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CHINOOK SALMON SPAWNER STOCKS IN CALIFORNIA'S CENTRAL VALLEY, 1994

Edited by

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Habitat Conservation Division
Wildlife & Habitat Data Analysis Branch

Inland Fisheries

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ABSTRACT

This report covers the 42nd annual inventory of chinook salmon, Oncorhynchus tshawytscha, spawner populations in the Sacramento-San Joaquin River system. It is a compilation of reports estimating the fall-, winter-, late-fall-, and spring-run salmon spawner populations for some streams which were surveyed.

Estimates were made from counts of fish entering hatcheries and migrating past dams, from surveys of dead and live fish and redds on spawning areas, and from aerial counts.

The estimated 1994 total escapement of chinook salmon in the Central Valley was 193,195 fish. This total consisted of 186,052 fall-, 6,065 spring-, 189 winter-, and 889 late-fall-run spawners. All of the spring-, late-fall-, and winter-run salmon were estimated to be in the Sacramento River system, while 8,547 fish of the fall run were in the San Joaquin River system.

The 1994 total salmon population was 13% larger than in 1993. Despite the higher population, winter- and fall-run salmon numbers in the Sacramento River mainstem decreased from 1993. The mainstem spring run was nearly double the 1993 population, which was one of the lowest recorded. It was not possible to completely estimate the numbers of late-fall-run fish in the mainstem.

San Joaquin tributary fall runs also increased over those for 1993. However, the San Joaquin system still only contributed a small portion (4.4%) of the total Central Valley escapement.

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INTRODUCTION

The Sacramento-San Joaquin River system (Figure 1), which flows through California's Central Valley, is the principle producer of chinook salmon caught in the state's ocean fisheries; its salmon runs also contribute to the ocean fisheries of Oregon and Washington. This report is the 42nd compilation of chinook salmon spawner stock surveys. The spring and fall runs have been monitored since 1953, and late-fall and winter runs since 1971. The four runs are distinguished as follows:

1) Late-fall run. These salmon spawn mainly in the upper Sacramento River and its tributaries near and upstream of Red Bluff. They arrive in this area in early November through February, with spawning occurring from January through early April. Adults of this run are usually larger in physical size than fall- and winter-run salmon spawning in the same area.

2) Winter run. These salmon spawn almost entirely in the Sacramento River and its tributaries upstream of Red Bluff, arriving there in late December through mid-July, and spawning from April to early August.

3) Spring run. Once widespread in Central Valley tributaries, this run has disappeared from many of the streams in which dam construction has blocked access to spawning habitat. Spring-run spawners return to the system from the ocean in March through June, oversummer in holding pools, and spawn from late August through early October.

4) Fall run. These are presently the most numerous and widely distributed salmon in the Central Valley. They return from the ocean in June through November and spawn from early October through early January.

Monitoring of salmon spawner escapement in Central Valley tributaries is an important component of the California Department of Fish and Game's (CDFG) fishery management effort. The primary objectives of this work are to determine size and composition of spawner populations. Any changes in spawning distribution and habitat conditions that may adversely affect salmon are noted to determine if corrective action is necessary.

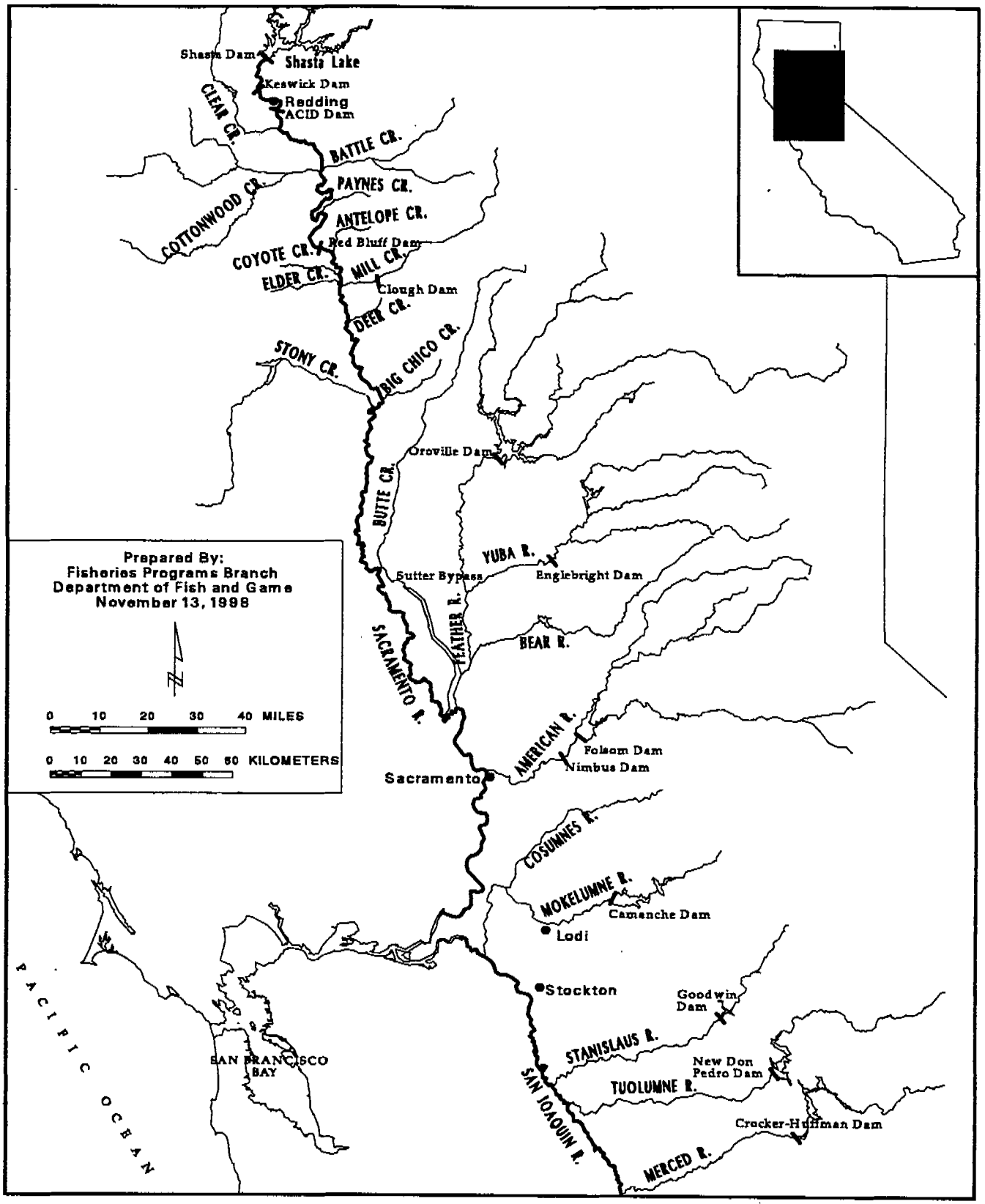

Figure 1. Sacramento-San Joaquin River system of California's Central Valley

GENERAL METHODS

During 1994, spawner stock data were collected in some Central Valley tributaries known to support chinook salmon runs by: monitoring fish entering hatcheries and migrating past dams; conducting stream surveys in spawning areas for live fish, carcasses, and redds; or making aerial counts.

The data collected usually represented only a sampling of the tributaries' spawners. For some tributaries, although surveys were conducted, data were not sufficient to calculate an estimate of the spawner population size; in some such cases, a decision of the number of spawners present was arrived at by "best professional judgement".

In other streams, salmon carcasses were marked throughout a series of survey periods. Upon recovery during subsequent trips, discrete marks applied to the carcasses allowed identification with individual surveys. All counted carcasses were either marked or cut in half to prevent recounting. Estimated spawner numbers were derived from this type of mark-and-recovery data using appropriate biometric calculations (Appendix 1).

Specific details of surveys (e.g. timing, duration, location), or other estimation methods are presented under the following individual tributary sections.

CHINOOK SALMON SPAWNER POPULATIONS FOR THE SACRAMENTO RIVER SYSTEM

Keswick Dam to Red Bluff Diversion Dam

by Frank W. Fisher and Colleen D. Harvey-Arrison
CDFG-Northern California and North Coast Region (NC/NCR)

Spawner population sizes were estimated for three of the four runs of chinook salmon in the Sacramento River mainstem (Figure 2) upstream of Red Bluff Diversion Dam (RBDD). Due to the RBDD gates being open during most of the late-fall-run migration period, it was not possible to completely estimate that run's population. Clear and Battle creeks were the only tributaries in this area for which individual fall-run population estimates were calculated. Spawning distribution in the mainstem was determined from aerial redd counts.

In 1994, 67,298 salmon were estimated for the Sacramento River system between Keswick Dam and Red Bluff, consisting of 65,480 fall-, 889 late-fall-, 189 winter- and 740 spring-run fish (Appendix 2). The mainstem portion of the fall- run spawner population was 19,669 fish. The mainstem totals which are reported include fish for tributaries in which a run might have occurred, but where no estimates were possible; e.g. the late-fall and spring runs in Clear and Cottonwood creeks, and the late-fall, winter, and spring runs in Battle Creek.

Sacramento River Mainstem

Estimates of the total numbers of salmon using the Sacramento River system upstream from RBDD during 1994 were based on daily counts made by the U.S. Fish and Wildlife Service and CDFG at the dam. Counts were obtained through closed-circuit television monitoring of salmon passing through the fishways.

Numbers of fish counted each week were adjusted for those periods when the fishways remained open but no counts were possible, such as when river turbidity was high, during flood conditions when the dam gates were temporarily opened, and when no observations were made at night. Adjustments to lapses in daytime counts were made by interpolation. Adjustments for the non-monitored nighttime hours were made by multiplying the 14-h day counts by a "night-factor", generated from weekly night counts. The adjusted weekly number of fish was apportioned among the four runs based on their relative proportions seen that week in random samples of salmon taken from the dam's east-bank trapping facility. Salmon were assigned to a run based on assessment of when they would spawn as indicated by coloration, scale absorption, secondary sexual characteristics, and relative degree of ripeness.

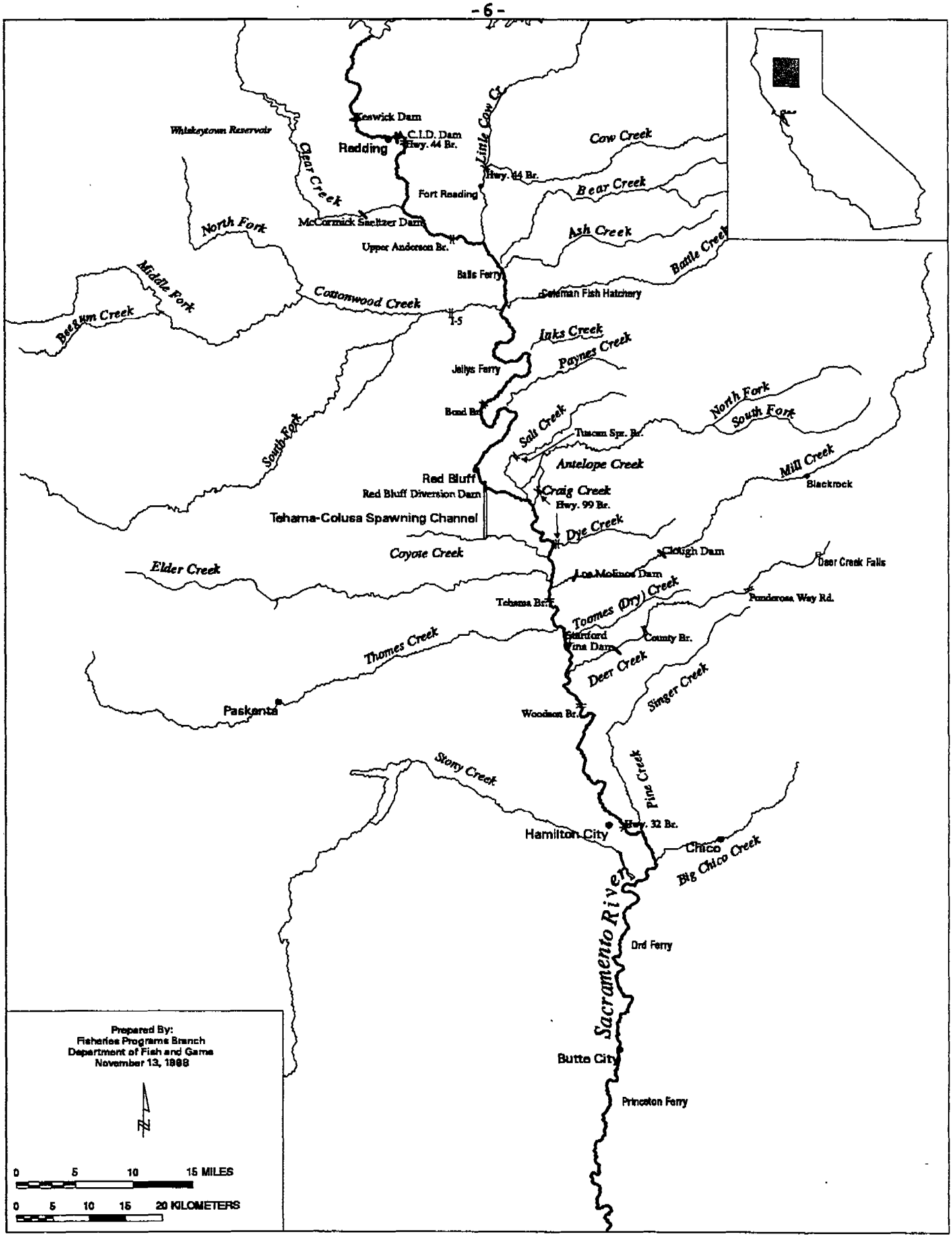

Figure 2. Sacramento River system from Keswick Dam downstream to Princeton Ferry

The numbers of spring- and fall-run salmon passing RBDD in a calendar year account for the entire annual run of these races. However, the late-fall and winter runs in a calendar year usually include the latter part of one annual run during the beginning of the year, and the first part of the next annual run at the end of that year. Approximately half of the late-fall annual run occurs in each portion of the calendar year, while most of the winter annual run usually occurs early in the year, with the smaller part of the following annual winter run at the end of the year. In 1994, it was only possible to obtain the total for 1994 winter-run potential spawners; this included the estimated numbers of fish from the 1993 calendar year that would spawn in 1994, but not that portion from the 1994 calendar year estimated numbers that would spawn in 1995.

The RBDD gates were raised from 17 October 1993 through 1 May 1994, and from 15 September through 31 December 1994, to facilitate upstream migration of winter-run chinook salmon. When the dam gates are open the fishways are essentially inoperable, and counts are not possible. Numbers of salmon passing the dam for these periods were calculated, from the numbers estimated through actual counts when the gates were closed, using migrational distributions based on historical data. The distributions represented an average timing derived from RBDD data for the 1970-1986 late-fall run, the 1982-1986 winter run, and the 1970-1988 spring and fall runs (Table 1).

The estimated potential spawner population upstream of RBDD was reduced by the number of fish taken in the sport fishery between Keswick Dam and Red Bluff; no attempt was made to account for any other prespawning mortality in the upper river. Numbers of sport-caught salmon were calculated using monthly estimated catches from an angler survey conducted by CDFG.

Finally, to obtain only the upper Sacramento River mainstem populations, the numbers of potential spawners of each run were reduced by the populations of the appropriate run in those tributaries where estimates were made, and by the numbers of fish transported from RBDD and Keswick Dam to Coleman National Fish Hatchery (CNFH).

Late-fall run. RBDD counts made of the 1994 late-fall run produced an estimated 137 salmon which passed immediately before the dam gates were raised in the latter part of 1993 (Table 2). It was felt that the remainder of the late-fall spawner population would not be adequately represented by an expansion of this small portion of the run, so no complete estimate was made. The only other available data were 154 late-fall-run fish transferred from Keswick Dam to CNFH.

TABLE 1. Distribution of migration for chinook salmon runs past Red Bluff Diversion Dam, used to estimate numbers of fish passing the dam during periods when actual counts were not possible.

Approximate monthly period	Julian week	Proportion of run (%) 1/			
		Late-fall run	Winter run	Spring run	Fall run
	1	6.50	1.70		
January	2	6.32	1.78		
	3	3.07	0.35		
	4	2.91	1.28		
	5	3.58	2.38		
February	6	4.08	3.12		
	7	4.19	3.08		
	8	4.38	0.97		
	9	3.29	6.35		
March	10	2.14	7.72		
	11	1.74	9.23		
	12	3.39	7.79	0.10	
	13	2.08	4.91	0.25	
	14	1.82	7.64	0.59	
April	15	1.39	8.26	0.96	
	16	0.24	9.19	1.38	
	17		3.47	1.63	
	18		2.02	1.60	
May	19		1.60	1.71	
	20		2.17	2.16	
	21		3.09	2.63	
	22		2.03	2.86	0.01
June	23		1.63	2.61	0.00
	24		1.84	2.93	0.01
	25		0.51	3.50	0.03
	26		0.76	3.10	0.08
	27		1.60	3.67	0.10
July	28		0.31	6.02	0.29
	29		1.04	4.75	0.49
	30		0.44	3.21	0.70
	31		0.01	4.12	0.96
August	32			6.97	1.68
	33			9.07	2.95
	34			6.75	3.53
	35			5.74	3.91
	36			7.22	4.54
September	37			6.68	5.59
	38			5.23	8.58
	39			3.70	9.24
	40			1.19	10.49
October	41	0.26		0.69	10.59
	42	2.06			8.97
	43	2.33			6.99
	44	3.27			6.70
November	45	4.24			4.67
	46	3.42			2.71
	47	3.65			2.23
	48	5.37			1.68
December	49	5.27	0.17		0.90
	50	5.27	0.38		0.66
	51	6.94	0.49		0.51
	52	6.81	0.71		0.19

1/ Distributions are averages based on the following years of data:
- Late-fall-run, 1970 through 1986.
-Winter-run, 1982 through 1986.
-Spring-run, 1970 through 1988.
-Fall-run, 1970 through 1988.

TABLE 2. Adjusted chinook salmon counts and estimated numbers of each run at Red Bluff Diversion Dam from 17 October 1993 through 31 December 1994. a/

Count period		Adjusted salmon count b/	Number of salmon examined c/	Distribution of runs: Late-fall % of fish examined	Late-fall Estimated number	Winter % of fish examined	Winter Estimated number d/	Spring % of fish examined	Spring Estimated number d/	Fall % of fish examined	Fall Estimated number d/
17 Oct '93 - 1 Jan '94 e/		--	--	--	137	--	3	--	--	--	--
1994											
02-Jan -	08-Jan	--	--	--		--	3 g/				
09-Jan -	15-Jan	--	--	--		--	3 g/				
16-Jan -	22-Jan	--	--	--		--	1 g/				
23-Jan -	29-Jan	--	--	--		--	2 g/				
30-Jan -	05-Feb	--	--	--		--	5 g/				
06-Feb -	12-Feb	--	--	--		--	6 g/				
13-Feb -	19-Feb	--	--	--		--	6 g/				
20-Feb -	26-Feb	--	--	--	f/	--	2 g/				
27-Feb -	05-Mar	--	--	--		--	12 g/				
06-Mar -	12-Mar	--	--	--		--	15 g/				
13-Mar -	19-Mar	--	--	--		--	17 g/				
20-Mar -	26-Mar	--	--	--		--	15 g/	--	1 g/		
27-Mar -	02-Apr	--	--	--		--	9 g/	--	2 g/		
03-Apr -	09-Apr	--	--	--		--	14 g/	--	4 g/		
10-Apr -	16-Apr	--	--	--		--	16 g/	--	7 g/		
17-Apr -	23-Apr	--	--	--		--	17 g/	--	10 g/		
24-Apr -	30-Apr	--	--	--		--	7 g/	--	12 g/		
01-May -	07-May	--	--	Total h/:	137	--	8 g/	--	45 g/		
08-May -	14-May	113	26			3.8	4	96.2	109		
15-May -	21-May	132	57			3.5	5	96.5	127		
22-May -	28-May	130	33			3.0	4	97.0	126		
29-May -	04-Jun	161	81			2.5	4	75.3	121	22.2	36
05-Jun -	11-Jun	253	95			0.0	0	47.4	120	52.6	133
12-Jun -	18-Jun	199	131			0.8	2	10.7	21	88.5	176
19-Jun -	25-Jun	324	111			1.8	6	3.6	12	94.6	306
26-Jun -	02-Jul	317	224			0.4	1	2.7	9	96.9	307
03-Jul -	09-Jul	289	161			0.0	0	0.6	2	99.4	287
10-Jul -	16-Jul	194	95			1.0	2	3.2	6	95.8	186
17-Jul -	23-Jul	168	39			Total h/:	189 i/	0.0	0	100.0	168
24-Jul -	30-Jul	261	76					0.0	0	100.0	261
31-Jul -	06-Aug	296	49					2.0	6	98.0	290
07-Aug -	13-Aug	473	149					Total h/:	740	100.0	473
14-Aug -	20-Aug	816	262							100.0	816
21-Aug -	27-Aug	658	117							100.0	658
28-Aug -	03-Sep	1,305	187							100.0	1,305
04-Sep -	10-Sep	2,817	258							100.0	2,817
11-Sep -	17-Sep	10,113	221							100.0	10,113
18-Sep -	24-Sep	--	--	--						--	6,322 g/
25-Sep -	01-Oct	--	--	--						--	6,809 g/
02-Oct -	08-Oct	--	--	--						--	7,730 g/
09-Oct -	15-Oct	--	--	--						--	7,804 g/
16-Oct -	22-Oct	--	--	--						--	6,610 g/
23-Oct -	29-Oct	--	--	--						--	5,151 g/
30-Oct -	05-Nov	--	--	--						--	4,937 g/
06-Nov -	12-Nov	--	--	--	f/					--	3,449 g/
13-Nov -	19-Nov	--	--	--						--	1,997 g/
20-Nov -	26-Nov	--	--	--						--	1,643 g/
27-Nov -	03-Dec	--	--	--						--	1,238 g/
04-Dec -	10-Dec	--	--	--		--				--	663 g/
11-Dec -	17-Dec	--	--	--		--	24 g/			--	486 g/
18-Dec -	24-Dec	--	--	--		--				--	376 g/
25-Dec -	31-Dec	--	--	--		--				--	140 g/
										Total h/:	73,687
Total for 1994 calendar year .		19,019	2,372				210 j/		740		73,687

a/ Red Bluff Diversion Dam gates were raised from 15 October 1993 through 4 May 1994, and from 15 September through 31 December 1994.

b/ Actual weekly counts were expanded to adjust for periods when the fishways were open and no observations were made.

c/ Salmon in the fishway trapping facility which were examined to determine the run composition, based on relative spawning readiness.

d/ Adjusted count x Proportion of examined fish assigned to run.

e/ Estimated numbers represent salmon passing the dam during this period in 1993 that were expected to spawn in 1994 (Kano 1999)

f/ It was not posssible to make estimates for the late-fall run during this period.

g/ Due to the dam gates being raised, estimated numbers were based on historical average proportional run distributions.

h/ Total estimated number of potential spawners for the 1994 run.

i/ Includes 42 fish trapped at Keswick and Red Bluff Diversion dams that were trucked to Coleman National Fish Hatchery.

j/ Including winter-run 1995 potential spawners.

Winter run. An estimated 189 winter-run 1994 potential spawners passed RBDD in 1993 and 1994 (Table 2); due to the RBDD gates being open, only 19% of this estimate was derived from actual counts at the dam. No winter-run salmon were caught in the sport-fishery, and a total of 42 fish was transferred from Keswick Dam and RBDD to CNFH, leaving a spawner population of 147 fish upstream of Red Bluff (Appendix 2). Some winter-run salmon may have used Battle Creek, but no spawner surveys were made in that stream for this run. Those fish are included in the upper mainstem population.

Based on the 42 fish transferred to CNFH, the winter run consisted of 81% adults and 19% grilse. Adults were considered to be those fish which were three years old and older, while grilse were 2-year-olds.

The 1994 winter-run spawner population upstream of RBDD was a decrease of 56% from the 1993 population (Appendix 3), and was the lowest run size ever recorded.

Spring run. An estimated 740 spring-run potential spawners passed RBDD in 1994 (Table 2); 95% of this estimate was derived from actual counts at the dam. No spring-run salmon were caught in the sport-fishery, nor were estimates made of the spring run in any of the tributaries upstream of RBDD. The spawner population in the mainstem upstream of Red Bluff was therefore assumed to be 740 fish (Appendix 2).

Based on a sample of 256 fish at RBDD, the spring run consisted of 59% adults and 41% grilse.

The 1994 spring-run spawner population of 740 fish upstream of RBDD was almost twice the size of the 1993 population, but still only 11% of the average run size for the previous ten years (Appendix 3).

Fall run. An estimated 73,687 fall-run potential spawners passed RBDD in 1994 (Table 2); due to the RBDD gates being open, only 25% of this estimate was derived from actual counts at the dam. The fall-run sport-catch was estimated to be 8,207 salmon, leaving 65,480 fish as a spawner population upstream of Red Bluff (Table 3). A total of 45,811 spawners was estimated for Clear and Battle creeks, leaving 19,669 salmon as the upper mainstem population (Appendix 2). This population included fall-run salmon which used other tributaries to the upper mainstem that were not surveyed.

Based on a sample of 2,114 fish at RBDD, the fall run consisted of 69% adults and 31% grilse.

The fall run in the Sacramento River system upstream of Red Bluff was a decrease of 42% from the 1993 population, and was also 42% of the average 1984-1993 population (Appendix 3).

TABLE 3. Calculation of the 1994 spawner population for each run of chinook salmon upstream of Red Bluff Diversion Dam.

Run	Number of fish passing dam in calendar year: 1993		1994		Number of potential spawners		Estimated sport catch		Estimated 1994 spawner population
Late-fall a/	---		---		---		---		
Winter	3	+	186 b/	=	189 c/	-	0	=	189
Spring			740	=	740 c/	-	0	=	740
Fall			73,687	=	73,687 c/	-	8,207	=	65,480
Totals:	**3**	**+**	**74,613**	**=**	**74,616**	**-**	**8,207**	**=**	**66,409**

a/ The RBDD gates were raised during almost all of the late-fall-run migration period, so it was not possible to estimate the entire run size.
b/ A total of 24 winter-run salmon passed RBDD in the latter part of 1994 (Table 2), and were not included in these counts; these fish were considered 1995 spawners.
c/ Due to the RBDD gates being open, only portions of these numbers were calculated from actual counts. These portions were: winter run, 19%; spring run, 95%; and fall run, 25%.

Mainstem spawning distribution. The 1994 relative redd distribution of the four runs of salmon in the mainstem Sacramento River from Keswick Dam downstream to RBDD was determined from data collected by airplane flights during the late-fall-, winter-, spring-, and fall-run spawning seasons. All of the winter- and the majority (93.5%) of the late-fall-run mainstem spawning occurred upstream from RBDD (Table 4). No redds were counted during a single flight made for the spring run. Fall-run spawning which occurred in this area constituted 76.4% of that observed in the entire mainstem.

Clear Creek

Late-fall run. No surveys were conducted for this run in 1994.

Spring run. Five snorkeling surveys of the 1.6-km (1-mi) creek section downstream of McCormick-Saeltzer Dam were conducted between 5 April and 7 June 1994; no adult salmon were seen. During the same period as the surveys downstream, monitoring of spring-run salmon immigrating past the dam was attempted. Fish

TABLE 4. Chinook salmon relative redd distribution during 1994 in the mainstem Sacramento River from Keswick Dam to Princeton Ferry.

River section	Late-fall run		Winter run		Spring run		Fall run	
	Redds counted a/	Proportional distribution	Redds counted b/	Proportional distribution	Redds counted c/	Proportional distribution	Redds counted d/	Proportional distribution
Keswick Dam to A.C.I.D. Dam e/	6	19.4%	0	0.0%	0	--	645	5.8%
A.C.I.D. Dam to Highway 44	5	16.1%	6	40.0%	0	--	1,047	9.4%
Highway 44 to Upper Anderson Bridge	8	25.8%	3	20.0%	0	--	1,678	15.1%
Upper Anderson Bridge to Balls Ferry	5	16.1%	5	33.3%	0	--	1,084	9.7%
Balls Ferry to Jellys Ferry	2	6.5%	0	0.0%	0	--	2,138	19.2%
Jellys Ferry to Bend Bridge	3	9.7%	1	6.7%	0	--	957	8.6%
Bend Bridge to Red Bluff Dam	0	0.0%	0	0.0%	0	--	950	8.5%
Red Bluff Dam to Tehama Bridge	2	6.5%	0	0.0%	0	--	1,490	13.4%
Tehama Bridge to Woodson Bridge	0	0.0%	0	0.0%	0	--	631	5.7%
Woodson Bridge to Hamilton City (Hwy. 32)	0	0.0%	--	--	0	--	301	2.7%
Hamilton City to Ord Ferry	0	0.0%	--	--	0	--	150	1.3%
Ord Ferry to Princeton Ferry	--	--	--	--	0	--	55	0.5%
Totals:	31		15				11,126	

a/ Count made during an aerial survey on 17 March 1994.

b/ Total count made for 15 aerial surveys from 21 April through 11 August 1994.

c/ Count made during an aerial survey on 9 September 1994.

d/ Total count made for five aerial surveys from 26 September through 9 December 1994.

e/ Anderson-Cottonwood Irrigation District Dam.

passage, through a 1.2-m long by 0.45-m diameter (4-ft L x 1.5-ft D) tunnel located at the upstream end of the fish ladder, was recorded by a Smith-Root Model 602 electronic fish counter. No upstream passages were counted, and it was assumed that there were no spring-run salmon in Clear Creek in 1994.

Fall run. Three surveys of Clear Creek were made during 7-30 November 1994 in a 4.8-km (3-mi) stretch downstream from McCormick-Saeltzer Dam. The first three weeks of this season's fall-run spawning was missed due to the late start. The length of creek covered by the surveys was also shorter than that of previous seasons; in the past an average of 40% of the spawning occurred downstream of the area that was covered this season.

Salmon carcasses were marked by attaching colored tape to the jaw with a hog ring, and replacing them back into running water for recovery during following surveys. Of the 663 carcasses observed, 60 were marked and 16 were subsequently recovered. A Petersen estimate (Appendix 1.A.1) of 2,546 spawners was calculated for Clear Creek in the area surveyed downstream of the dam.

The fall-run spawner population of Clear Creek consisted of 40% male adults (fork length [FL] > 64 cm [25.2 in]), 49% female adults, 11% grilse (FL ≤ 64 cm).

No pre-spawning mortality was observed in Clear Creek this season.

Cow Creek

Late-fall run. No surveys for this run in this tributary were made in 1994.

Fall run. Carcass surveys were not conducted for this run in Cow Creek in 1994. However, three aerial surveys to count redds in the Cow Creek drainage were made between 13 October and 22 November. Twenty-three redds were counted in the mainstem downstream of the north and south fork confluence to the mouth. Salmon were prevented from ascending the north and south forks by numerous beaver dams.

No estimate of the Cow Creek fall-run population was made.

Cottonwood Creek

Late-fall and spring runs. Surveys for these runs were not made in this tributary in 1994.

Fall run. No carcass surveys were made in 1994. However, five aerial surveys to count salmon redds were made of the

Cottonwood Creek drainage from 13 October through 22 November. Salmon were prevented from ascending the system upstream of the south fork confluence by beaver dams. A maximum of 79 redds was observed in the mainstem downstream of the south fork.

A fall-run spawner population estimate was not made.

Battle Creek

Late-fall run. No surveys were made of this run's in-river spawner population. A total of 598 late-fall-run salmon entered CNFH in 1994, consisting of 40% male adults, 37% female adults, and 23% grilse.

Winter and spring runs. No spawner surveys were conducted for these runs in Battle Creek during 1994.

Fall run. Seven carcass surveys were conducted during 5 October through 29 November 1994, covering the 5.6-km (3.5-mi) stretch of river between CNFH and the old hatchery location. Surveys could not be continued into December due to high stream flows. Salmon carcasses were marked by attaching colored tape to the jaw with a hog ring; fresh carcasses were marked on the upper jaw, while decayed carcasses were marked on the lower jaw.

Using fresh carcass mark-and-recovery data with the Schaefer model (Appendix 1.B), the spawner population in Battle Creek downstream of CNFH was estimated to be 24,274 fish (Table 5). Combined with an additional 18,991 fish which entered CNFH, the total Battle Creek fall-run population was 43,265 salmon (Appendix 2).

The composition of the fall run in Battle Creek was 37% male adults (FL > 64 cm [25.2 in]), 55% female adults, and 8% grilse (FL ≤ 64 cm), based on an examination of 11,370 carcasses. In comparison, fall-run fish entering CNFH consisted of 38% male adults, 23% female adults, and 39% grilse.

Pre-spawning mortality of fall-run salmon in Battle Creek averaged 5.3% in 1994.

The 1994 fall-run spawner population for Battle Creek of 43,265 fish was more than twice the size of the 1993 run, and 1½ times larger than the average run size for 1984 through 1993 (Appendix 3).

TABLE 5. Chinook salmon carcass mark-and-recovery data used to estimate the 1994 fall-run spawner population in Battle Creek from Coleman National Fish Hatchery to the old hatchery location. a/

Recovery period (j)	Number of marked carcasses recovered from marking period (i): 1	2	3	4	5	6	Total marked carcasses recovered (Rj)	Total carcasses observed (Cj) b/	Population estimate (N) c/
2	19	--	--	--	--	--	19	693	1,093
3	7	190	--	--	--	--	197	2,408	4,259
4		15	492	--	--	--	507	6,486	10,354
5			26	163	--	--	189	3,198	7,156
6			5	10	76	--	91	927	1,951
7				3	8	26	37	468	1,327
Total recovered (Ri	26	205	523	176	84	26		Total:	26,140
Total carcasses marked (Mi):	41	364	832	412	177	81			
							Adjusted estimate d/:		**24,274**

a/ Surveys were conducted from 5 October to 29 November 1994.

b/ Includes salmon carcasses which were marked and marked carcasses that were recovered.

c/ Schaefer (1951) estimate equation: $N = \Sigma (Rij \times (Mi/Ri) \times (Cj/Rj))$.

d/ Adjusted estimate reflects the modified Schaefer equation (Hoopaugh 1978), where marked carcasses (Mi) from the second marking period subtracted from the total estimate, i.e. 26,140 - 1,866 = 24,274.

Red Bluff Diversion Dam to Princeton Ferry

by Frank W. Fisher and Colleen D. Harvey-Arrison, CDFG-NC/NCR

A total of 8,672 chinook salmon spawners was estimated for 1994 in the Sacramento River system between Red Bluff and Princeton Ferry (Figure 2). This total consisted of 1,208 spring- and 7,464 fall-run salmon (Appendix 2). Mill and Deer creeks were the only tributaries in this area for which individual estimates were made, and their combined numbers of fish constituted all of the spring- and 1,388 fish of the fall-run populations.

Sacramento River Mainstem

Late-fall run. During a single aerial survey made on 17 March 1994, only two redds were seen in the mainstem Sacramento River downstream of Red Bluff (Table 4). An estimate of the late-fall run in this area was not made.

Winter run. During 15 aerial surveys between 21 April and 11 August 1994, no evidence of winter-run spawning was observed in the mainstem Sacramento River downstream of Red Bluff (Table 4). It was assumed that no winter-run salmon spawned in this area.

Spring run. No redds were observed in the mainstem Sacramento River downstream of Red Bluff during an aerial survey on 9 September 1994, and it was assumed that no spring-run salmon spawned in this stretch of the river.

Fall run. Based on five aerial surveys from 26 September through 9 December 1994, 6,076 fall-run salmon were estimated for the mainstem Sacramento River between RBDD and Princeton Ferry (Appendix 2). This run size was 53% smaller than the 1993 population, and 34% of the average run size from 1984 to 1993 (Appendix 3).

Mainstem spawning distribution. Redd counts made during the aerial surveys in 1994 were used to determine the relative spawning distribution of the four runs of salmon in the mainstem Sacramento River between Red Bluff and Princeton Ferry. In proportion to the entire mainstem (including upstream of RBDD) spawning activity, 6.5% of the late-fall-, none of the winter- or spring-, and 23.6% of the fall-run redds were observed this section of the river (Table 4).

Antelope Creek

Spring run. Parts of the Antelope Creek drainage were surveyed on 28 July 1994 by snorkeling. A 6.4-km (4-mi) stretch

from Paynes Place Road on the mainstem upstream and into the South Fork was covered. No salmon were observed, and an estimate of the run size was not made.

Fall run. No surveys were conducted for this run in Antelope Creek in 1994.

Mill Creek

Spring run. During the spring-run spawning period, 14 surveys were made from 11 August through 25 October 1994. Sections of the creek from Hot Springs upstream of the Hwy.36 crossing to 4.8 km (3 mi) downstream of Blackrock were covered. A total of 24 salmon carcasses, 100 live fish, and 70 redds was observed.

Prior to these surveys, spring-run salmon were monitored immigrating past Clough Dam during 1 March through 14 June 1994. Fish passage, through a 1.2-m long by 0.45-m diameter (4-ft L x 1.5-ft D) tunnel located at the upstream end of the fish ladder, was recorded by a Smith-Root Model 602 electronic fish counter. Electronic counts were supplemented by visual observations three days each week. From this monitoring, 723 salmon was estimated as the 1994 spring run in Mill Creek.

Fall run. Monitoring of fall-run salmon immigrating past Clough Dam was conducted starting 11 October 1994. Fish passage, through a 1.2-m long by 0.45-m diameter (4-ft L x 1.5-ft D) tunnel located at the upstream end of the fish ladder, was recorded by a Smith-Root Model 602 electronic fish counter. Electronic counts were supplemented by visual observations twice each week. From this monitoring, it was estimated that 1,081 fall-run salmon were in Mill Creek in 1994.

Deer Creek

Spring run. During 17 spawner surveys from 2 August through 4 October 1994, a total of 15 salmon carcasses, 95 live fish, and 48 redds was observed in the 12.8 km (8 mi) from Upper Deer Creek Falls to A-line bridge.

Prior to these spawner surveys, the known holding habitat for spring-run salmon was snorkeled on 2 August. A total of 485 fish was counted. This was felt to be the spring-run spawner population for 1994.

Fall run. Monitoring of fall-run salmon immigrating past Stanford-Vina Dam was conducted during 17 October through 6 December 1994. Fish passage at the south fish ladder was electronically recorded by a Smith-Root Model 602 counter in a 1.2-m long by 0.45-m diameter (4-ft L x 1.5-ft D) tunnel located

at the upstream end of the ladder. Visual counts were made at the north fish ladder twice a week. From the 85 electronically-recorded passages and the 38 visually-counted fish, 307 salmon were estimated as the 1994 fall-run spawner population.

Big Chico Creek to the American River

A total of 108,678 chinook salmon was estimated in 1994 for the Sacramento River tributaries from Big Chico Creek to the American River (Figure 3). This total consisted of 4,117 spring-run and 104,561 fall-run fish (Appendix 2).

Big Chico Creek

Spring run. Based on snorkeling observations made during a survey of the creek, only two fish composed the 1994 spring run in Big Chico Creek.

Fall run. No surveys were conducted for this run in 1994.

Butte Creek

Spring run. In late June 1994, stretches of Butte Creek from Centerville Diversion Dam to Helltown Bridge, and from Centerville Powerhouse to Covered Bridge were surveyed by snorkeling. Based on counts of salmon seen, the 1994 spring run was felt to be about 474 fish.

Fall run. No surveys were conducted for this run in 1994.

Feather River - by Fred Meyer, CDFG-Sacramento Valley and Central Sierra Region (SV/CSR)

Spring run. A total of 3,641 salmon classified as spring-run fish entered Feather River Hatchery (FRH) in 1994 (B. Barngrover, CDFG-CV/CSR, pers. comm.). These fish consisted of 38.9% male adults (FL > 55.9 cm [22 in]), 37.6% female adults, and 23.5% grilse (FL ≤ 55.9 cm). In the river itself, no attempt was made to estimate numbers of in-river spring-run salmon.

The 3,641 spring-run salmon at FRH in 1994 was a decrease of 22% from the 1993 run, but still 21% higher than that of the average run size observed in the past ten years (Appendix 3).

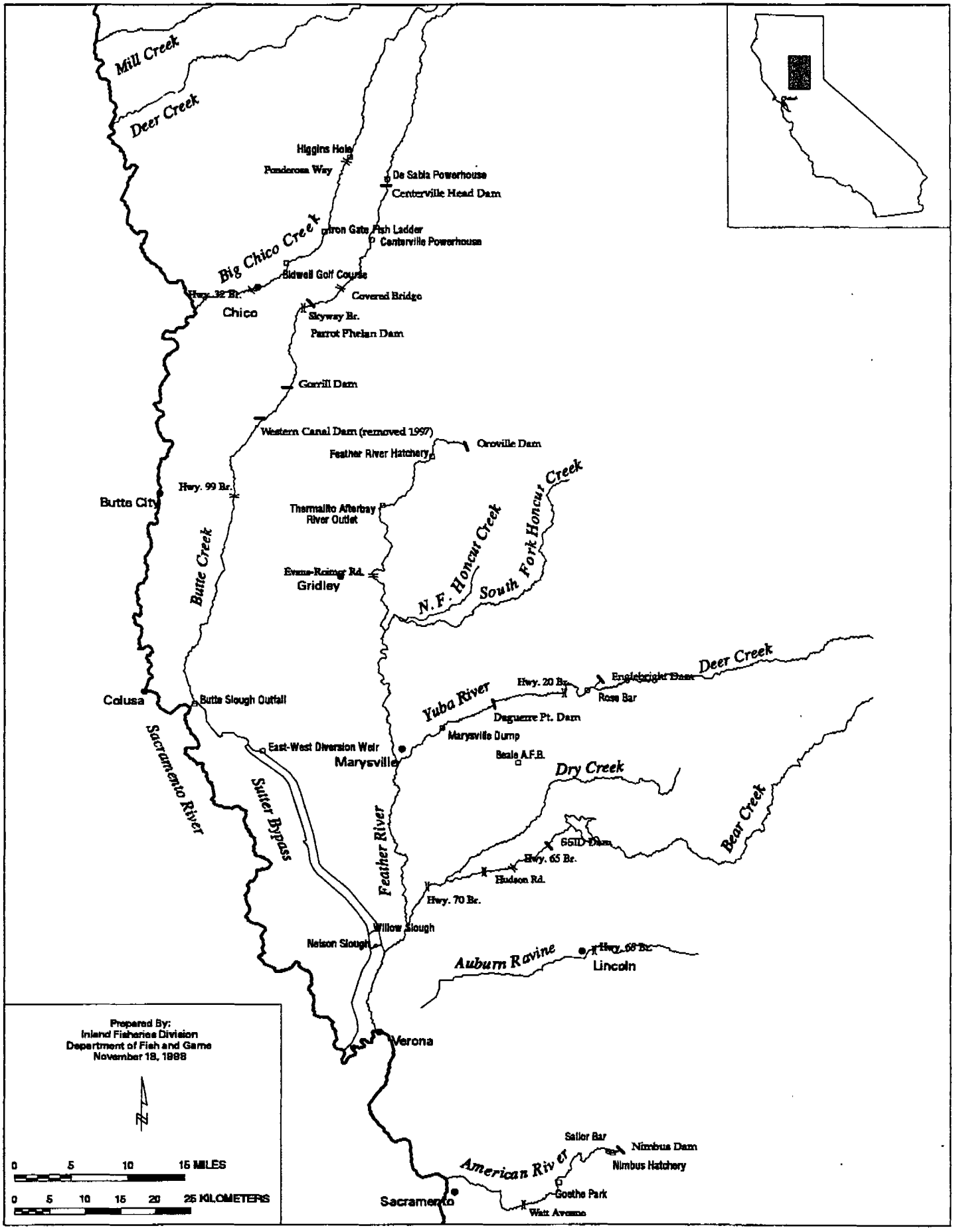

Figure 3. Sacramento River system from Big Chico Creek downstream to American River.

Fall run. Salmon carcass mark-and-recovery surveys were conducted in the Feather River between the hatchery barrier dam and the Gridley boat ramp. This stretch of river was surveyed in two sections, characterized by different flow regimes. The reach between the hatchery barrier dam and Thermalito Afterbay Outlet (Section 1) had constant flows of 17 m^3/s (600 cfs) throughout the survey period of 6 October through 1 December 1994. Flow downstream of Thermalito Afterbay to the Gridley boat ramp (Section 2) was about 34 m^3/s (1,200 cfs); surveys in this section were conducted from 4 November through 2 December. Visibility through the water was about 2.4 m (8 ft) in Section 1, and 1.8 m to 2.4 m (6-8 ft) in Section 2.

Only fresh adult salmon carcasses were marked, with a colored ribbon attached to the lower jaw by a hog ring, and released into flowing water for later recovery; for each marking period a different ribbon color was used. Fresh carcasses were distinguished by having at least one clear eye, while the adult distinction was a fish having a FL > 67 cm (26.3 in). The length used to separate adults from grilse was determined through length frequency analysis of salmon measured at FRH at the beginning of the season. Fresh grilse (FL ≤ 67 cm) carcasses were counted to determine the grilse proportion in the population and then chopped in half, as were all other carcasses including those that were recovered with marks.

Schaefer (Appendix 1.B) estimates, calculated from the mark-and-recovery data, were 24,499 adult salmon for Section 1, and 5,075 adults for Section 2 (Table 6). Each adult estimate was expanded to include the grilse proportion seen in the respective section (21.2% in Sect. 1 and 30.4% in Sect. 2), resulting in a combined total in-river estimate of 38,382 fish. A total of 15,202 fall-run salmon entered FRH (B. Barngrover CDFG-SV/CSR, pers. comm.), bringing the 1994 fall run in the Feather River to 53,584 fish (Appendix 2).

The composition of fall-run salmon in the river, based on examination of 4,115 fresh carcasses, was 38.4% male adults (FL > 67 cm [26.3 in]), 42.4% female adults, 18.9% male grilse (FL ≤ 67 cm), and 3.9% female grilse. In comparison, salmon entering FRH consisted of 36.6% male adults (FL ≥ 55.9 cm [22 in]), 38% female adults, and 33.4% grilse (FL < 55.9 cm).

The 1994 Feather River population of 53,584 salmon was 19% larger than the 1993 run, and about the same as the average population from 1984 to 1993 (Appendix 3); that period's average excludes the 1990 run size, when no estimate was made of the in-river population.

TABLE 6. Chinook salmon carcass mark-and-recovery data used to estimate the 1994 fall-run adult spawner population in the Feather River. a/

SECTION 1. Hatchery barrier dam to Thermalito Afterbay outlet

Recovery period (j)	Number of marked carcasses recovered from marking period (i): 1	2	3	4	5	6	7	8	Total marked carcasses recovered (Rj)	Total carcasses observed (Cj) b/	Population estimate (N) c/
2	3	--	--	--	--	--	--	--	3	126	714
3		17	--	--	--	--	--	--	17	535	1,691
4		8	84	--	--	--	--	--	92	1,500	4,227
5			11	224	--	--	--	--	235	2,528	4,740
6			3	60	255	--	--	--	318	3,540	6,643
7				3	49	235	--	--	287	2,296	3,909
8				1	9	52	144	--	206	1,482	2,615
9				1	3	20	25	31	80	1,106	2,331
Total recovered (Ri):	3	25	98	289	316	307	169	31		Total:	26,870
Total carcasses marked (Mi):	17	79	273	529	593	511	303	83			

Adjusted estimate d/ : 24,499

SECTION 2. Thermalito Afterbay outlet to Gridley boat ramp

Recovery period (j)	Number of marked carcasses recovered from marking period (i): 1	2	3	4	5	6	7	8	Total marked carcasses recovered (Rj)	Total carcasses observed (Cj) b/	Population estimate (N) c/
2	--	--	--	--	--	--	--	--	--	--	--
3	--	--	--	--	--	--	--	--	--	--	--
4	--	--	--	--	--	--	--	--	--	--	--
5	--	--	--	--	--	--	--	--	--	--	--
6	--	--	--	--	47	--	--	--	47	668	1,055
7	--	--	--	--	2	74	--	--	76	789	1,385
8	--	--	--	--	7	20	109	--	136	982	1,656
9	--	--	--	--	1	6	13	44	64	591	1,487
Total recovered (Ri):	--	--	--	--	57	100	122	44		Total:	5,583
Total carcasses marked (Mi):	--	--	--	--	90	176	205	127			

Adjusted estimate e/ : 5,075

a/ Surveys were conducted in Section 1 from 6 October to 1 December 1994, and in Section 2 from 4 November to 2 December.

b/ Includes salmon carcasses which were marked and marked carcasses that were recovered.

c/ Schaefer (1951) estimate equation: $N = \sum(Rij \times (Mi/Ri) \times (Cj/Rj))$.

d/ Adjusted estimate reflects the modified Schaefer equation (Hoopaugh 1978), where marked carcasses (Mi) from the second marking period on were subtracted from the total estimate, i.e. 26,870 - 2,371 = 24,499.

e/ Adjusted estimate, where marked carcasses (Mi) from the second marking period on were subtracted, i.e. 5,583 - 508 = 5,075.

Yuba River - by John Nelson and Katherine Hill, CDFG-SV/CSR

Spring Run. No surveys were conducted for this run in 1994.

Fall run. The 1994 fall-run salmon spawner surveys were conducted jointly by CDFG, and staff of Jones & Stokes Associates, Inc. and the Yuba County Water Agency.

Salmon carcass mark-and-recovery surveys were made in the Yuba River from the Rose Bar bridge downstream to the E Street bridge near Marysville. The surveyed reach was covered in three sections: Rose Bar to Hwy.20 bridge (Section 1), Hwy.20 to Daguerre Point Dam (Section 2), and Daguerre Point Dam to Marysville (Section 3). This was the first season in 20 years that a regular mark-and-recovery survey was made in Section 1; past estimates of this section's population was based on an assumed 15.5% proportion of the run. Weekly surveys were conducted in Sections 1 and 2 during 19 October through 14 December, and in Section 3 from 27 October through 15 December.

Mean daily releases from Englebright Dam ranged from 19.1 to 67 m^3/s (676 - 2,365 cfs), averaging 20.9 m^3/s (740 cfs). Mean daily flow at Marysville ranged from 8.5 to 115 m^3/s (300 - 4,054 cfs), averaging 16.9 m^3/s (596 cfs). Average daily temperature ranged from 17.2°C (63°F) in October to 8.3°C (47°F) in December.

This season, both adult and grilse fresh salmon carcasses were marked; carcasses were considered fresh if they were clear-eyed, while the adult designation was a FL $\geq$ 68 cm (26.8 in). Marks consisted of pieces of surveyor's tape tied to hog rings and attached to the fish's jaws; different colors of tape were used to identify carcasses with distinct marking periods. Marked carcasses were returned into flowing water for subsequent recovery. Decayed carcasses and recovered marked carcasses were counted and then chopped in half. The sex of fresh and decayed adult carcasses was recorded in all sections, while the sex of fresh grilse carcasses was determined only in Section 1.

Using carcass mark-and-recovery data with the Schaefer model (Appendix 1.B), estimates of 1,726 adults and 2,212 grilse were calculated for Section 1 (Table 7), 3,783 adults and 1,204 grilse in Section 2 (Table 8), and 1,539 adults and 426 grilse in Section 3 (Table 9). Combining these estimates gave 10,890 total salmon (7,048 adults and 3,842 grilse) as the 1994 Yuba River run.

The numbers of adult males and females in the run were determined from each section's estimated number of adults and observed sex ratio. Grilse were apportioned using only the Section 1 male-female grilse ratio with each of the three sections' estimated grilse numbers. Overall, the 1994 run was composed of 32.4% male

TABLE 7. Chinook salmon carcass mark-and-recovery data used to estimate the 1994 fall-run spawner population in the Yuba River from Rose Bar to Highway 20 (Section 1). a/

ADULT ESTIMATE

Recovery period (j)	Number of marked carcasses recovered from marking period (i): 1	2	3	4	5	6	7	8	Total marked carcasses recovered (Rj)	Total carcasses observed (Cj) b/	Population estimate (N) c/
2	8	--	--	--	--	--	--	--	8	148	284
3	2	29	--	--	--	--	--	--	31	195	298
4	2	2	10	--	--	--	--	--	14	159	234
5		1	9	8	--	--	--	--	18	212	435
6			1		15	--	--	--	16	129	266
7			1		3	11	--	--	15	97	176
8					1	1	1	--	3	31	157
9						1			1	18	50
Total recovered (Ri):	12	32	21	8	19	13	1	0		Total:	1,900
Total carcasses marked (Mi):	23	48	29	23	40	23	10	1			

Adjusted estimate d/: 1,726

GRILSE ESTIMATE

Recovery period (j)	Number of marked carcasses recovered from marking period (i): 1	2	3	4	5	6	7	Total marked carcasses recovered (Rj)	Total carcasses observed (Cj) b/	Population estimate (N) c/
2	1	--	--	--	--	--	--	1	32	224
3		6	--	--	--	--	--	6	67	145
4			3	--	--	--	--	3	84	294
5			1	7	--	--	--	8	144	473
6				1	7	--	--	8	101	372
7					0	2	--	2	74	666
8					1		0	1	16	60
9							1	1	11	88
Total recovered (Ri):	1	6	4	8	8	2	1		Total:	2,322
Total carcasses marked (Mi):	7	13	14	26	30	18	7			

Adjusted estimate e/: 2,212

a/ Surveys were conducted from 19 October to 14 December 1994.

b/ Includes salmon carcasses which were marked and marked carcasses that were recovered.

c/ Schaefer (1951) estimate equation: $N = \sum (Rij \times (Mi/Ri) \times (Cj/Rj))$.

d/ Adjusted estimate reflects the modified Schaefer equation (Hoopaugh 1978), where marked carcasses (Mi) from the second marking period on were subtracted frm the total estimate, i.e. 1,900 - 174 = 1,726.

** Adjusted estimate where marked carcasses (Mi) from the second marking period on were subtracted from the total estimate, 2,322 - 110 = 2,212.

TABLE 8. Chinook salmon carcass mark-and-recovery data used to estimate the 1994 fall-run spawner population in the Yuba River from Highway 20 to Daguerre Point Dam (Section 2). a/

ADULT ESTIMATE

Recovery period (j)	Number of marked carcasses recovered from marking period (i): 1	2	3	4	5	6	7	8	Total marked carcasses recovered (Rj)	Total carcasses observed (Cj) b/	Population estimate (N) c/
2	8	--	--	--	--	--	--	--	8	130	364
3	2	2	--	--	--	--	--	--	4	194	1,193
4		3	15	--	--	--	--	--	18	213	870
5		1	12	33	--	--	--	--	46	304	717
6			2	10	11	--	--	--	23	178	441
7			0	11	9	17	--	--	37	199	554
8			1				0	--	1	5	20
9							0	0	0	5	5
Total recovered (Ri):	10	6	30	54	20	17	0	0		Total:	4,164
Total carcasses marked (Mi):	28	57	90	103	58	56	16	1			
									Adjusted estimate d/ :		**3,783**

GRILSE ESTIMATE

Recovery period (j)	Number of marked carcasses recovered from marking period (i): 1	2	3	4	5	6	7	Total marked carcasses recovered (Rj)	Total carcasses observed (Cj) b/	Population estimate (N) c/
2	0	--	--	--	--	--	--	0	20	20
3	0	0	--	--	--	--	--	0	36	36
4	0	0	2	--	--	--	--	2	100	263
5	0	0	4	7	--	--	--	11	121	456
6	0	0	2	1	0	--	--	3	28	90
7				4	3	7	--	14	147	459
8							0	0	2	2
9							0	0	2	2
Total recovered (Ri):	0	0	8	12	3	7	0		Total:	1,328
Total carcasses marked (Mi):	2	11	21	53	18	8	13			
								Adjusted estimate e/ :		**1,204**

a/ Surveys were conducted from 19 October to 14 December 1994.

b/ Includes salmon carcasses which were marked and marked carcasses that were recovered.

c/ Schaefer (1951) estimate equation: $N = \sum (Rij \times (Mi/Ri) \times (Cj/Rj))$.

d/ Adjusted estimate reflects the modified Schaefer equation (Hoopaugh 1978), where marked carcasses (Mi) from the second marking period on were subtracted from estimate, i.e. 4,164 - 381 = 3,783.

e/ Adjusted estimate where marked carcasses (Mi) from the second marking period on were subtracted from the total estimate, i.e. 1,328 - 124 = 1,204.

TABLE 9. Chinook salmon carcass mark-and-recovery data used to estimate the 1994 fall-run spawner population in the Yuba River from Daguerre Point Dam to Marysville (Section 3). a/

ADULT ESTIMATE

Recovery period (j)	Number of marked carcasses recovered from marking period (i): 1	2	3	4	5	6	Total marked carcasses recovered (Rj)	Total carcasses observed (Cj) b/	Population estimate (N) c/
2	1	--	--	--	--	--	1	29	261
3		0	--	--	--	--	0	17	17
4		1	2	--	--	--	3	120	403
5		2	3	16	--	--	21	163	436
6				2	12	--	14	123	578
Total recovered (Ri):	1	3	5	18	12	0		Total:	1,695
Total carcasses marked (Mi):	9	17	11	43	61	24			
							Adjusted estimate d/ :		**1,539**

GRILSE ESTIMATE

Recovery period (j)	Number of marked carcasses recovered from marking period (i): 1	2	3	4	5	6	Total marked carcasses recovered (Rj)	Total carcasses observed (Cj) b/	Population estimate (N) c/
2	0	--	--	--	--	--	0	12	12
3		0	--	--	--	--	0	16	16
4		0	0	--	--	--	0	29	29
5		1		3	--	--	4	60	330
6					4	--	4	39	78
7						0	0	1	1
Total recovered (Ri):	0	1	0	3	4	0		Total:	466
Total carcasses marked (Mi):	2	11	5	11	8	5			
							Adjusted estimate e/ :		**426**

a/ Surveys were conducted from 27 October to 15 December 1994.

b/ Includes salmon carcasses which were marked and marked carcasses that were recovered.

c/ Schaefer (1951) estimate equation: $N = \sum (Rij \times (Mi/Ri) \times (Cj/Rj))$.

d/ Adjusted estimate reflects the modified Schaefer equation (Hoopaugh 1978), where marked carcasses (Mi) from the second marking period on subtracted from the total estimate, i.e. 1,695 - 156 = 1,539.

e/ Adjusted estimate where marked carcasses (Mi) from the second marking period on were subtracted from the total estimate, i.e. 466 - 40 = 426.

adults (FL ≥ 68 cm), 32.3% female adults, 28.2% male grilse (FL < 68 cm), and 7.1% female grilse.

The 1994 Yuba River run of 10,890 salmon was 1½ times larger than the 1993 population, and 94% of the average run size from 1984 to 1993 (Appendix 3).

American River

Fall run. Weekly salmon carcass mark-and-recovery surveys in the American River were conducted between 16 October 1994 and 14 January 1995, covering the 22.5-km (14-mi) reach from Watt Avenue upstream to Sailor Bar (Snider and Bandner 1996). Average river flow during the first three survey weeks were about 22 m^3/s (800 cfs), then increased to 42.5 m^3/s (1,500 cfs) for the remainder of the surveys. Water clarity, measured by secchi disk, averaged from 3.2 to 1.2 m (10.5 - 4.0 ft). Average water temperature was 17.8°C (64°F) at the start of the surveys, decreasing to 9.4°C (49°F) towards the end.

This season fresh and decayed salmon carcasses were distinctly marked by attaching a tag to their jaws; fresh carcasses were tagged on the upper jaw and decayed carcasses on the lower jaw. A carcass was considered fresh if it had at least one clear eye or pink gills. Marked carcasses were replaced into running water immediately upstream of where originally found, or left in place in backwater areas. Any carcass not tagged, as well as those recovered with tags were counted and cut in half. Length, sex, and degree of egg-retention were recorded for most of the fresh carcasses.

A total of 1,969 fresh carcasses and 11,885 non-fresh carcasses was observed. The salmon spawner population of the Watt Avenue to Sailor Bar section of the river, estimated from mark-and-recovery data using the Schaefer model (Appendix 1.B), was 31,520 fish (Table 10). An additional 8,567 salmon entered Nimbus Hatchery (B. Barngrover, CDFG-SV/CSR, pers. comm.), bringing the total American River 1994 fall-run population to 40,087 fish (Appendix 2).

Based on examination of 1,049 fresh carcasses, the run consisted of 45.5% male adults (FL > 70 cm [27.6 in]), 45.2% female adults (FL > 65 cm [25.6 in]), 7.8% male grilse (FL ≤ 70 cm), and 1.5% female grilse (FL ≤ 65 cm). The general size criteria distinguishing adults from grilse was determined from length frequency distributions for both sexes separately. Salmon entering Nimbus Hatchery consisted of 39.8% male adults (FL ≥ 60 cm), 49.8% female adults, and 10.4% grilse (FL < 60 cm).

TABLE 10. Chinook salmon carcass mark-and-recovery data used to estimate the 1994 fall-run spawner population in the American River from Watt Avenue to Sailor Bar. a/

Recovery period (j)	Number of marked carcasses recovered from marking period (i): 1	2	3	4	5	6	7	8	9	Total marked carcasses recovered (Rj)	Total carcasses observed (Cj) b/	Population estimate (N) c/
2	0	--	--	--	--	--	--	--	--	0	140	140
3	1	15	--	--	--	--	--	--	--	16	624	2,428
4		1	82	--	--	--	--	--	--	83	2,824	6,037
5			7	293	--	--	--	--	--	300	3,427	6,739
6			3	67	190	--	--	--	--	260	4,347	9,096
7				9	24	91	--	--	--	124	1,835	4,670
8				4	11	8	33	--	--	56	937	2,590
9						0	1	4	--	5	211	1,109
10						1	2	1	2	6	148	584
Total recovered (Ri):	1	16	92	373	225	100	36	5	2		Total:	33,393
Total carcasses marked (Mi):	21	44	196	732	481	271	111	29	9			
										Adjusted estimate d/:		**31,520**

a/ Surveys were conducted from 16 October to 14 January 1994; data used to calculate estimates is from 30 Oct. - 14 Jan.

b/ Includes salmon carcasses which were marked and marked carcasses that were recovered.

c/ Schaefer (1951) estimate equation: $N = \Sigma (Rij \times (Mi/Ri) \times (Cj/Rj))$.

d/ Adjusted estimate reflects the modified Schaefer equation (Hoopaugh 1978), where marked carcasses (Mi) from the second marking period on were subtracted from the total estimate, i.e. 33,393 - 1,873 = 31,520.

The 1994 run of 40,087 salmon in the American River was about the same size as the previous year's population, but 13% higher than the average run size from 1984 through 1993 (Appendix 3).

CHINOOK SALMON SPAWNER POPULATIONS FOR THE SAN JOAQUIN RIVER SYSTEM

The Mokelumne, Stanislaus, Tuolumne, and Merced rivers of the San Joaquin River system (Figure 4) were surveyed for chinook salmon spawners. A total of 8,547 salmon, consisting entirely of fall-run fish, was estimated for 1994 (Appendix 2).

Cosumnes River

Fall run. This tributary was not surveyed in 1994.

Mokelumne River

Fall run. A cooperative program (between CDFG, Woodbridge Irrigation District, and East Bay Municipal Utility District [EBMUD]) to benefit fall-run salmon spawning in the Mokelumne River was continued during 1994. Increased flows from the draining of Lodi Lake and releases from Camanche Dam were intended to attract spawners into the river. Water temperatures in the spawning areas ranged from 14°C (57.2°F) in early November to 9.3°C (48.7°F) in late December.

EBMUD also contracted with Natural Resources Consulting Services to monitor salmon at Woodbridge Dam from 7 October through 31 December 1994 (Hartwell 1995). A total of 3,421 salmon was counted migrating past the dam by using video equipment and a fish trap. Of these salmon, 1,922 fish entered the Mokelumne River Fish Installation (B. Barngrover, CDFG-SV/CSR, pers. comm.), so the 1994 fall-run in-river spawner population was assumed to be 1,499 fish (Appendix 2).

The run at Woodbridge Dam consisted of 46.5% male adults, 37.8% female adults, 13.8% male grilse, and 1.9% female grilse. The composition of the salmon entering the hatchery was 30.5% male adults (FL > 61 cm [24 in]), 30.3% female adults, and 39.2% grilse (FL < 61 cm).

The 1994 spawner population of 3,421 fish in the Mokelumne River was an increase of 8% from the previous year's run, and 9% larger than the average population size estimated from 1984 through 1993 (Appendix 3).

Calaveras River

This tributary was not surveyed in 1994.

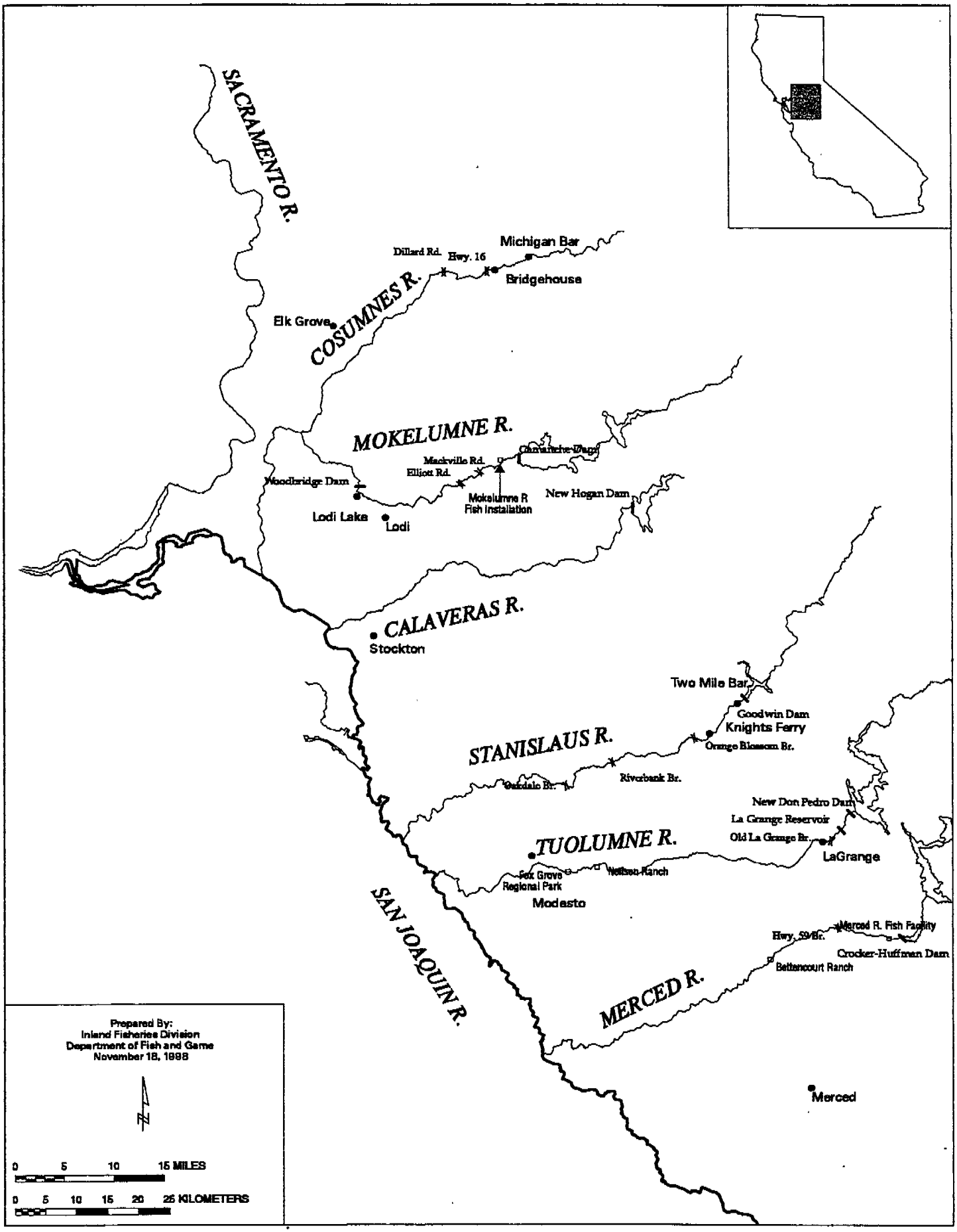

Figure 4. San Joaquin River system from the Merced River to the Cosumnes River.

Stanislaus River

Fall run. Spawner surveys were conducted during 8 November through 28 December 1994 in the 30.9-km (19.2 mi) stretch of the river from Knights Ferry to Riverbank. This season, all salmon carcasses, regardless of condition or age-class, were marked using serially-numbered tags attached to a jaw with a hog-ring. Marked carcasses were released into running water for subsequent recovery. Carcasses not marked and skeletons, as well as those marked carcasses which were recovered, were counted and chopped in half to prevent recounting.

The carcass marking protocol and use of numbered tags was intended to allow post-season distinction of age-class and condition, so the data could be better compiled for estimating the population through several biometric models. Analysis of the data indicated that the Petersen estimate (Appendix 1.A.1) was the most appropriate technique. From a total of 269 carcasses marked, of which 95 were recovered, the salmon population of the surveyed section was estimated at 1,031 fish. The population was not estimated for the Goodwin Dam and Two-Mile Bar areas.

The run consisted of 38.3% male adults, 45.1% female adults, 11.5% male grilse, and 5.1% female grilse. The length used to distinguish in-river adult from grilse salmon was determined from analysis of measurements taken this season during the San Joaquin River tributary surveys. Adipose-clipped (hatchery-reared) fish with a FL $\geq$ 59 cm (23.2 in) were considered adults. For non-adipose-clipped fish, males with a FL $\geq$ 70 cm (27.6 in) and females with a FL $\geq$ 65 cm (25.6 in) were considered adults.

The 1994 Stanislaus River fall-run spawner population of 1,031 salmon was over 1½ times larger the previous year's run, but still only 20% of the average run size for 1984-1993 (Appendix 3).

Tuolumne River

Fall run. The 1994 fall-run chinook salmon spawner surveys in the Tuolumne River were conducted from 3 November 1994 through 5 January 1995. Surveys covered the river stretch from Old LaGrange Bridge downstream to Fox Grove Regional Park, a distance of 38.5 km (24 mi). Visibility through the water was never less than 3.3 m (11 ft). Water temperatures ranged from 12.0°C (53.6°F) in November to 10°C (50°F) in December.

This season all salmon carcasses, regardless of condition or age-class, were marked using serially-numbered tags attached to a jaw with a hog-ring. Marked carcasses were released into running water for subsequent recovery. Carcasses not marked and skeletons, as well as those marked carcasses which were

recovered, were counted and chopped in half to prevent recounting.

The carcass marking protocol and use of numbered tags was intended to allow post-season distinction of age-class and condition, so the data could be better compiled for estimating the population through several biometric models. Analysis of the data indicated that the Petersen estimate (Appendix 1.A.1) was the most appropriate technique.

The population in the river section between Old LaGrange Bridge and Fox Grove Regional Park was 506 salmon, estimated from a total of 184 carcasses marked and 105 subsequently recovered. The population up- and down-stream of the mark-and-recovery survey area was not estimated.

The run consisted of 27.5% male adults, 45.1% female adults, 22.5% male grilse, and 10.6% female grilse. The length used to distinguish in-river adult from grilse salmon was determined from analysis of measurements taken this season during the San Joaquin River tributary surveys. Adipose-clipped (hatchery-reared) fish with a FL $\geq$ 59 cm (23.2 in) were considered adults. For non-adipose-clipped fish, males with a FL $\geq$ 70 cm (27.6 in) and females with a FL $\geq$ 65 cm (25.6 in) were considered adults.

The 1994 fall run of 506 salmon was 7% larger than the previous year's population, but still only 6% of the average run size for the past ten years (Appendix 3).

Merced River

Fall run. Weekly carcass mark-and-recovery surveys were conducted in the 17.4-km (10.8-mi) stretch of the Merced River from Crocker-Huffman Dam downstream to Hwy.59. Surveys were conducted from 8 November 1994 through 5 January 1995.

This season all salmon carcasses, regardless of condition or age-class, were marked using serially-numbered tags attached to a jaw with a hog-ring. Marked carcasses were released into running water for subsequent recovery. Carcasses not marked and skeletons, as well as those marked carcasses which were recovered, were counted and chopped in half to prevent recounting.

The carcass marking protocol and use of numbered tags was intended to allow post-season distinction of age-class and condition, so the data could be better compiled for estimating the population through several biometric models. Analysis of the data indicated that the Jolly-Seber estimate (Appendix 1.C) was the most appropriate technique.

An estimate of 1,913 adult salmon was calculated for the river stretch from Crocker-Huffman Dam to Hwy.59 (Table 11). The adult estimate was expanded to include a grilse proportion of 27.7%, resulting in a total in-river estimate of 2,646 fish. Merced River Fish Facility took in 943 salmon (M. Cozart, CDFG-San Joaquin Valley & Southern Sierra Region, pers. comm.), for a total 1994 fall-run spawner population of 3,589 fish.

The in-river run consisted of 32.9% male adults, 39.4% female adults, 22.7% male grilse, and 5.0% female grilse. Salmon which entered the Merced River Fish Facility consisted of 26.6% male adults (FL ≥ 61 cm [24 in]), 26.1% female adults, 41.6% male grilse (FL < 61 cm), and 5.7% female grilse. The length used to distinguish in-river adult from grilse salmon was determined from analysis of measurements taken this season during the San Joaquin River tributary surveys. Adipose-clipped (hatchery-reared) fish with a FL ≥ 59 cm (23.2 in) were considered adults. For non-adipose-clipped fish, males with a FL ≥ 70 cm (27.6 in) and females with a FL ≥ 65 cm (25.6 in) were considered adults.

The 1994 Merced River fall run of 3,589 salmon was more than twice the previous year's run size, and 55% of the average population size from 1984 through 1993 (Appendix 3).

TABLE 11. Chinook salmon carcass mark-and-recovery data used in the calculation of a Jolly-Seber estimate of the 1994 fall-run spawner population in the Merced River. a/

Recovery Period	Total carcasses observed (Ci) b/	Carcasses recovered from marking period: 1	2	3	4	5	6	7	8	Marked carcasses recovered (Mi)	(Ki)	Calculated estimates c/ (N1)	(Di)
1	49	--	--	--	--	--	--	--	--	--	--	219	563
2	148	6	--	--	--	--	--	--	--	6	8	--	177
3	235	4	52	--	--	--	--	--	--	56	32	--	542
4	260	3	14	40	--	--	--	--	--	57	65	--	-95
5	199		8	31	57	--	--	--	--	96	64	--	330
6	207		4	15	18	26	--	--	--	63	37	--	136
7	143		2	4	13	7	21	--	--	47	18	--	51
8	68				6	3	5	8	--	22	5	--	-10
9	20	1			1		2	1	14	19	--	--	0
Total recovered (Ri):		14	80	90	95	36	28	9	14				
Total marked (Ti):		46	140	169	176	86	93	61	20				
										Population estimate d/:			**1,913**

a/ Surveys were conducted from 8 November 1994 to 5 January 1995.

b/ Includes salmon carcasses which were marked and marked carcasses that were recovered.

c/ Estimates represent the Jolly-Seber values N(1) for period 1, and D(i) for subsequent periods (Appendix 1.C).

d/ Estimated population = N1 + D1 + D2 + ... + Dj.

SUMMARY

The total estimated 1994 Central Valley chinook salmon spawner population was 193,195 fish (Table 12). This was 13% higher than the 1993 total of 171,315 salmon (Kano 1999).

Despite the higher 1994 total population, Sacramento River mainstem winter- and fall-run salmon decreased in numbers. It was also not possible to completely estimate the numbers of late-fall-run salmon upstream of Red Bluff. The mainstem spring run nearly doubled that of 1993, which was one of the lowest populations recorded.

The total of all runs in Sacramento River tributaries was 35% higher than in 1993, with the largest increase in population seen in the Yuba River.

The San Joaquin River tributary fall runs also increased over those of 1993. However, this system still only contributed a small portion (4.4%) of the total Central Valley escapement. The largest increase for this system was in the Merced River fall-run population, which more than doubled the previous year's run.

TABLE 12. Summary of the 1994 Sacramento-San Joaquin river system chinook salmon spawner populations.

Spawning area	Late-fall run	Winter run	Spring run	Fall run	Total
Sacramento mainstem	291 a/	189	740	25,745	26,965
Sacramento tributaries	598 b/	--	5,325	151,760	157,683
San Joaquin tributaries	--	--	--	8,547	8,547
Totals:	**889**	**189**	**6,065**	**186,052**	**193,195**

a/ Represents only a partial estimate of the run size.
b/ Consists only of fish which entered Coleman Hatchery (Battle Creek).

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APPENDIX 1. Calculation methods used with carcass mark-and-recovery data to estimate chinook salmon spawner populations.

A. The Petersen equation:

1.

$$N=\frac{M\times C}{R}$$

or,

2. Chapman's version in Ricker (1975);

$$N=\frac{(M+1)\times(C+1)}{(R+1)}$$

where N = estimated spawner population,

M = number of carcasses marked,

C = number of carcasses observed, including those marked and those recovered with marks, and

R = number of marked carcasses recovered.

B. A modification of the Schaefer (1951) equation, which was initially used in the 1976 Central Valley spawner stock report (Hoopaugh 1978);

$$N=\sum\left(R_{ij}\times\frac{M_i}{R_i}\times\frac{C_j}{R_j}\right)-\sum_2^i M_i$$

where N = the estimated spawner population,

R_{ij} = carcasses marked in the ith marking period which were recovered in the jth recovery period,

M_i = carcasses marked in the ith marking period,

R_i = total marked carcasses recovered from the ith marking period,

R_j = total marked carcasses recovered during the jth recovery period,

C_j = total carcasses observed in the jth recovery period, including those with marks, and

$\Sigma_2{}^{i}M_i$ = total carcasses marked from the second marking period on. Subtraction of this factor adjusted for replacement of recovered marked fish.

C. The Jolly-Seber calculations as modified by Boydstun (1994):

$E = N_1 + D_1 + D_2 + \ldots D_j$, where

E = the estimated spawner population

N_1 = number of carcasses in the surveyed population in period 1, the first "week" of spawning, and

D_i = number of carcasses joining the population between period *i* and *i*+1, with *j* being the last survey period.

Three basic quantities are first calculated:

1) An estimate of the number of marked carcasses available for recovery during each survey (B_i):

$$B_i = \frac{(T_i+1)\times(K_i)}{(R_i+1)} + (M_i+1)$$

- To estimate B_j, the number of marked carcasses in the population just before the last survey, it is assumed that the proportion of marked carcasses in the last survey is the same as the estimated proportion in the previous survey, and:

$$B_j = \frac{B_{j-1} \times M_j}{M_{j-1}}$$

2) An estimate of the number of carcasses in the population immediately before each survey (N_i):

$$N_i = \frac{B_i \times (C_i+1)}{M_i+1}$$

and,

3) An estimate of the "survival rate" of marked carcasses from the *i*th to the *i*th+1 periods (S_i):

$$S_i = \frac{b_{i+1}}{b_i - m_i + T_i}$$

- to estimate survival of carcasses for period 1, the following equation was used:

$$S_1 = \frac{B_2}{T_1}$$

In the above equations, the variables are defined as:

T_i = number of carcasses marked in the *i*th period,

K_i = total marked carcasses recovered after the *i*th period that were marked before the *i*th period,

R_i = total recovered marked carcasses that were marked in the *i*th period,

M_i = total recovered marked carcasses for the *i*th period, and

C_i = number of carcasses examined for marks during the *i*th period, including those marked and recovered marks in the period.

D_i can then be calculated:

$$D_i = \frac{(N_{i+1} - S_i) \times (N_i - C_i + T_i)}{\sqrt{S_i}}$$

and,

N_1 can also be calculated, assuming equal sampling efficiency between weeks 1 and 2:

$$N_1 = \frac{N_2 \times C_1 \div C_2}{\sqrt{S_1}}$$

(The use of the square root of S*i* in the denominator of the above two equations is a further modification by Frank Fisher, CDFG, personal comm.)

APPENDIX 2. 1994 chinook salmon spawner population estimates for the Central Valley river system.

River area / Tributary	Estimated number of fish: Late-fall run	Winter run	Spring run	Fall run	Total for all runs
Sacramento River System:					
Keswick Dam to Red Bluff					
Sacramento River mainstem a/	137 b/	147	740	19,669	20,693
Transferred from Keswick to CNFH c/	154	30	--	--	184
Transferred from RBDD to CNFH d/	--	12	--	--	12
Clear Creek	-- e/	--	0	2,546	2,546
Battle Creek					0
Coleman National Fish Hatchery	598	--	--	18,991	19,589
Downstream of hatchery	-- e/	-- e/	-- e/	24,274	24,274
(Totals for tributary):	(598)			(43,265)	(43,863)
Totals for area:	889 b/	189	740	65,480	67,298
Sacramento River System:					
Red Bluff to Princeton Ferry					
Sacramento River mainstem					
Red Bluff to Tehama Bridge	-- f/	0	0	3,450	3,450
Tehama Bridge to Woodson Bridge	-- f/	0	0	1,467	1,467
Woodson Br. to Hamilton City	-- f/	--	0	695	695
Hamilton City to Ord Bend	-- f/	--	0	335	335
Ord Bend to Princeton Ferry	-- f/	--	0	129	129
(Totals for tributary):				(6,076)	(6,076)
Mill Creek	--	--	723	1,081	1,804
Deer Creek	--	--	485	307	792
Totals for area:		0	1,208	7,464	8,672
Sacramento River System:					
Big Chico Creek to American River					
Big Chico Creek	--	--	2	-- e/	2
Butte Creek	--	--	474	-- e/	474
Feather River					
Feather River Hatchery	--	--	3,641	15,202	18,843
In-river	--	--	-- e/	38,382	38,382
(Totals for tributary):	--	--	(3,641)	(53,584)	(57,225)
Yuba River	--	--	-- e/	10,890	10,890
American River					
Nimbus Hatchery	--	--	--	8,567	8,567
In-river	--	--	--	31,520	31,520
(Totals for tributary):	--	--	--	(40,087)	(40,087)
Totals for area:	--	--	4,117	104,561	108,678
Sacramento River System Totals:	889	189	6,065	177,505	184,648
San Joaquin River System:					
Mokelumne River					
Mokelumne River Fish Installation	--	--	--	1,922	1,922
In-river	--	--	--	1,499	1,499
(Totals for tributary):	--	--	--	(3,421)	(3,421)
Stanislaus River	--	--	--	1,031	1,031
Tuolumne River	--	--	--	506	506
Merced River					
Merced River Fish Facility	--	--	--	943	943
In-river	--	--	--	2,646	2,646
(Totals for tributary):	--	--	--	(3,589)	(3,589)
San Joaquin River system totals:	--	--	--	8,547	8,547

a/ Includes numbers of fish for tributaries in this river area that were not surveyed or for which an estimate was not made.

b/ Represents only a partial estimate of the run , due to the Red Bluff Diversion Dam gates being raised.

c/ Fish from Keswick Dam that were transported to and spawned at Coleman National Fish Hatchery .

d/ Fish from Red Bluff Diversion Dam that were transported to and spawned at Coleman National Fish Hatchery .

e/ Tributary was not surveyed for this run.

f/ An estimate of the run size was not made.

APPENDIX 3. Chinook salmon spawner population estimates from 1984 through 1994 in California's Central Valley tributaries.

Tributary / Race	Estimated number of fish											1984-1993 average
	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	
Sacramento River mainstem upstream of Red Bluff												
Late-fall run	6,540	8,136	7,811	15,393	11,324	11,351	7,136	6,721	9,733	739	--- a/	8,488
Winter run	2,662	3,684	2,394	1,978	2,075	527	437	190	1,177	333	**147**	1,546
Spring run	7,823	10,200	15,824	10,972	9,568	5,139	3,856	762	372	386	**740**	6,490
Fall run	36,965	52,120	67,940	75,958	68,623	50,679	33,024	22,937	25,391	33,824	**19,669**	46,746
Battle Creek												
Fall run b/	29,893	39,808	31,252	24,249	67,475	31,048	21,088	17,241	12,708	18,616	**43,265**	29,338
Sacramento River mainstem downstream of Red Bluff												
Fall run	19,166	46,780	34,372	32,588	21,250	10,056	16,127	9,936	8,101	12,895	**6,076**	21,127
Feather River												
Spring run c/	1,562	1,632	1,433	1,213	6,833	5,078	1,893	4,303	1,497	4,672	**3,641**	3,012
Fall run b/	51,056	56,002	55,471	77,846	49,036	48,119	6,126 c/	42,062	40,545	42,914	**53,584**	51,450 d/
Yuba River												
Fall run	9,665	13,042	19,328	18,518	9,000	7,622	e/	14,008	6,362	6,703	**10,890**	11,583
American River												
Fall run b/	39,696	65,213	55,067	46,143	33,514	28,923	10,239	25,211	11,267	39,410	**40,087**	35,468
Mokelumne River												
Fall run b/	8,298	7,682	7,167	1,630	528	281	499	410	1,645	3,157	**3,421**	3,130
Stanislaus River												
Fall run	11,439	13,473	6,497	6,292	10,212	1,510	480	394	255	677	**1,031**	5,123
Tuolumne River												
Fall run	13,689	40,322	7,404	14,751	5,779	1,275	96	77	132	471	**506**	8,400
Merced River												
Fall run b/	29,749	16,052	7,439	4,126	4,592	427	82	119	986	1,678	**3,589**	6,525

a/ An estimate of the run size was not made.

b/ Estimate includes numbers of salmon at the tributary's hatchery.

c/ Numbers are only those salmon which entered Feather River Hatchery; in-river spawner estimates were not made.

d/ Average does not include the 1990 estimate.

e/ Tributary was not surveyed.