 to 0.213. Appropriate trap efficiency test results are 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). Confidence intervals for each day and night abundance estimate are generated using the upper and lower 95 percent confidence limits approximated from a binomial distribution for each trap efficiency used.

Results

Estimated Abundance

The estimated number of juvenile fall-run chinook salmon emigrating weekly from the Mokelumne River at Woodbridge in 2000 is shown in Figure A-3. The estimated number of fry and juvenile chinook salmon emigrating from the Mokelumne River each year is presented in Table A-4.

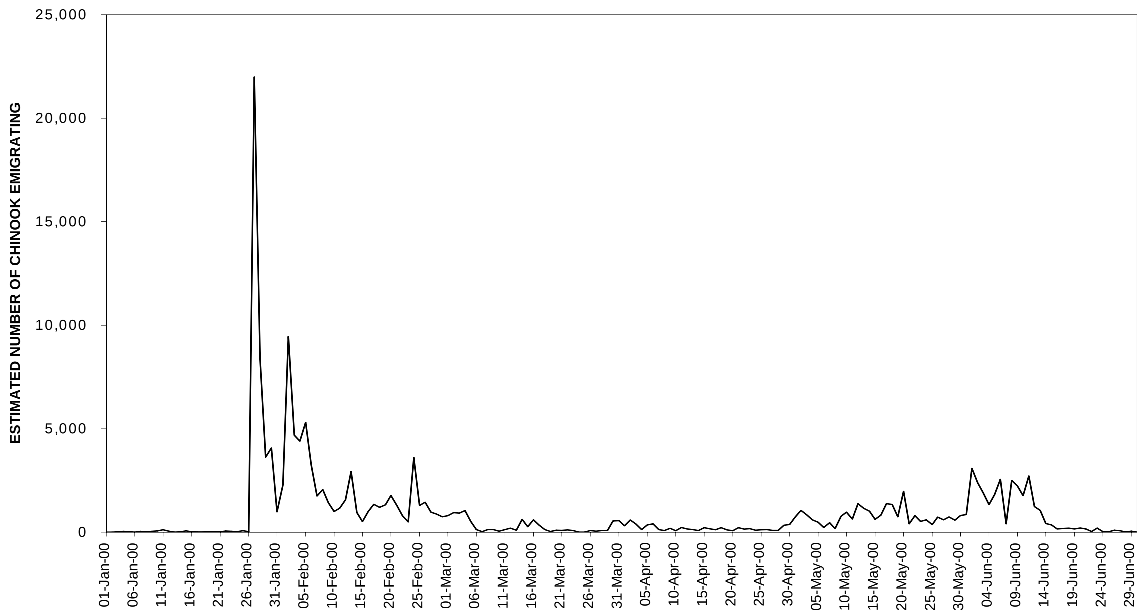

FIGURE A-3
Estimated Number of Juvenile Fall-run Chinook Salmon Emigrating from the Mokelumne River During 2000

Juvenile fall-run chinook salmon exhibited a bimodal pattern of emigration in the lower Mokelumne River during 2000 (Vogel and Marine, 2000). Large numbers of fry (fork length 50 mm) migrated past Woodbridge Dam during late-January and February followed by relatively fewer fish from March through April. Larger juvenile salmon were observed to start emigrating around mid-March through April. These juvenile salmon were composed almost exclusively of smolts (fork length ≥50 mm). This rapid switch from fry to smolt migrants from mid-March to early April has been observed for the Mokelumne River fall-run chinook salmon in recent years (Vogel and Marine 1994, 1996, 1998 a, b, 1999 a, b, 2000).

TABLE A-4
Estimated Number of Fry (< 50 mm) and Juvenile (50mm to 125 mm) Fall-run Chinook Salmon Emigrating from the Mokelumne River
(from Vogel and Marine, 2000)

	Estimated Number of Outmigrants					
Life Stage	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
Fry (less than 50 mm)	260,103	103,270	405,350	1,336,768	1,232,958	107,134
Juvenile (50-125 mm)	174,103	80,744	135,116	511,771	302,481	61,391
Total	**434,206**	**184,014**	**540,466**	**1,848,539**	**1,535,439**	**168,525**
95% Confidence Interval Lower Bound	287,000	148,689	389,327	1,543,355	1,143,989	133,823
95% Confidence Interval Upper Bound	1,100,000	247,165	1,874,313	2,592,219	2,318,804	235,713

Stanislaus River

Methods

Since 1994, RSTs have been used to monitor juvenile emigration on the lower Stanislaus River at Caswell State Park (RM 8.6) (Demko et al., 2001). In 1994, CDFG fished one trap and in 1995, USFWS fished two traps at the site. 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 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. Trapping during the 2000 season was conducted from December 16, 1999 through June 30, 2000. Data from the entire sampling period are included in this report. In general, methods used for RST sampling on the lower Stanislaus River in 1996 through 2000 were consistent with the CAMP standard protocol.

Since 1995, two RSTs (8 foot diameter) have been used side-by-side at Caswell State Park (RM 8.6). Traps were fished 24 hours a day, 7 days a week, except for the period after May 26, 2000 when they were fished five days a week due to heavy weekend recreational traffic on the river. The traps were also raised during the Christmas and New Year's holiday periods during 2000.

The traps are checked daily during the sampling period. However, in times of high turbid flows and when marked fish had been recently released, trap catches are retrieved in the morning and during the day to document daytime catches of juvenile chinook. The traps are monitored frequently after releasing marked fish until marked fish are no longer being recaptured. During each trap check, the contents of the liveboxes are removed and all fish are identified and counted. Random samples of 50 chinook and 20 of each other species are measured and their lengths recorded in millimeters during morning trap checks. Subsamples of 20 chinook and 10 of each other species are examined during all other trap checks.

Measured salmonids are visually classified as fry, parr, or smolts. Turbidity, velocity at trap mouth, water temperature, and effort are recorded each day. Daily water temperatures are also calculated from continuously recording thermographs.

Trap efficiency tests were conducted in 1996 through 2000. Tests were conducted with naturally produced fish when available in sufficient numbers; fish from the Merced River Fish Facility also were used. Trap efficiency tests were limited in 1997 by the availability of hatchery fish for use in tests. After marking, fish are 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 are also checked for marks.

Following 1997 sampling, a regression was developed relating flow, water turbidity, and fish size to trap efficiency. This regression was updated in subsequent years, using the efficiency data from each year's sampling. In 2000, 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 number of juvenile fall-run chinook salmon emigrating daily from the lower Stanislaus River in 2000 is shown in Figure A-4. In 2000, there was a period of relatively high emigration during February with a distinct peak of emigration in mid-February. Another peak in emigration occurred in mid-March. Table A-5 presents the estimated number of fall-run chinook salmon emigrating from the lower Stanislaus River from 1996 through 2000.

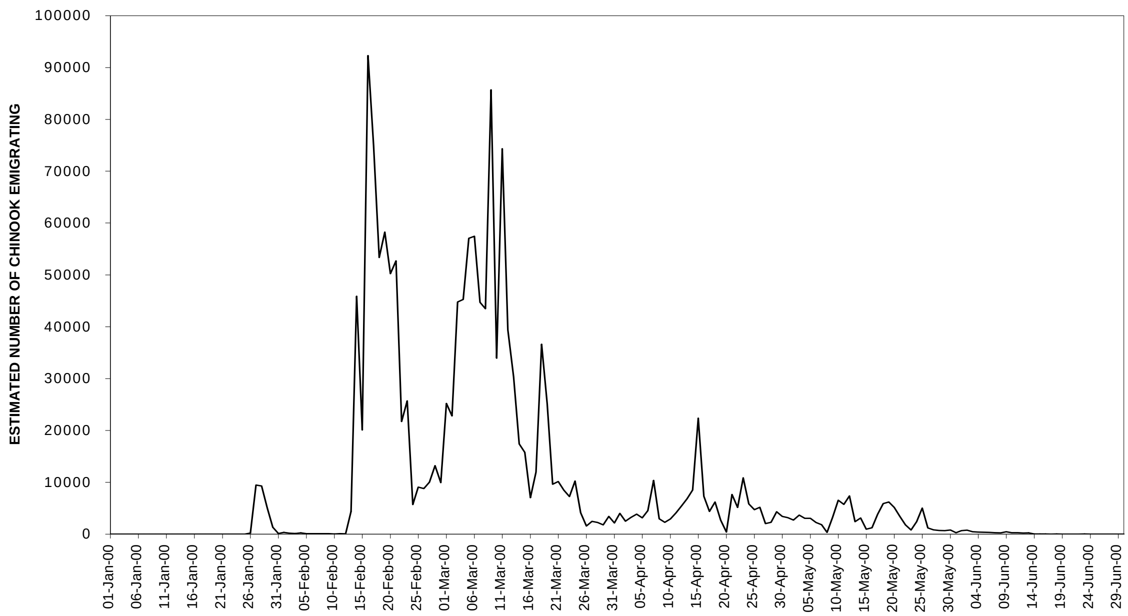

FIGURE A-4
Estimated Number of Juvenile Fall-run Chinook Salmon Emigrating from the Stanislaus River During 2000

TABLE A-5
Estimated Number of Fry (< 50 mm) and Juvenile (50mm to 125 mm) Fall-run Chinook Salmon Emigrating from the Lower Stanislaus River (From Demko et al., 2001)

	Estimated Number of Outmigrants				
Life Stage	**1996**	**1997**	**1998**	**1999**	**2000**
Fry	31,767	0	186,024	1,155,424	631,460
Parr	1,596	7,011	209,911	92,618	929,042
Smolt	81,896	60,333	197,885	73,012	59,091
Total	**115,258**	**67,344**	**593,819**	**1,321,054**	**1,619,593**
95% Confidence Interval	85,634	51,598	443,599	1,006,219	609,635

TABLE A-5
Estimated Number of Fry (< 50 mm) and Juvenile (50mm to 125 mm) Fall-run Chinook Salmon Emigrating from the Lower Stanislaus River (From Demko et al., 2001)

	Estimated Number of Outmigrants				
Life Stage	**1996**	**1997**	**1998**	**1999**	**2000**
Lower Bound					
95% Confidence Interval Upper Bound	144,883	83,090	744,039	1,635,889	2,629,552

Battle Creek

Methods

The USFWS has been operating RSTs in Battle Creek for juvenile chinook salmon and steelhead since 1998. During 2000, two five-foot diameter RST were operated in Battle Creek. One RST was located approximately 2.8 miles upstream of the confluence with the Sacramento River. The second RST was located approximately 225 yards upstream of the Coleman National Fish Hatchery (CNFH) barrier weir at river mile 5.8 (RK 9.3).

In general, the methods used for RST sampling on Battle Creek are consistent with the CAMP standard protocol. The RSTs in Battle Creek were fished during 2000 from January 1 through December 31, covering the outmigration period for all races of chinook salmon. Traps are fished continuously seven days per week, except when high creek flows or debris loads jeopardize equipment or the safety of personnel.

The RST's are serviced once per day unless high flows, heavy debris loads, or high fish densities require multiple trap checks to reduce mortality of captured fish, or prevent equipment damage or loss. At each trap servicing, crews process the collected fish, clear the RST of debris, provide maintenance, and obtain environmental and RST data. Collected data include dates and times of RST operation, creek depth at the RST, number of rotations of the RST cone, amount and type of debris collected, weather conditions, current velocity, water turbidity, and water temperature.

All captured fish are identified, counted, and measured to the nearest 1.0 mm fork length. Exceptions to this protocol occur when greater than 250 juvenile salmonids are captured. For these events, a random sub-sample of approximately 150 - 250 individuals is taken. All fish in the sub-sample are identified, counted, and measured. All other fish are counted unless capture exceeds approximately 1,000 fish. When large catches (>1,000) of juvenile salmon occur, counts are estimated based on the weight and number of individuals from two random sub-samples and the weight of the total catch.

Trap efficiency tests are conducted using mark/recapture trials. Trials are conducted twice weekly for each trap when fish capture is sufficient and weather conditions permit sampling. Fish are marked with a photonic tag and released approximately 1.0 km upstream of the RST. Marked chinook that are recaptured by the RST are counted, measured, and allowed to recover before being released downstream of the sampling station. Trap efficiencies were not reported, but were used to generate estimates of juvenile passage (estimated passage = total number captured/trap efficiency).

Results

Estimated Abundance

The estimated number of fall-run chinook salmon emigrating weekly from the upper and lower Battle Creek sampling locations in 2000 is shown in Figure A-5. The outmigrants were not separated into fry and juvenile size classes. In 2000, there was a period of relatively high emigration during January and February with a distinct peak of emigration past the upper site in mid-January and past the lower site in mid-February. Table A-6 presents the estimated number of chinook salmon emigrating from Battle Creek during 1999 and 2000. This total includes all fish captured, not just those captured during the CAMP standard monitoring period of January 1 through June 30. A small number of fall-run chinook salmon emigrated after June 30 and captures in November and December indicated that some fall-run chinook began emigrating prior to January 1.

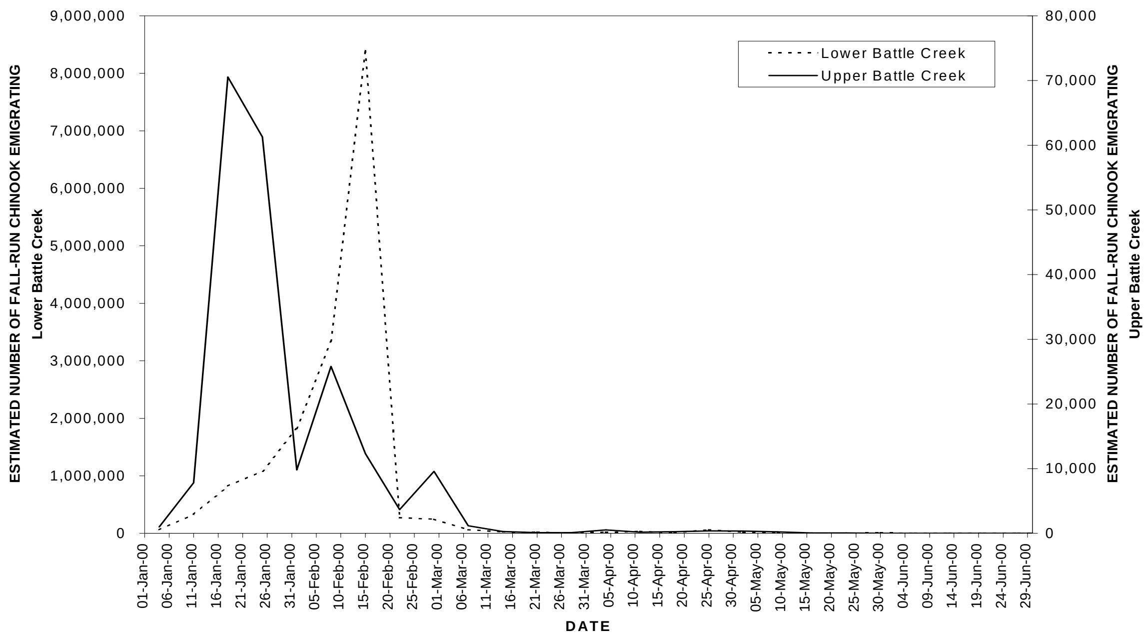

FIGURE A-5
Estimated Number of Juvenile Fall-run Chinook Salmon Emigrating from Battle Creek During 2000

TABLE A-6
Estimated Number of Juvenile Chinook Salmon Emigrating from Battle Creek

	Estimated Number of Outmigrants[a]	
Location	**1999[b]**	**2000**
Upper Battle Creek		
Fall-run	1,466,274	211,662
Late fall-run	218	53
Winter-run	16	0
Spring-run	4,589	10,061
Lower Battle Creek		
Fall-run	4,909,700	16,697,610
Late fall-run	113,684	99,803
Winter-run	8,316	2,711
Spring-run	7,077	38,263

[a] Estimates include all captures from January 1 through December 31.
[b] Revised based on adjustment in RST efficiency (pers. comm., Phillip Gaines, USFWS)

Clear Creek

Methods

The USFWS has been operating a single RST on Clear Creek for juvenile chinook salmon and steelhead since 1998. This trap is located 1.7 miles above the confluence with the Sacramento River. In general, the methods used for RST sampling on Clear Creek are consistent with the CAMP standard protocol. The RST is fished continuously seven days per week, except when high creek flows or debris loads jeopardize equipment or the safety of personnel.

The RST is serviced once per day unless river conditions require multiple trap checks to reduce mortality of captured fish, or avoid equipment damage or loss. At each trap servicing, crews process the collected fish, clear the RST of debris, provide maintenance, and obtain environmental and RST data. Collected data include dates and times of RST operation, creek depth at the RST, number of rotations of the RST cone, amount and type of debris collected, weather conditions, current velocity, water turbidity, and water temperature.

All captured fish are identified, counted, and measured to the nearest 1.0 mm fork length. Exceptions to this protocol occur when greater than 250 juvenile salmonids are captured. For these events, a random sub-sample of approximately 150 - 250 individuals is taken. All fish in the sub-sample are identified, counted, and measured. All other fish are counted unless capture exceeds approximately 1,000 fish. When large catches (>1,000) of juvenile salmon occur, counts are estimated based on the weight and number of individuals from two random sub-samples and the weight of the total catch.

Trap efficiency tests are conducted using mark/recapture trials. Trials are conducted twice weekly for each trap when fish capture is sufficient and weather conditions permit sampling. Fish are marked with a photonic tag and released approximately 1.0 km upstream of the RST. Marked chinook that are recaptured by the RST are counted, measured, and allowed to recover before being released downstream of the sampling station. Trap efficiencies were not reported, but were used to generate estimates of juvenile passage (estimated passage = total number captured/trap efficiency).

Results

Estimated Abundance

The estimated number of fall-run chinook salmon emigrating weekly from Clear Creek in 2000 is shown in Figure A-6. The outmigrants were not separated into fry and juvenile size classes. In 2000, there was a period of relatively high emigration during January and February with a distinct peak of emigration in early-February. Table A-7 presents the estimated number of chinook salmon emigrating from Clear Creek during 1999 and 2000. This total includes all fish captured, not just those captured during the CAMP standard monitoring period of January 1 through 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.

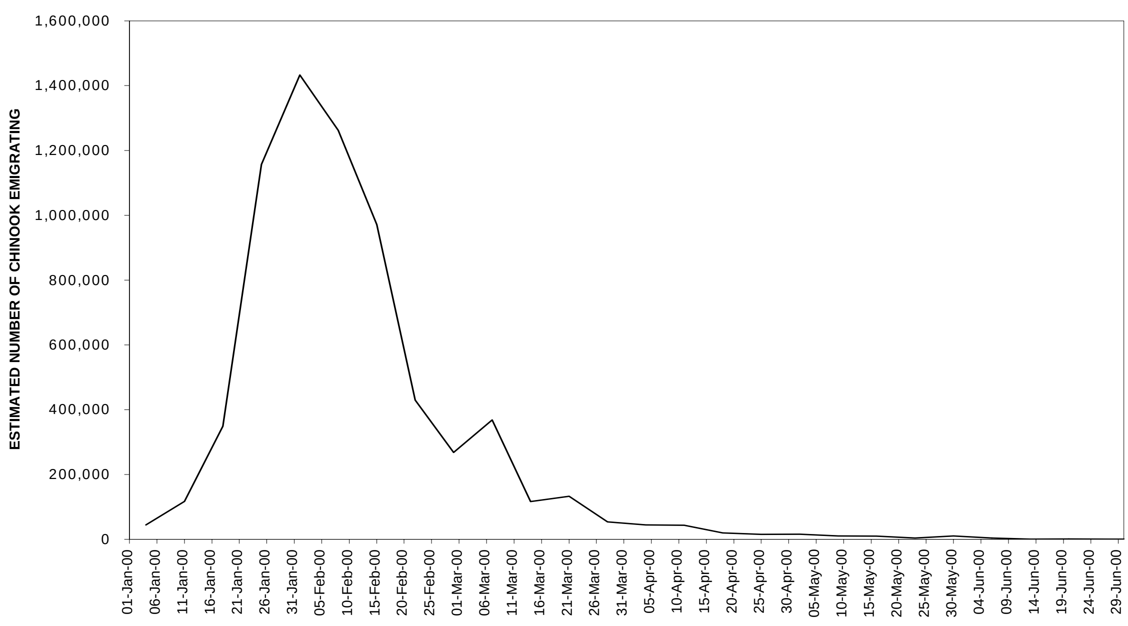

FIGURE A-6
Estimated Number of Juvenile Fall-run Chinook Salmon Emigrating from Clear Creek Each Week During 2000

TABLE A-7
Estimated Number of Juvenile Chinook Salmon Emigrating from Clear Creek

Location	Estimated Number of Outmigrants[a]	
	1999	2000
Clear Creek		
Fall-run	7,586,097	6,890,479
Late fall-run	272,941	106,225
Winter-run	869	2,819
Spring-run	52,427	10,747

[a] Estimates include all captures from January 1 through December 31.
[b] Revised based on adjustment in RST efficiency (pers. comm., Phillip Gaines, USFWS)

Tuolumne River

Methods

In 2000, two traps were operated in the lower watershed near Grayson Fishing Access (RM 6) from January 9 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 Tuolumne River are consistent with the CAMP standard protocol.

Traps are fished 24 hours a day, 7 days a week, and checked twice or three times daily. At the start of the 2000 season, the traps were raised so that they did not sample on weekends. The traps began operating seven days a week starting on February 13. During peak outmigration periods or when debris loading is heavy, the trap is monitored more frequently. During each trap check, fish are removed from the trap, sorted, and counted by species. A representative subsample of approximately 100 juvenile salmon is measured to the nearest millimeter (fork length) and the remainder of the catch is counted during each trap check.

Trap efficiency tests were conducted in 2000 with fish produced at the Merced River Fish Facility. After marking, fish were held one to four days in live cars at the release location and then released upstream of the trap site. Regression analysis was used to estimate trap efficiency as a function of flow. Daily estimates of efficiency were used to expand daily 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 number of fry and other juvenile fall-run chinook salmon emigrating daily from the Tuolumne River in 2000 is shown in Figure A-7. In 2000, the majority of chinook salmon emigrated from the Tuolumne River as fry, as shown in Table A-8. In 2000, fry emigration was greatest in late-February. The emigration of larger juveniles was highest in late April and May.

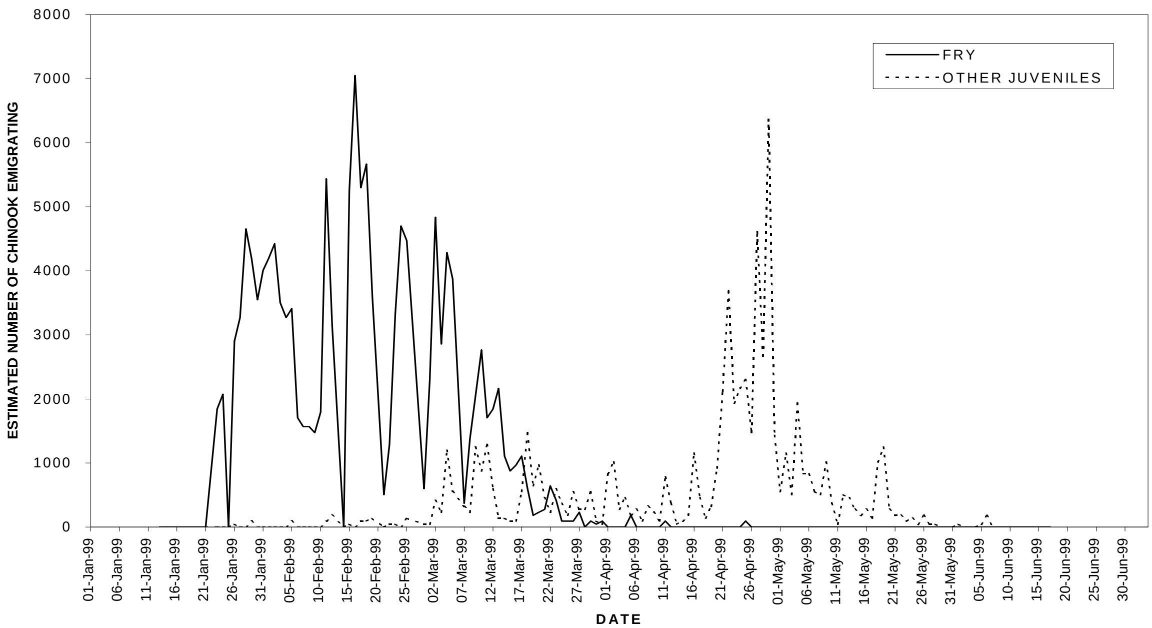

FIGURE A-7
Estimated Number of Juvenile Fall-run Chinook Salmon Emigrating from the Tuolumne River During 2000

TABLE A-8
Estimated Number of Fry (< 50 mm) and Juvenile (50mm t0 125 mm) Fall-run Chinook SalmonEmigrating from the Tuolumne River in 1999 and 2000. (From Vasques and Kundargi, 2001)

	Estimated Number of Outmigrants	
Life Stage	**1999**	**2000**
Fry (less than 65 mm)	1,102,238	90,064
Juvenile (>65 mm)	31,650	48,960
Total	**1,133,887**	**139,024**

References

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APPENDIX B

CAMP Juvenile Monitoring Program: Restoration Actions in CAMP Watersheds

Appendix B

This Appendix includes restoration 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 watersheds covered by this report. As more actions are monitored over a greater number of years, it is 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, Stanislaus, and Tuolumne rivers, and Battle and Clear creeks.

American River

On the lower American River, flow releases from Folsom Dam have been modified 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 as higher fall flows are believed to result in increased salmonid 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 cubit feet per second (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, and additional releases were made starting in mid-December for flood management. Between October 15, 1997 and February 28, 1998, flows were 900 cfs, with some flood releases in February. For the next two years (1999 and 2000), flows were returned to the base flow of 600 cfs, and spawning use was monitored under this release regime.

Monitoring results during augmented flow periods indicated significant salmon spawning in the low flow channel. Juvenile data for 1996 and 1998-2000 on the lower Feather River indicate 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 1996 Federal Energy Regulatory Commission (FERC) Principles of Agreement, which included increased year-round flow releases for the benefit of fall-run chinook salmon and steelhead spawning, rearing, and outmigration.

It is believed that increased flow releases will 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 and 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. The Calfed Environmental Water Account has also been used to purchase additional summer flows for steelhead from Oakdale and South San Joaquin Irrigation Districts. In 2000, 50 cfs were purchased for this use.

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.

Tuolumne River

The Don Pedro Project license from the Federal Energy Regulatory Commission (FERC) requires minimum stream flows in the lower Tuolumne River below La Grange Dam (as measured above the town of La Grange). These flows were established in 1995. The minimum flow schedules vary as a result of different actual and forecasted runoff amounts with the annual minimum flow volume ranging from about 94,000 to 301,000 acre-feet. Annual schedules are established for the period running from April 15 through April 14 of the following year. Baseline minimum flow requirements typically range from 50-180 cubic feet per second (cfs) to 250-300 cfs throughout the year, depending on runoff year type, with higher flow targets during spring and fall pulse periods (TID, 2002).

It is believed that the modified flow requirements will 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 and direct comparison of juvenile production before and after implementation of the new schedule is not possible.

Battle Creek

Since 1995, the Department of the Interior has purchased environmental water for Battle Creek using funds from the CVPIA Water Acquisition Program. Water releases have gone toward increasing attraction, holding, spawning, and rearing flows in Battle Creek, and increasing minimum instream flows. In 2000, 30 cfs were purchased for each of the two forks of Battle Creek. Water management actions associated with the FERC relicensing of Pacific Gas and Electric company (PG&E) facilities on Battle Creek are still in the planning stage. A Memorandum of Understanding was signed between National Marine Fisheries Service, USBR, USFWS, CDFG, and PG&E in 1999.

Clear Creek

In 2000, the Department of the Interior acquired water using funds from the CVPIA water acquisition program for the benefit of steelhead, fall-run chinook salmon, late-fall run chinook salmon, and spring-run chinook salmon. Approximately 150 cfs was released starting in the fall through spring, and 50 cfs released in summer.

Habitat Restoration

Habitat restoration projects have been implemented in the Mokelumne, Stanislaus, American, Tuolumne, and Merced Rivers, and Clear Creek.

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, an additional 100 cubic yards of gravel were placed in this area. 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). Approximately 1,200 cubic yards of gravel were placed at two sites in October 1998 and about 2,900 cubic yards were placed at two sites in 1999. Two sites received about 1,200 cubic yards in 2000 (AFRP, 2002).

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 have not been published and were not available for inclusion in this report.

Stanislaus River

Several gravel restoration projects have been implemented in recent years. In 1994, three spawning riffles at 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 1/2 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. In 2000, 1,300 tons of spawning gravel were added below Goodwin Dam, funded through CVPIA Section b(13) and 300 tons were added through funding provided by the U.S. Bureau of Reclamation (pers. communication with Rhonda Reed, CDFG, February, 2002).

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. Continued monitoring of adult and juvenile production will allow spawning success in these areas to be verified and quantified.

Tuolumne and Merced Rivers

Efforts are underway to restore the Tuolumne River Mining Reach and to restore the channel at Special Run Pools 9 and 10. The objectives of these restoration efforts are to restore and increase riparian and instream habitat to support natural production of fall-run chinook salmon. Restoration activities will include reconstruction of the natural channel geometry, restoration of native riparian plant communities, and reduction of habitat for predators on salmonid fish species (AFRP, 2002). In general, environmental permitting and documentation is complete with project design and construction to follow. Construction at

Special Run Pool 9 was completed in the summer 2001, with revegetation during the following fall and winter (pers. communication with Rhonda Reed, CDFG, May, 2002).

Phase I of the gravel replenishment project was completed in 1999, with approximately 11,000 tons of gravel added to the riffle area below the Old La Grange Bridge. A cooperative agreement between the AFRP and CDFG to enhance salmon and steelhead spawning habitat by adding gravel to three riffles below the Old La Grange Bridge (Phase II) was completed in 2000. A joint EA/IS is being prepared and implementation is scheduled to begin in 2001 (pers. communication with Rhonda Reed, CDFG, May, 2002).

A perpetual restoration easement to 137 acres known as Grayson River Ranch on the lower Tuolumne River has been acquired and the Natural Resource Conservation Service holds title. The objective of restoration activities in this reach is to create a functioning riparian floodway along 1.2 miles of river. This will increase the quality and quantity of juvenile chinook salmon rearing and migratory habitat and provide secondary benefits of increased flood protection. Earthmoving work was completed in the summer of 2000 and revegetation occurred in the fall of 2000/winter 2001 (pers. communication with Rhonda Reed, CDFG, May, 2002).

Efforts are underway to restore the Mining Reach of the Merced River as part of the Merced River Salmon Habitat Enhancement Project. Objectives of the project are to eliminate juvenile salmon predator habitat by filling unnatural instream ponds; to increase the quantity and quality of spawning habitat for chinook salmon by adding spawning gravel, reconfiguring spawning beds and the river course thorough the filled pond; to increase the quantity and quality of rearing habitat for chinook salmon by increasing available in-channel diversity; improve river and floodplain dynamics by reconfiguring the channel to better conform with the present flow regime; enhance riparian and seasonally inundated vegetation by expanding and revegetating floodplain areas (AFRP, 2002). Channel and floodplain reconstruction to eliminate predator habitat in the Ratzlaff segment were completed in 1999. Revegetation in this segment began in 2000 and is ongoing. Work in other segments has yet to begin. Gravel additions to Riffle 1A and 1B are ongoing (pers. communication with Rhonda Reed, CDFG, May, 2002).

Clear Creek

In 2000, Saeltzer dam was demolished and removed, removing the passage barrier for anadromous species access into the upper watershed. Spawning gravel was also added at three sites along the Creek, including a site below Whiskeytown Reservoir, a site below the former Saeltzer Dam, and a site in between Whiskeytown Reservoir and Saeltzer Dam. Phase II of a large-scale restoration project is also moving forward on Clear Creek. Restoration actions consist of filling in large ponds created by gravel mining, and restoring historic floodplain hydrology in a two-miles reach of river that was heavily mined for gravel. This effort is a multiple-phase, multiple-year project funded jointly through CVPIA and Calfed (pers. communication with Matt Brown, USFWS, March 2002).

Structural Modifications

Only two structural modifications have been completed on the rivers 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 juvenile abundance is not possible, because comparable juvenile monitoring data were not collected before the project. Extreme high flows in winter 1997 likely had an overriding adverse effect on juvenile outmigrant abundance in 1997.

Battle Creek

Planning activities are ongoing under a Memorandum of Understanding between NMFS, USBR, USFWS, CDFG, and PG&E to open 42 miles of anadromous fish habitat and improve water quality for Coleman National Fish Hatchery. Structural modifications include: 1) decommissioning of five diversion dams; 2) fish ladder installations at three diversion dams and screening of their associated diversions; 3) increasing flow releases from all remaining diversion dams in the anadromous reaches of Battle Creek; and 4) constructing powerhouse tailrace connectors to eliminate redundant screening requirements and mixing of waters from the North and South Forks.

A project to improve the Coleman National Fish Hatchery barrier-weir was selected for funding by Calfed in 1999. Improvements are designed to better contain hatchery fish behind the barrier-weir and prevent their passage upstream, while improving fish passage for natural runs of winter-run chinook salmon, spring-run chinook salmon, late-fall run chinook salmon, and steelhead. The project is currently in the planning and engineering feasibility stage (pers. communication with Matt Brown, USFWS, March 2002).

Fish Screens

Numerous fish screens have been installed at locations along the mainstem Sacramento River and Butte Creek (IEP 2000). In 1999, Calfed partially funded a project to install fish screens on two of the Coleman National Fish Hatchery's largest water intake structures in Battle Creek. Calfed had previously funded a screening project for the hatchery's smallest water intake that diverts approximately 60 cfs. Current juvenile salmonid data serves as pre-screen information (as appropriate) for juvenile salmon production on the watersheds evaluated in this report. As more watersheds are brought into the CAMP juvenile salmon monitoring program, both pre-and post-screen conditions will be assessed. CAMP is currently reviewing existing and planned fish screen facilities to select representative locations for conducting focused evaluations of the effectiveness of fish screens in meeting AFRP goals. A pilot program to evaluate fish screen effectiveness is expected to be initiated in 2000.

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