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CHINOOK SALMON SPAWNER STOCKS IN CALIFORNIA'S CENTRAL VALLEY, 1996

Edited by

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Habitat Conservation Division
Native Anadromous Fish & Watershed Branch

Inland Fisheries

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ABSTRACT

This report covers the 44th annual inventory of chinook salmon, Oncorhynchus tshawytscha, spawner populations in the Sacramento-San Joaquin River system. It is a compilation of sources estimating the fall-, winter-, late-fall-, and spring-run populations for 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 in spawning areas, and from aerial counts.

The estimated 1996 total escapement of chinook salmon in the Central Valley was 367,695 fish, which was 13% higher than in 1995. The population consisted of 355,879 fall-, 9,082 spring-, 1,349 winter-, and 1,385 late-fall-run spawners. All of the spring-, late-fall-, and winter-run salmon were in the Sacramento River system. In the upper mainstem of that system, the winter run decreased 17% from the 1995 population, while the spring run increased by 19%. The fall run consisted of 339,142 fish in the Sacramento River system and 16,737 fish in the San Joaquin River system.

Although the total San Joaquin tributary population still only contributed a small portion (4.5%) of the total Central Valley escapement, it showed an increase of 71% over that of 1995.

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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 44th 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 during 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.

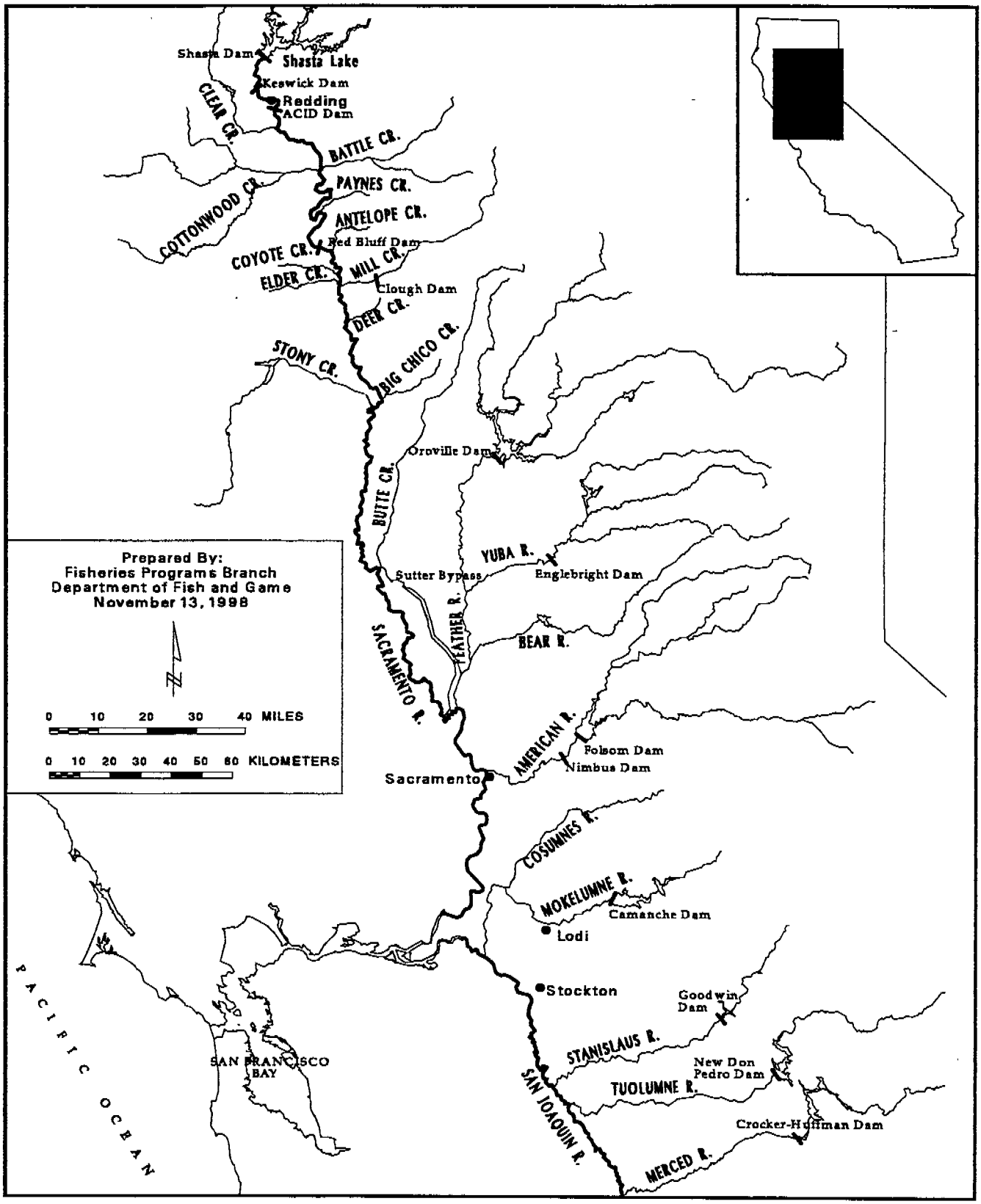

Figure 1. Sacramento-San Joaquin River system of California's Central Valley

GENERAL METHODS

During 1996, 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. Discrete marks allowed identification with individual surveys upon recovery during subsequent trips. All counted carcasses were either marked or cut in half to prevent recounting. Estimated spawner numbers were calculated from mark-and-recovery data.

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

In this report, adult salmon are considered those fish three years old and older. Two-year-old salmon, although sexually mature, are referred to as grilse.

CHINOOK SALMON SPAWNER POPULATIONS FOR THE SACRAMENTO RIVER SYSTEM

Keswick Dam to Red Bluff Diversion Dam [2/]

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 all 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 1996, 153,867 salmon were estimated for the Sacramento River system between Keswick Dam and Red Bluff, consisting of 150,715 fall-, 1,385 late-fall-, 1,349 winter- and 418 spring-run fish (Appendix 1). The mainstem portion of the fall- run spawner population was 71,206 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 runs in Clear, Cottonwood and Battle creeks, and the fall run in Cottonwood Creek.

Sacramento River Mainstem

Estimates of the total numbers of salmon using the Sacramento River upstream from RBDD during 1996 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 winter, spring, and fall runs based on their relative ratios seen that week in random samples of salmon from the dam's east-bank trapping facility. These sampled fish were assigned to a run based on

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[2/] Fisher, F.W., C.D. Harvey-Arrison, and D. Killam. Chinook Salmon Spawning Populations for the Sacramento River System, 1996. File Report. September 2000. CDFG-Northern California and North Coast Region (NCNCR), Red Bluff Office.

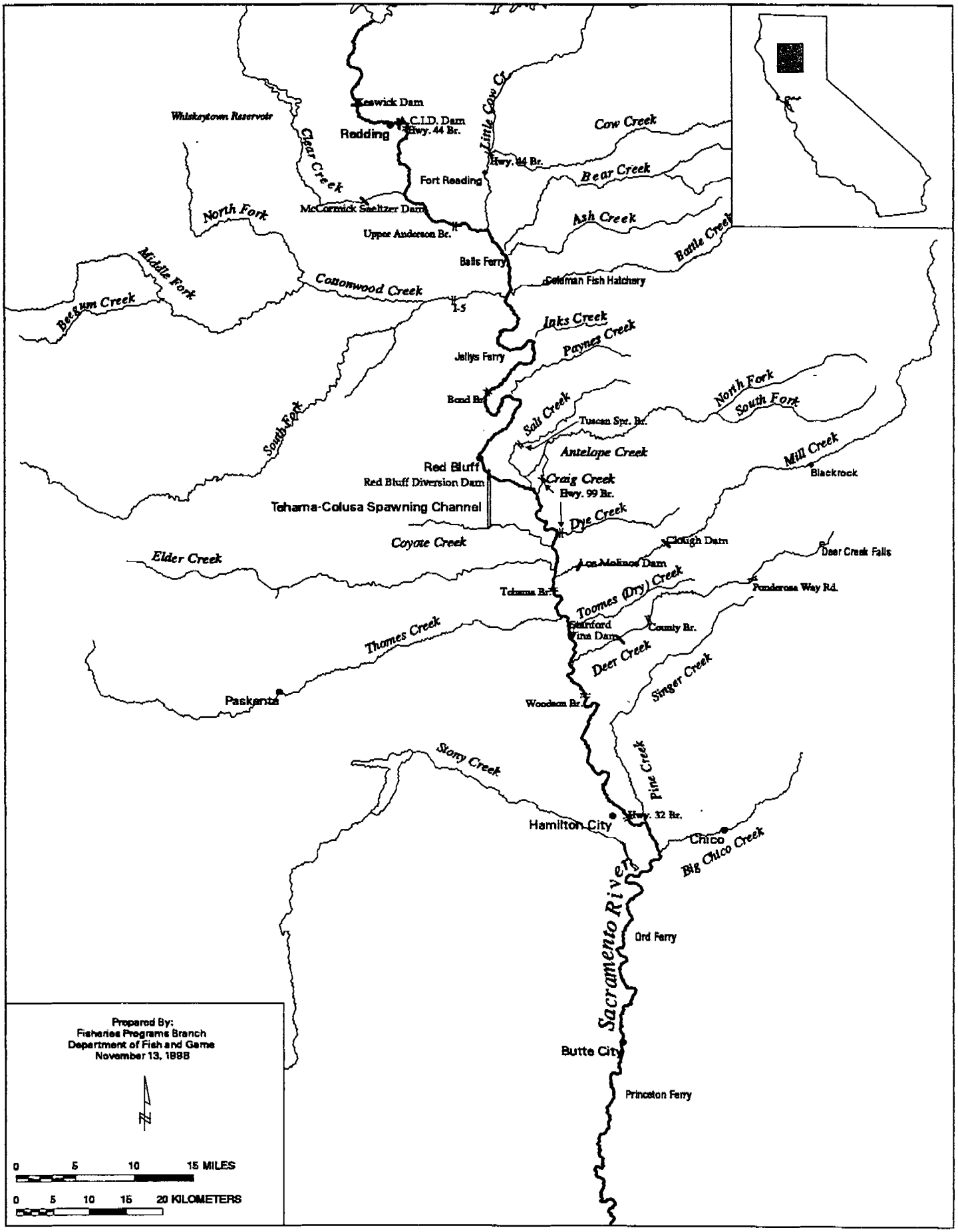

Figure 2. Sacramento River system from Keswick Dam downstream to Princeton Ferry

assessment of when they would spawn as indicated by coloration, scale absorption, secondary sexual characteristics, and relative degree of ripeness.

The numbers of spring- and fall-run salmon passing RBDD in a calendar year account for the entire annual run of these races. However, for the winter run, a calendar year usually includes the majority of the annual run during the beginning of the year, and the first part of the next annual run at the end of that year. The 1996 winter-run potential spawners included the estimated numbers of fish from the 1995 calendar year that would spawn in 1996, but not that portion from the 1996 calendar year estimated numbers that would spawn in 1997.

The RBDD gates were raised from 17 September 1995 through 16 May 1996, and from 15 September 1996 through 3 January 1997, 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 used represented an average timing derived from RBDD data for the 1982-1986 winter runs, 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. The estimated number of sport-caught fall-run salmon was based on the average harvest rate (8%) seen during 1991-1994, when angler surveys were conducted by CDFG upstream of RBDD. It was assumed that no winter- or spring-run fish were harvested, due to an angling closure in effect from 15 January through 31 July.

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 Keswick Dam to Coleman National Fish Hatchery (CNFH).

Late-fall run. The RBDD gates were raised during the entire late-fall migration period, and it was not possible to estimate the numbers of this run passing the dam. The only available data for this run in the mainstem were 48 fish transferred from Keswick Dam to CNFH (Appendix 1).

Winter run. The 1996 winter run at RBDD was estimated to be 1,360 salmon (Table 2); due to the RBDD gates being open, only 15% of this estimate was derived from actual counts at the dam. Eleven of the fish were removed from the population at the dam

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 made, due to the dam gates being open.

Approximate monthly period	Julian week	Proportion of run (%) 1/		
		Winter run	Spring run	Fall run
	1	1.70		
January	2	1.78		
	3	0.35		
	4	1.28		
	5	2.38		
February	6	3.12		
	7	3.08		
	8	0.97		
	9	6.35		
March	10	7.72		
	11	9.23		
	12	7.79	0.10	
	13	4.91	0.25	
	14	7.64	0.59	
April	15	8.26	0.96	
	16	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		0.69	10.59
	42			8.97
	43			6.99
	44			6.70
November	45			4.67
	46			2.71
	47			2.23
	48			1.68
December	49	0.17		0.90
	50	0.38		0.66
	51	0.49		0.51
	52	0.71		0.19

1/ Distributions are averages based on the following years of data:
-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 10 December 1995 through 3 January 1997. a/

Count period		Adjusted salmon count b/	Number of salmon examined c/	Distribution of runs: Late-fall % of fish examined	Late-fall Estimated number d/	Winter % of fish examined	Winter Estimated number e/	Spring % of fish examined	Spring Estimated number e/	Fall % of fish examined	Fall Estimated number e/
10-30 Dec '95 f/		--	--	--	--	--	24	--	--	--	--
1996											
31-Dec-95 -	06-Jan	--	--	--	--	--	23				
07-Jan -	13-Jan	--	--	--	--	--	24				
14-Jan -	20-Jan	--	--	--	--	--	5				
21-Jan -	27-Jan	--	--	--	--	--	17				
28-Jan -	03-Feb	--	--	--	--	--	32				
04-Feb -	10-Feb	--	--	--	--	--	43				
11-Feb -	17-Feb	--	--	--	--	--	42				
18-Feb -	24-Feb	--	--	--	--	--	13	-- g/			
25-Feb -	02-Mar	--	--	--	--	--	86				
03-Mar -	09-Mar	--	--	--	--	--	105				
10-Mar -	16-Mar	--	--	--	--	--	125				
17-Mar -	23-Mar	--	--	--	--	--	106	--	0		
24-Mar -	30-Mar	--	--	--	--	--	67	--	1		
31-Mar -	06-Apr	--	--	--	--	--	104	--	2		
07-Apr -	13-Apr	--	--	--	--	--	112	--	4		
14-Apr -	20-Apr	--	--	--	--	--	125	--	6	g/	
21-Apr -	27-Apr	--	--	--	--	--	47	--	7		
28-Apr -	04-May	--	--			--	28	--	7		
05-May -	11-May	--	--			--	22	--	7		
12-May -	18-May	14	1			100	14	--	0	0	0
19-May -	25-May	23	4			25 0	6	75 0	17	0	0
26-May -	01-Jun	47	22			31.8	15	68.2	32	0	0
02-Jun -	08-Jun	53	33			45.5	24	51.5	27	3 0	2
09-Jun -	15-Jun	90	54			38.9	35	40 7	37	20 4	18
16-Jun -	22-Jun	100	50			26.0	26	14 0	14	60 0	60
23-Jun -	29-Jun	127	46			26 1	33	10 9	14	63 0	80
30-Jun -	06-Jul	267	103			11 7	31	8 7	23	79 6	213
07-Jul -	13-Jul	219	94			2 1	5	11 7	26	86 2	189
14-Jul -	20-Jul	379	81			1.2	5	3.7	14	95 1	360
21-Jul -	27-Jul	750	92			2 2	16	1 1	8	96 7	726
28-Jul -	03-Aug	742	156			Total h/	1,360 i/	1 3	9	98 7	733
04-Aug -	10-Aug	677	69					4 4	29	95 7	648
11-Aug -	17-Aug	1,413	75					1 3	19	98 7	1,394
18-Aug -	24-Aug	1,416	65					0	0	100	1,416
25-Aug -	31-Aug	3,167	86					2 3	74	97 7	3,093
01-Sep -	07-Sep	7,269	111					0	0	100	7,269
08-Sep -	14-Sep	23,669	0					0	0	100	23,669
15-Sep -	21-Sep	--	--	--				--	22	--	13,751
22-Sep -	28-Sep	--	--	--				--	16	g/ --	14,808
29-Sep -	05-Oct	--	--	--				--	5	--	16,812
06-Oct -	12-Oct	--	--	--				--	3	--	16,972
13-Oct -	19-Oct	--	--	--				Total h/	425 j/	--	14,376
20-Oct -	26-Oct	--	--	--						--	11,202
27-Oct -	02-Nov	--	--	--						--	10,738 - g/
03-Nov -	09-Nov	--	--	--						--	7,500
10-Nov -	16-Nov	--	--	--						--	4,343
17-Nov -	23-Nov	--	--	--						--	3,574
24-Nov -	30-Nov	--	--	--						--	2,692
01-Dec -	07-Dec	--	--	--						--	1,442
08-Dec -	14-Dec	--	--	--		--				--	1,058
15-Dec -	21-Dec	--	--	--		--	28 g/			--	817
22-Dec -	28-Dec	--	--	--		--				--	309
29-Dec -	03-Jan-97	--	--	--		--				Total h/	160,263
Total for 1996 calendar year		40,422	1,142				1,364 k/		425		160,263

a/ Red Bluff Diversion Dam gates were raised from 17 September 1995 through 16 May 1996, and from 15 September 1996 through 3 January 1997

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/ The dam gates were open during the entire late-fall-run period in 1995 and 1996, so it was not posssible to estimate the run.

e/ Adjusted count x Proportion of examined fish assigned to run

f/ Estimated number represents salmon passing the dam during this period in 1995 that were expected to spawn in 1996.

g/ Due to the dam gates being open, no counts were possible Estimated numbers based on historical average proportional run distributions.

h/ Total estimated number of potential spawners for the 1996 run at RBDD

i/ Eleven fish were removed from the run at the dam for coded-wire tag recovery, estimated potential spawners passing RBDD were 1,349 salmon.

j/ Seven fish were removed from the run at the dam for coded-wire tag recovery; estimated potential spawners passing RBDD were 418 salmon.

k/ Including winter-run 1997 potential spawners.

for coded-wire tag recovery, and 1,349 potential spawners passed into the system upstream. It was assumed that no winter-run salmon were caught in the sport-fishery. An estimated 325 of the potential spawners were CNFH-origin fish (identified by an adipose-fin clip), and all were assumed to have returned to Battle Creek, leaving 1,024 salmon as the upper mainstem spawner population (Appendix 1).

Based on 63 winter-run salmon sampled at RBDD, the run consisted of 65% adults and 35% grilse.

The 1996 winter-run spawner population of 1,024 salmon in the mainstem upstream of RBDD was 17% lower than the 1995 population, but only 2% lower than the average population for 1986-1995 (Appendix 2).

Spring run. The 1996 spring run at RBDD was estimated to be 425 salmon (Table 2); 88% of this estimate was derived from actual counts at the dam. Seven of the fish were removed from the population at the dam for coded-wire tag recovery, and 418 potential spawners passed into the system upstream. It was assumed that no spring-run salmon were caught in the sport-fishery, and a total of 40 fish was estimated to be in Cottonwood and Battle creeks, leaving 378 fish as the spawner population in the mainstem upstream of Red Bluff (Appendix 1).

Based on a sample of 101 spring-run salmon at RBDD, the run consisted of 83% adults and 17% grilse.

The 1996 spring-run population of 378 fish in the mainstem upstream of RBDD was 19% higher than the 1995 population, but still only 8% of the average population for 1986-1995 (Appendix 2).

Fall run. An estimated 160,263 fall-run potential spawners passed RBDD in 1996 (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 9,548 salmon, leaving 150,715 fish as a spawner population in the system upstream of Red Bluff (Table 3). A total of 79,509 spawners was estimated for Clear and Battle creeks, and the upper mainstem population was 71,206 salmon (Appendix 1). This estimated population includes fall-run salmon which used other tributaries to the upper mainstem that were not surveyed.

Based on a sample of 954 fall-run salmon sampled at RBDD, the run consisted of 90.6% adults and 9.4% grilse.

The 1996 fall run in the mainstem Sacramento River upstream of Red Bluff was over 2½ times higher than the 1995 population, and 1½ greater than the average 1986-1995 population (Appendix 2).

TABLE 3. Calculation of the 1996 spawner population for each run of chinook salmon upstream of Red Bluff Diversion Dam (RBDD).

Run	Number of fish passing dam in calendar year: 1995		1996		Number of potential spawners		Estimated sport catch		Estimated 1996 spawner population
Late-fall a/	---		---		---		---		
Winter	24	+	1,325 b/	=	1,349 c/	-	d/	=	1,349
Spring			418 e/	=	418 c/	-	d/	=	418
Fall			160,263	=	160,263 c/	-	9,548	=	150,715
Totals:	**24**	**+**	**162,006**	=	**162,030**	-	**9,548**	=	**152,482**

a/ The RBDD gates were raised during all of the late-fall-run salmon migration period, so it was not possible to estimate the run size.
b/ Eleven fish were removed from the run at the dam for coded-wire tag recovery, and are not included. Twenty-eight winter-run salmon which passed the dam in the latter part of 1996 (Table 2) are also not included; these fish were considered 1997 spawners.
c/ Due to the RBDD gates being open, only portions of these numbers were calculated from actual counts. These portions were: winter run, 15%; spring run, 89%; and fall run, 25%.
d/ A sport-fishing closure was in effect during the run's migration period, and it was assumed that no fish were caught.
e/ Seven fish were removed from the run at the dam for coded-wire tag recovery, and are not included.

Mainstem spawning distribution. The 1996 relative salmon redd distribution in the mainstem Sacramento River from Keswick Dam downstream to RBDD was determined from data collected by airplane flights during the winter-, spring-, and fall-run spawning seasons; no aerial surveys were made during the late-fall-run season. All of the winter run spawning in the mainstem occurred upstream from Upper Anderson Bridge, and no spring-run salmon redds were observed (Table 4). Fall-run spawning from Keswick Dam to RBDD constituted 85.3% of that observed for the entire mainstem.

Clear Creek

Late-fall run. No surveys were conducted for this run in 1996.

Spring run. No adult salmon were seen during snorkeling surveys of the 1.6-km (1-mi) creek section downstream of McCormick-Saeltzer Dam, conducted on 6 April and 28 May 1996. Fish passage at the dam was not monitored this season. It was assumed that no spring-run salmon immigrated into Clear Creek this season.

TABLE 4. Chinook salmon relative redd distribution observed during 1996 aerial surveys of the mainstem Sacramento River from Keswick Dam to Princeton Ferry.

	Late-fall run	Winter run		Spring run	Fall run	
River section	Redds counted a/	Redds counted b/	Proportional distribution	Redds counted c/	Redds counted d/	Proportional distribution
Keswick Dam to A.C.I.D. Dam e/	--	3	6.8%	0	130	4.2%
A.C.I.D. Dam to Highway 44	--	25	56.8%	0	968	31.4%
Highway 44 to Upper Anderson Bridge	--	16	36.4%	0	637	20.7%
Upper Anderson Bridge to Balls Ferry	--	0	0.0%	0	345	11.2%
Balls Ferry to Jellys Ferry	--	0	0.0%	0	265	8.6%
Jellys Ferry to Bend Bridge	--	0	0.0%	0	196	6.4%
Bend Bridge to Red Bluff Dam	--	0	0.0%	0	84	2.7%
Red Bluff Dam to Tehama Bridge	--	0	0.0%	0	258	8.4%
Tehama Bridge to Woodson Bridge	--	0	0.0%	0	107	3.5%
Woodson Bridge to Hamilton City (Hwy. 32)	--	--	--	--	73	2.4%
Hamilton City to Ord Bend	--	--	--	--	15	0.5%
Ord Bend to Princeton Ferry	--	--	--	--	0	0.0%
Totals:		44		0	3,078	

a/ No aerial surveys were made during the late-fall-run spawning period.

b/ Total count made for 15 aerial surveys from 30 April through 7 August 1996.

c/ Aerial surveys made on 16 August and 6 September 1996.

d/ Total count made for four aerial surveys from 24 September through 1 November 1996.

e/ Anderson-Cottonwood Irrigation District Dam.

Fall run. Seven spawner surveys of Clear Creek were made during 9 October through 17 December 1996 in the 6.7-km (4.2-mi) stretch downstream of McCormick-Saeltzer Dam. Fresh salmon carcasses were marked by attaching colored tape to their jaws with hog rings, and replacing them back into running water for recovery during following surveys.

Using carcass mark-and-recovery data with the Schaefer model (Appendix 3), the spawner population in Clear Creek downstream of McCormick-Saeltzer Dam was estimated to be 5,922 fish (Table 5).

Based on examination of 2,807 salmon carcasses, the fall-run spawner population of Clear Creek consisted of 34% male adults (fork length [FL] > 64 cm [25.2 in.]), 47% female adults, and 19% grilse (FL ≤ 64 cm).

Pre-spawning mortality of female salmon in Clear Creek this season was 0.5%.

Cow Creek

Late-fall and fall runs. No surveys for these runs in this tributary were made in 1996.

Cottonwood Creek

Late-fall run. No surveys for this run were made in 1996.

Spring run. Beegum Creek, a tributary to Cottonwood Creek, was surveyed on 23 September 1996. A 4.8-km (3-mi) stretch downstream of the north and south forks' confluence was covered by snorkeling. Six adult salmon were counted, and it was concluded that they constituted the entire 1996 spring run in this system.

Fall run. No surveys were made for this run in Cottonwood Creek during 1996.

Battle Creek

Late-fall run. No surveys were made of this run's in-river spawner population. A total of 1,337 late-fall-run salmon entered CNFH in 1996, consisting of 32% male adults, 41% female adults, and 27% grilse.

Winter run. No spawner surveys were conducted for this run in Battle Creek during 1996. However, it was assumed that all of the estimated 325 winter-run adipose-fin-clipped salmon which passed RBDD returned to this tributary.

TABLE 5. Chinook salmon carcass mark-and-recovery data used to estimate the 1996 fall-run spawner population for Clear Creek in the 4.2-mi stretch of stream downstream of McCormick-Saeltzer Dam. 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	0	--	--	--	--	--	0	352	352
3		59	--	--	--	--	59	857	1,947
4		9	128	--	--	--	137	1,125	2,187
5		2	12	31	--	--	45	522	1,268
6				1	20	--	21	207	514
7				1	1	5	7	42	259
Total recovered (Ri):	0	70	140	33	21	5		Total:	6,527
Total carcasses marked (Mi):	3	159	269	87	52	38			
							Adjusted estimate d/:		**5,922**

a/ Surveys were conducted from 9 October through 17 December 1996.

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. 6,527 - 605 = 5,922.

Spring run. No surveys were conducted for this run during 1996. However, videotape monitoring of the CNFH barrier dam fish ladder was conducted from 26 March through 1 July. During this period, it was assumed that any salmon passing through the ladder were either hatchery-origin winter-run fish (adipose-fin-clipped) or naturally-spawned spring-run fish (non-adipose-fin-clipped). From the estimated 262 salmon which passed upstream of CNFH, 34 fish were determined to be spring-run.

Fall run. Eight carcass surveys were conducted during 30 September through 16 December 1996, covering the 5.6-km (3.5-mi) stretch of river between CNFH and the old hatchery location. Fresh salmon carcasses were marked by attaching colored tape to their jaws with hog rings, and placed into running water for recovery. No surveys were made of Gover's Ditch which was blocked by a weir, nor of the creek upstream of the CNFH barrier dam.

Using carcass mark-and-recovery data with the Schaefer model (Appendix 3), the spawner population in Battle Creek downstream of CNFH was estimated to be 52,409 fish (Table 6). Combined with an additional 21,178 fish which entered CNFH, the total 1996 Battle Creek fall-run population was 73,587 salmon (Appendix 1).

The composition of the fall run in Battle Creek was 33% male adults (FL > 64 cm [25.2 in.]), 62% female adults, and 5% grilse (FL ≤ 64 cm), based on an examination of 18,550 carcasses. In comparison, fall-run fish entering CNFH consisted of 47% male adults, 42% female adults, and 11% grilse.

Pre-spawning mortality of fall-run salmon in Battle Creek was 8% in 1996.

The 1996 fall-run spawner population for Battle Creek of 73,587 fish was 11% lower than the size of the 1995 population, but still more than twice the average run population for 1986 through 1995 (Appendix 2).

TABLE 6. Chinook salmon carcass mark-and-recovery data used to estimate the 1996 fall-run spawner population in Battle Creek from Coleman National Fish Hatchery to the old hatchery site. a/

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	246	1,230
3		32	--	--	--	--	--	32	3,779	16,672
4		2	370	--	--	--	--	372	6,147	12,789
5			70	529	--	--	--	599	7,980	17,477
6			2	12	101	--	--	115	1,483	5,676
7				2	8	17	--	27	303	1,334
8							0	0	17	17
Total recovered (Ri):	1	34	442	543	109	17	0		Total:	55,195
Total carcasses marked (Mi):	5	150	914	1198	442	82	0			
								Adjusted estimate d/:		**52,409**

a/ Surveys were conducted from 30 September through 16 December 1996.

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. 55,195 - 2,786 = 52,409.

Red Bluff Diversion Dam to Princeton Ferry [3/]

A total of 13,222 chinook salmon spawners was estimated for 1996 in the Sacramento River system between Red Bluff and Princeton Ferry (Figure 2). This total consisted of 868 spring-run salmon in Antelope, Mill, and Deer creeks, and 12,354 fall-run salmon in the mainstem Sacramento River (Appendix 1).

Sacramento River Mainstem

Late-fall run. No aerial surveys were made of the mainstem Sacramento River downstream of Red Bluff during the late-fall-run spawning period. Therefore, it was not possible to make an estimate for the run in this area.

Winter run. During 15 aerial surveys between 30 April and 7 August 1996, no redds were observed in the mainstem Sacramento River downstream of Red Bluff (Table 4). An estimate of the winter-run population in this area was not made.

Spring run. No redds were observed in the mainstem Sacramento River downstream of Red Bluff during the aerial surveys made on 16 August and 6 September 1996 (Table 4). An estimate of the spring-run population in this stretch of the river was not made.

Fall run. Based on four aerial surveys from 24 September through 1 November 1996, an estimated 12,354 fall-run salmon were in the mainstem Sacramento River between RBDD and Princeton Ferry (Appendix 1). This population was 2¼ times greater than the 1995 run, and 78% of the average run size from 1986 to 1995 (Appendix 2).

Mainstem spawning distribution. Redd counts made during the aerial surveys in 1996 were used to determine the relative spawning distribution of fall-run salmon in the mainstem Sacramento River between Red Bluff and Princeton Ferry. In proportion to the entire mainstem (including upstream of RBDD) spawning activity, 14.7% of the fall-run redds were observed this section of the river (Table 4).

Antelope Creek

Spring run. The known holding habitat for spring-run salmon in the Antelope Creek drainage was surveyed by snorkeling on

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[3/] Fisher, F.W., C.D. Harvey-Arrison, and D. Killam. Chinook Salmon Spawning Populations for the Sacramento River System, 1996. File Report. September 2000. CDFG-NCNCR, Red Bluff Office.

31 July 1996. Sections of the mainstem, from the confluence of the north and south forks downstream to 3.2 km (2 mi) past Payne Place Road, and upstream into the North Fork to McClure Place, were covered. The South Fork, upstream from its mouth to Round Mountain Creek was also surveyed. Only one adult salmon was observed and assumed to be the entire 1996 spring-run population in this tributary.

Fall run. No surveys were conducted for this run in Antelope Creek in 1996.

Mill Creek

Spring run. Spring-run salmon were monitored immigrating past Clough Dam during 5 February through 24 June 1996. 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. A total of 253 salmon was estimated to have passed the dam.

Snorkeling surveys of approximately half of the spring-run holding habitat from Little-Hole-in-the-Ground Camp to Little Mill Creek were made during 21 August through 6 September 1996. A total of 69 adult salmon was counted.

During the spring-run spawning period, 19 surveys were made during 6 September through 5 November 1996. Sections of the creek from the Hwy.36 crossing to 4.8 km (3 mi) downstream of Blackrock were covered. A total of 10 salmon carcasses, 13 live fish, and 89 redds was counted.

The 253 salmon estimated from monitoring at Clough Dam was determined to be the 1996 spring run in Mill Creek.

Fall run. No surveys were conducted for this run in Mill Creek in 1996.

Deer Creek

Spring run. The known holding habitat for spring-run salmon from Upper Deer Creek Falls to Iron Mountain was snorkeled on 7 August 1996. A total of 614 adult fish was counted.

During 18 spawner surveys from 6 September through 23 October 1996, a total of 107 salmon carcasses, 242 live fish, and 374 redds was observed in sections of the creek from Upper Deer Creek Falls to Murphy Trail.

The 1996 spring run in Deer Creek was felt to be 614 salmon.

Fall run. No surveys were conducted for this run in Deer Creek in 1996.

Big Chico Creek to the American River

A total of 183,869 chinook salmon was estimated for 1996 in the Sacramento River tributaries from Big Chico Creek to the American River (Figure 3). This total consisted of 7,796 spring-run and 176,073 fall-run fish (Appendix 1).

Big Chico Creek

Spring run. Based on a snorkeling survey in July 1996 only two fish were counted for the 1996 spring run in Big Chico Creek.

Fall run. No surveys were conducted for this run in 1996.

Butte Creek

Spring run. Surveys were conducted during 19-23 August 1996 by snorkeling the creek between Centerville Head Dam and the Hwy. 99 crossing.[4/] Based on survey counts of adult fish, it was estimated that a maximum of 1,413 salmon were holding in the creek.

Fall run. Based on counts of live salmon and carcasses during the spawner season, a minimum of 500 fish constituted the 1996 fall run.[5/]

Feather River

Spring run. A total of 6,381 salmon classified as spring-run fish entered Feather River Hatchery (FRH) in 1996.[6/] These fish consisted of 43.6% male adults (FL > 55.9 cm [22 in.]), 43.7% female adults, and 12.7% grilse (FL ≤ 55.9 cm). In the river itself, no attempt was made to estimate numbers of spring-run salmon.

[4/] Hill, K. Butte Creek Snorkel Survey, August 19-23, 1996. Memorandum to files. 30 September 1996. CDFG-Sacramento Valley and Central Sierra Region (SVCSR), Rancho Cordova Office.

[5/] Hill, K. CDFG-SVCSR. Personal communication.

[6/] Barngrover, B. CDFG-SVCSR. Personal communication.

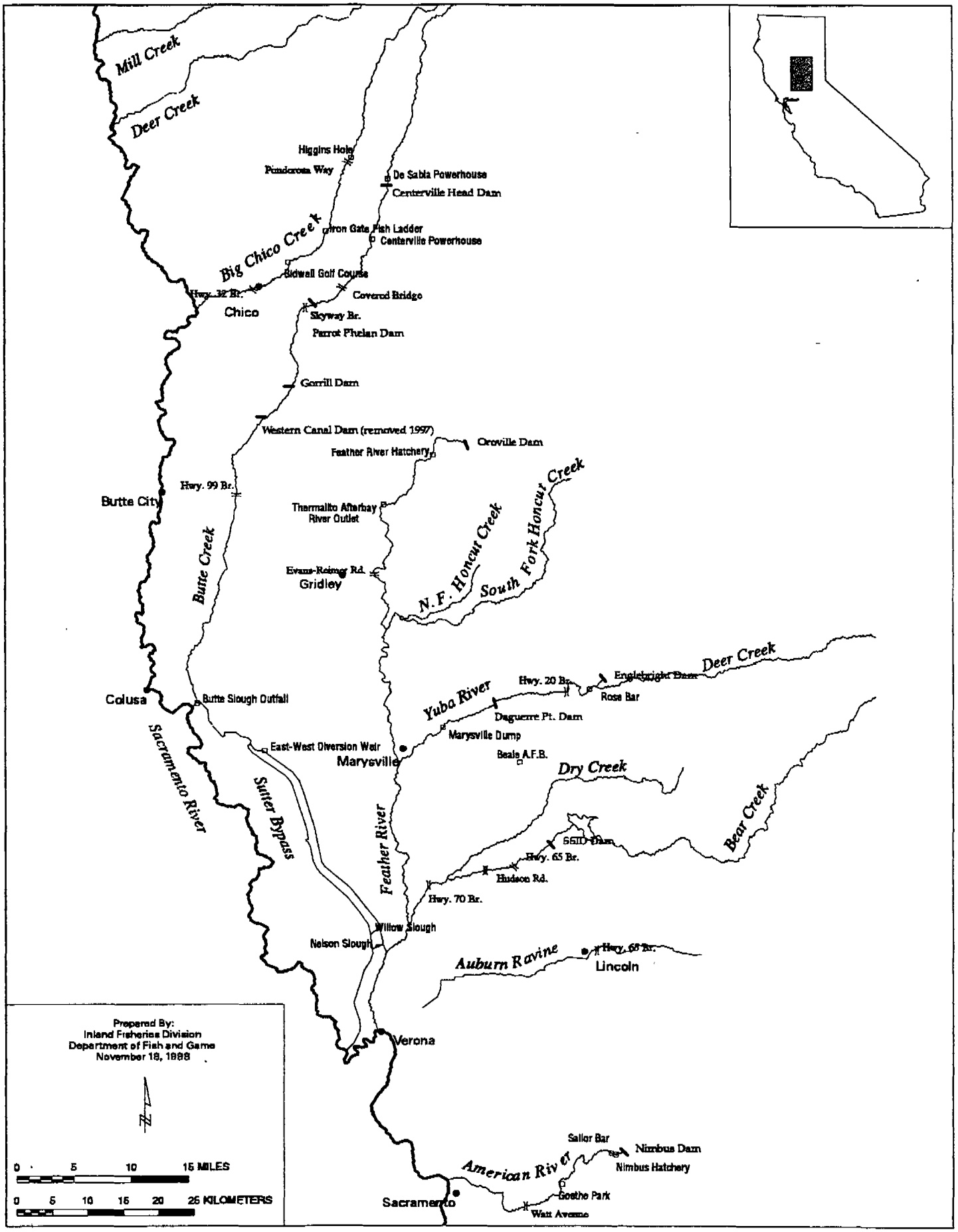

Figure 3. Sacramento River system from Big Chico Creek downstream to American River.

The 6,381 spring-run salmon at FRH in 1996 was an increase of 18% from the 1995 run, and was 77% higher than that of the average run size observed in the past ten years (Appendix 2).

Fall run. Salmon carcass mark-and-recovery surveys were conducted in the Feather River between the hatchery barrier dam and the Gridley boat ramp from 3 October through 6 December 1996; surveys could not be continued through the latter part of December due to high flows.[7/] The 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 45.3 m^3/s (1600 cfs) throughout the survey period. The flow in this reach was much higher this season than in past years (typically about 16.9 m^3/s [600 cfs]), as part of a salmon spawning study conducted by the Department of Water Resources. Flow downstream of Thermalito Afterbay to the Gridley boat ramp (Section 2) was about 68 m^3/s (2400 cfs), except for during the last survey when flows increased to 170 m^3/s [6000 cfs]; surveys in this section were conducted from 18 October through 6 December. Visibility through the water was about 2.4 m (8 ft) in Section 1, and ranged from 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 (26.4 in.). The size criteria used to distinguish adults from grilse was determined from 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 3) estimates, calculated from the mark-and-recovery data, were 31,652 adult salmon for Section 1, and 12,957 adults for Section 2 (Table 7). Each adult estimate was expanded to include the grilse proportion seen in the respective section (20.0% in Sect. 1, and 26.4% in Sect. 2), resulting in a combined total in-river estimate of 57,170 fish. A total of 8,107 fall-run salmon entered FRH[8/], bringing the 1996 fall run in the Feather River to 65,277 fish (Appendix 1).

[7/] Meyer, F. 1996 Feather River Chinook Salmon Run. Memorandum to files. 3 March 1997. CDFG-SVCSR, Rancho Cordova Office.

[8/] Barngrover, B. CDFG-SVCSR. Personal communication.

TABLE 7. Chinook salmon adult carcass mark-and-recovery data used to estimate the 1996 fall-run spawner population in the Feather River. a/

SECTION 1, Feather River 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	9	Total marked carcasses recovered (Rj)	Total carcasses observed (Cj) b/	Population estimate (N) c/
2	45	--	--	--	--	--	--	--	--	45	1,074	2,788
3	7	129	--	--	--	--	--	--	--	136	1,254	3,138
4		43	109	--	--	--	--	--	--	152	1,937	4,993
5		22	20	150	--	--	--	--	--	192	2,329	6,161
6		1	2	49	157	--	--	--	--	209	2,293	6,348
7			0	1	15	50	--	--	--	66	1,008	3,737
8			2	1	5	30	32	--	--	70	1,058	3,703
9						2	10	57	--	69	770	1,730
10							3	15	34	52	476	1683
Total recovered (R	52	195	133	201	177	82	45	72	34		Total:	34,281
Total carcasses marked (M1):	135	487	347	537	496	328	145	145	144			
										Adjusted estimate d/:		**31,652**

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	9	Total marked carcasses recovered (Rj)	Total carcasses observed (Cj) b/	Population estimate (N) c/
4	--	--	4	--	--	--	--	--	--	4	175	817
5	--	--	1	15	--	--	--	--	--	16	539	1,911
6	--	--	1	2	45	--	--	--	--	48	782	2,511
7	--	--			6	70	--	--	--	76	936	2,408
8	--	--			3	20	70	--	--	93	1,021	2,661
9	--	--					19	114	--	133	1,082	2,463
10	--	--						8	15	23	145	1341
Total recovered (R1):			6	17	54	90	89	122	15		Total:	14,112
Total carcasses marked (Mi):			28	59	171	227	232	271	195			
										Adjusted estimate e/:		**12,957**

a/ Surveys were conducted in Section 1 from 3 October to 5 December, and in Section 2 from 18 October to 6 December 1996.

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. 34,281 - 2,629 = 31,652.

e/ Adjusted estimate, where marked carcasses (M1) from the second marking period on were subtracted, i.e. 14,112 - 1,155 = 12,957.

The composition of fall-run salmon in the river, based on examination of 5,224 fresh carcasses, was 31.5% male adults, 46.5% female adults, 18.0% male grilse, and 4.0% female grilse. In comparison, salmon entering FRH consisted of 32.3% male adults (FL ≥ 55.9 cm [22 in.]), 47.8% female adults, and 19.9% grilse (FL < 55.9 cm).

The 1996 Feather River population of 65,277 salmon was 9% lower than the 1995 run, but 18% higher than the average population from 1986 to 1995 (Appendix 2); that period's average excludes the 1990 run, when no estimate was made of the in-river population.

Yuba River

Fall run. The 1996 fall-run salmon spawner surveys were conducted by staff of Jones & Stokes Associates, Inc. under contract to Yuba County Water Agency (Jones & Stokes Associates, 1997).

Salmon carcass mark-and-recovery surveys were made in the Yuba River from Rose Bar downstream to the Hwy.70 bridge in Marysville. The surveyed reach was covered in three sections: Rose Bar to Parks Bar (Section 1), Parks Bar to Daguerre Point Dam (Section 2), and Daguerre Point Dam to Marysville (Section 3). These reaches included nearly all of the spawning areas used by chinook salmon in the Yuba River; some fish may have spawned upstream of Rose Bar to Englebright Dam, although suitable habitat is scarce in that area. Weekly surveys were conducted in Section 1 during 8 October through 3 December 1996, in Section 2 during 9 October through 4 December, and in Section 3 from 17 October through 5 December. High river flows after the first week of December prevented continuation of surveys through the end of the spawning season.

River flows were stable throughout the surveys, averaging approximately 31.1 m^3/s (1100 cfs) downstream of Englebright Dam and 39.6 m^3/s (1400 cfs) near Marysville. The mean daily water temperature in Section 3 in early October was 15°C (59°F) and declined to 10.5°C (51°F) by mid-December. Visibility through the water ranged from 1.5 to 6.1 m (5-20 ft), providing fair to good conditions for carcass recovery.

During the surveys, fresh (clear-eyed) salmon carcasses were marked with pieces of surveyor's tape tied to hog rings and attached to the fish's jaws; different tape colors identified carcasses with distinct marking periods. Marked carcasses were returned into flowing water for subsequent recovery. Decayed carcasses and recovered marked carcasses were counted and chopped in half. The sex of fresh adult (FL > 67 cm [26.5 in]) carcasses was noted for determination of the male to female ratio in the population.

Both adult and grilse (FL ≤ 67 cm) carcasses were marked with the intent of estimating the population of each. However, numbers of grilse recovered were insufficient to make a reliable estimate of that age class. Therefore, the estimated number of adults for the three sections was expanded by the overall observed fresh grilse proportion to obtain a total population.

Using carcass mark-and-recovery data with the Schaefer model (Appendix 3), estimates of 8,599, 7,563, and 7,330 adults were calculated for Sections 1, 2, and 3, respectively (Table 8). Adult estimates, expanded to include the grilse proportion (15.8%), resulted in an overall total estimate of 27,900 fish as the 1996 Yuba River fall run.

The 1996 fall run consisted of 37.9% male adults (FL > 67 cm [26.4 in.]), 46.3% female adults, and 15.8% grilse (FL ≤ 67 cm). The size criteria used to distinguish adults from grilse was determined from length frequency distribution of salmon at FRH in early September.

The 1996 Yuba River fall run of 27,900 salmon was almost two times greater than the 1995 population (Appendix 2), and was the highest since the run of 39,367 fish in 1982 (Reavis 1984).

American River

Fall run. Weekly salmon carcass mark-and-recovery surveys in the American River were conducted between 14 October and 4 December 1996, covering the 22.5-km (14-mi) reach from Watt Avenue upstream to Sailor Bar.[9/] Average water clarity, measured by secchi disk, ranged from 1.5 m to 3.3 m (5-11 ft). Water temperature ranged from 17.8°C to 11.1°C (64-52°F).

This season both fresh adult and grilse salmon carcasses were distinctly marked by attaching a hog ring and colored engineers' flagging to their jaws; different colors were used each marking period. A carcass was considered fresh if it had at least one clear eye or pink gills. Marked carcasses were replaced into running water near the location 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 and sex were recorded for a sample of the fresh carcasses.

[9/] Fjelstadt, M. American River Salmon Stock Estimate. Memorandum to files. 23 September 1997. CDFG-SVCSR, Rancho Cordova office.

TABLE 8. Chinook salmon adult carcass mark-and-recovery data used to estimate the 1996 fall-run spawner population in the Yuba River. a/

Section 1: Rose Bar to Parks Bar

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	7	--	--	--	--	--	--	--	7	184	569
3	3	9	--	--	--	--	--	--	12	203	836
4	1	4	12	--	--	--	--	--	17	316	1,154
5			2	4	--	--	--	--	6	284	2,786
6				1	10	--	--	--	11	185	1,214
7					2	6	--	--	8	139	805
8						2	0	--	2	82	472
9							1	1	2	77	1,079
Total recovered (Ri).	11	13	14	5	12	8	1	1		Total:	8,915
Total carcasses marked (Mi)	34	58	48	65	71	46	13	15			
									Adjusted estimate d/:		**8,599**

Section 2: Parks Bar to Daguerre Point Dam

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	124	279
3	1	8	--	--	--	--	--	--	9	153	612
4		0	10	--	--	--	--	--	10	227	749
5		1		15	--	--	--	--	16	277	929
6				1	7	--	--	--	8	216	1,811
7				1	2	0	--	--	3	254	2,076
8							8	--	8	207	845
9							4	10	14	170	611
Total recovered (Ri):	4	9	10	17	9	0	12	10		Total:	7,912
Total carcasses marked (Mi)	9	38	33	56	82	57	49	34			
									Adjusted estimate e/:		**7,563**

Section 3: Daguerre Point Dam to Marysville

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	--	0	--	--	--	--	--	--	0	60	60
4	--	0	5	--	--	--	--	--	5	112	426
5	--	1		5	--	--	--	--	6	259	1,448
6	--			4	11	--	--	--	15	242	1,254
7	--				2	8	--	--	10	322	2,130
8	--				1		9	--	10	265	2,175
9	--						1	2	3	8	164
Total recovered (Ri):		1	5	9	14	8	10	2		Total:	7,657
Total carcasses marked (Mi)		13	19	37	78	55	85	53			
									Adjusted estimate f/:		**7,330**

a/ Surveys were conducted in Section 1 from 8 October through 3 December, in Section 2 from 9 October through 4 December, and in Section 3 from 17 October through 5 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 from the total estimate, i.e. 8,915 - 316 = 8,599

e/ Adjusted estimate, where 7,912 - 349 = 7,563.

f/ Adjusted estimate, where 7,657 - 327 = 7,330.

The salmon spawner population of the Watt Avenue to Sailor Bar section of the river, estimated from carcass mark-and-recovery data using the Schaefer model (Appendix 3) was 65,904 fish (Table 9). An estimated 8,841 fish were entrained on the Nimbus Racks or passed upstream to Nimbus Basin. In addition, 7,651 salmon entered Nimbus Hatchery[10/], bringing the total American River 1996 fall-run population to 82,396 fish (Appendix 1).

Based on examination of 406 fresh carcasses, the run consisted of 51.2% male adults (FL > 68 cm [26.8 in.]), 39.4% female adults, 7.9% male grilse (FL ≤ 68 cm), and 1.5% female grilse (FL ≤ 65 cm). Salmon entering Nimbus Hatchery consisted of 46.5% male adults (FL ≥ 60 cm [23.6 in.]), 47.3% female adults, and 6.2% grilse (FL < 60 cm).

The 1996 run of 82,396 salmon in the American River was 5% lower than the previous year's population, but was still over twice the average population for 1986-1995 (Appendix 2).

[10/] Barngrover, B. CDFG-SVCSR. Personal communication.

TABLE 9. Chinook salmon carcass mark-and-recovery data used to estimate the 1996 fall-run spawner population in the American River from Sailor Bar to Watt Avenue. a/

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	11	11
3			--	--	--	--	--	0	128	128
4			4	--	--	--	--	4	529	2,539
5			0	27	--	--	--	27	2,405	8,195
6			1		49	--	--	50	3,363	11,858
7					2	21	--	23	4,256	31,499
8					1	1	55	57	4,071	12,304
Total recovered (Ri):	0	0	5	27	52	22	55		Total:	66,534
Total carcasses marked (Mi):	1	0	24	92	182	171	161			
								Adjusted estimate d/:		**65,904**

a/ Surveys were conducted from 14 October through 4 December 1996.

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 subtracte subtracted from the total estimate, i.e. 66,534 - 630 = 65,904.

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 16,737 salmon, consisting entirely of fall-run fish, was estimated for 1996 (Appendix 1).

Cosumnes River

Fall run. This tributary was not surveyed in 1996.

Mokelumne River

Fall run. In 1996, the upstream migration of fall-run salmon was monitored by Natural Resources Scientist, Inc. under contract to East Bay Municipal Utilities District (Setka 1997). Counts of salmon were made, using video equipment and trapping, in the Woodbridge Irrigation District Dam fish ladders during 3 September through 10 December. Monitoring was not possible through the entire migration period due to high river flows.

A total of 7,775 salmon was counted migrating past or relocated upstream of the dam. Of these salmon, 3,883 fish entered the Mokelumne River Fish Installation, and the 1996 in-river fall-run spawner population was assumed to be 3,892 fish (Appendix 1).

The run at Woodbridge Dam consisted of 31.2% male adults, 26.3% female adults, 34.2% male grilse, and 8.3% female grilse. The composition of the salmon entering the hatchery was 24.4% male adults (FL > 61 cm [24 in.]), 22.7% female adults, and 52.9% grilse (FL ≤ 61 cm.)[11/].

The 1996 spawner population of 7,775 fish in the Mokelumne River was an increase of 44% from the previous year's run (Appendix 2), and was the largest since the run of 8,298 fish in 1984 (Kano et al. 1996).

Calaveras River

This tributary was not surveyed in 1996.

[11/] Barngrover, B. CDFG-SVCSR. Personal communication.

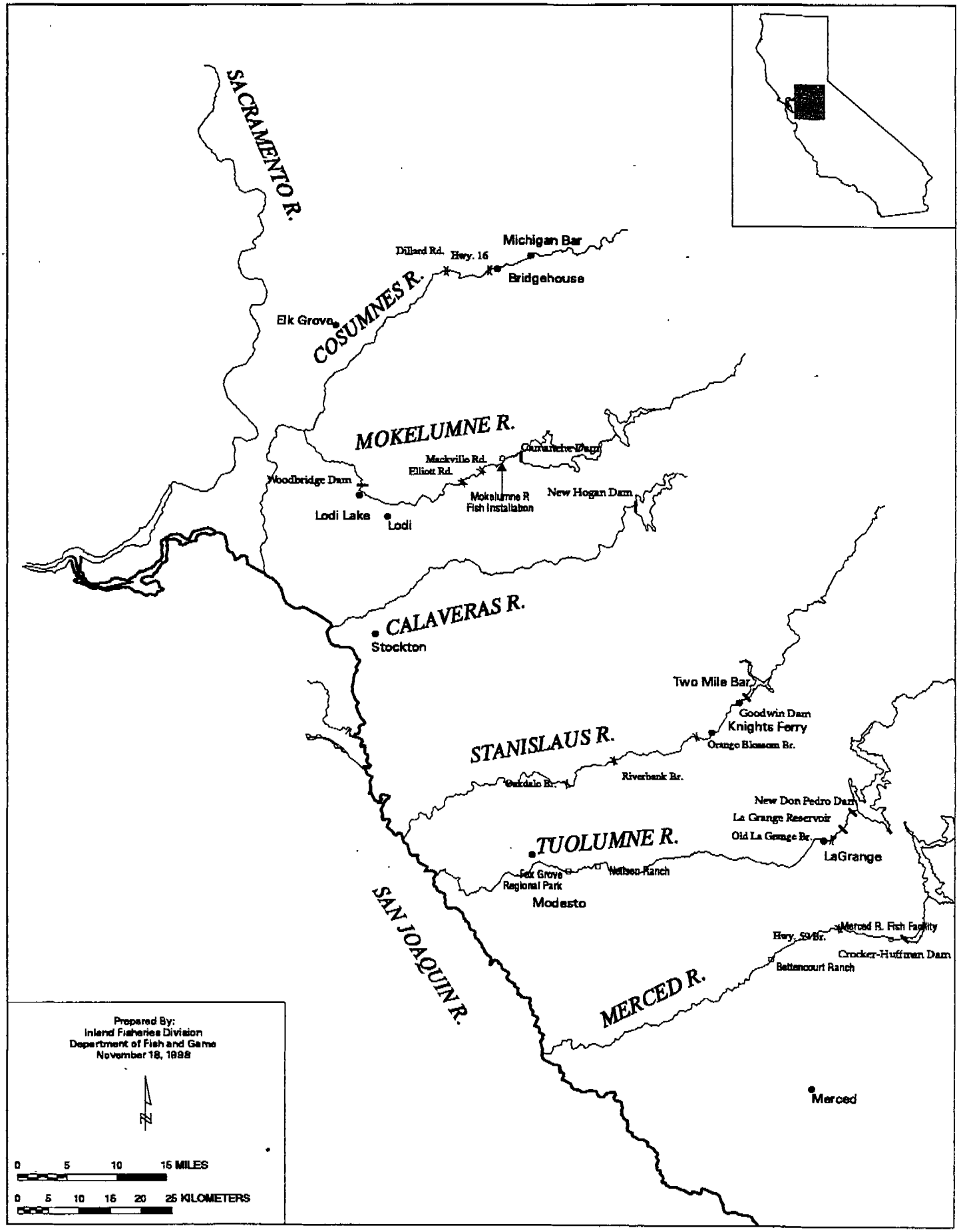

Figure 4. San Joaquin River system from the Merced River to the Cosumnes River.

Stanislaus River

Fall run. Spawner surveys were conducted during 6 October through 5 December 1996 in the 30.9-km (19.2-mi) stretch of the river from Knights Ferry to Riverbank. Only one survey was made of the Goodwin Dam/Two-mile Bar area during that period.

All salmon carcasses, regardless of condition or age-class, were marked using serially-numbered tags attached to their jaws with hog-rings. 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 were intended to allow post-season distinction of age-class and condition, so the data could be better compiled for estimating the population.

High stream flows made it difficult to conduct the surveys, and the entire spawning season was not covered. A total of only 48 carcasses was marked, and none were recovered. A spawner population estimate was based on those carcasses marked this season, and the average recovery rate (0.0285) for surveys made from 1990 through 1995.[12/] The 1996 population in the Knights Ferry to Riverbank stretch of the Merced River was estimated to be 168 fish. The population was not estimated for the Goodwin Dam and Two-mile Bar area.

The adult-grilse composition of the population was determined from frequency distributions of length measurements for fresh carcasses taken this season during all of the San Joaquin River tributary surveys. The length criteria used to distinguish adult from grilse salmon was calculated separately for males and females of both hatchery- and naturally-spawned-origin; salmon carcasses of hatchery-origin were identified as those having an adipose fin-clip (Ad-clip) or a coded-wire tag (CWT), while those with neither an Ad-clip or CWT were classified as being of natural origin. Hatchery-origin male salmon with a FL $\geq$ 66 cm (26 in.) and female fish with a FL $\geq$ 63 cm (24.8 in.) were considered adults. Natural-origin males with a FL $\geq$ 69 cm (27.1 in.) and females with a FL $\geq$ 65 cm (25.6 in.) were considered adults. Based on these length criteria, the entire run consisted of 19.6% male adults, 21.7% female adults, 39.1% male grilse, and 19.6% female grilse.[13/]

[12/] Neillands, W.G. CDFG-San Joaquin Valley-Southern Sierra Region (SJVSSR). Personal communication.

[13/] Loudermilk, W., W.G. Neillands, and S.J. Baumgartner. Sportfish Restoration Act Annual Report, 1996-1997. Grant F-51-9-9, Project 5, Job 2. CDFG-SJVSSR, Fresno office.

The 1996 Stanislaus River fall-run spawner population of 168 salmon was a decrease of 73% from the previous year's run, and only 6% of the average run size for 1986-1995 (Appendix 2).

Tuolumne River

Fall run. Fall-run chinook salmon spawner surveys in the Tuolumne River were conducted from 23 October through 4 December 1996. Surveys covered the river stretch from Old LaGrange Bridge downstream to Fox Grove Regional Park, a distance of 38.5 km (24 mi).

All salmon carcasses, regardless of condition or age-class, were marked using serially-numbered tags attached to their jaws with hog-rings. 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 were 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 Schaefer estimate (Appendix 3) was the most appropriate technique.[14/]

The salmon population in the river section between Old LaGrange Bridge and Fox Grove Regional Park was estimated at 4,362 fish, using the fresh carcass mark-and-recovery data in the Schaefer model (Table 10). The population up- and down-stream of the mark-and-recovery survey area was not estimated.

The adult-grilse composition of the population was determined from frequency distributions of length measurements for fresh carcasses taken this season during all of the San Joaquin River tributary surveys. The length criteria used to distinguish adult from grilse salmon was calculated separately for males and females of both hatchery- and naturally-spawned-origin; salmon carcasses of hatchery-origin were identified as those having an adipose fin-clip (Ad-clip) or a coded-wire tag (CWT), while those with neither an Ad-clip or CWT were classified as being of natural origin. Hatchery-origin male salmon with a FL $\geq$ 66 cm (26 in.) and female fish with a FL $\geq$ 63 cm (24.8 in.) were considered adults. Natural-origin males with a FL $\geq$ 69 cm (27.1 in.) and females with a FL $\geq$ 65 cm (25.6 in.) were considered adults. Based on these length criteria, the entire run consisted of 15.7% male adults, 16.4% female adults, 50.5% male grilse, and

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[14/] Neillands, W.G. CDFG-SJVSSR. Personal communication.

TABLE 10. Chinook salmon carcass mark-and-recovery data used to estimate the 1996 fall-run spawner population in the Tuolumne River from Old LaGrange Bridge to Fox Grove Regional Park. 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	1	--	--	--	--	--	1	105	578
3	1	11	--	--	--	--	12	196	555
4		4	20	--	--	--	24	321	755
5		1	12	31	--	--	44	375	974
6		1	1	20	16	--	38	345	1,178
7				1	1	6	8	73	731
Total recovered (Ri):	2	17	33	52	17	6		Total:	4,771
Total carcasses marked (Mi):	11	44	76	141	75	73			
							Adjusted estimate d/:		**4,362**

a/ Surveys were conducted from 23 October through 4 December 1996.

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. 4,771 - 409 = 4,362.

17.4% female grilse.[15/]

The 1996 fall run of 4,362 salmon in the Tuolumne River was over five times greater than the previous year's population, and the highest since 1988 (Appendix 2).

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 30 October through 11 December 1996.

This season all salmon carcasses, regardless of condition or age-class, were marked using serially-numbered tags attached to their jaws with hog-rings. 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 were 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 Schaefer estimate (Appendix 3) was the most appropriate technique.[16/]

A Schaefer estimate of 3,291 salmon was calculated for the river stretch from Crocker-Huffman Dam to Hwy.59 (Table 11). Merced River Hatchery took in 1,141 salmon[17/], for a total 1996 fall-run spawner population of 4,432 fish (Appendix 1).

The adult-grilse composition of the population was determined from frequency distributions of length measurements for fresh carcasses taken this season during all of the San Joaquin River tributary surveys. The length criteria used to distinguish adult from grilse salmon was calculated separately for males and females of both hatchery- and naturally-spawned-origin; salmon carcasses of hatchery-origin were identified as those having an adipose fin-clip (Ad-clip) or a coded-wire tag (CWT), while those with neither an Ad-clip or CWT were classified as being of natural origin. Hatchery-origin male salmon with a FL $\geq$ 66 cm

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[15/] Loudermilk, W., W.G. Neillands, and S.J. Baumgartner. Sportfish Restoration Act Annual Report, 1996-1997. Grant F-51-9-9, Project 5, Job 2. CDFG-SJVSSR, Fresno office.

[16/] Neillands, W.G. CDFG-SJVSSR. Personal communication.

[17/] Cozart, M. CDFG-SJVSSR. Personal communication.

TABLE 11. Chinook salmon carcass mark-and-recovery data used to estimate the 1996 fall-run spawner population in the Merced River from Crocker-Huffman Dam to Hwy. 59. a/

Recovery period (j)	Number of marked carcasses recovered from marking period (i): 1	2	3	4	5	Total marked carcasses recovered (Rj)	Total carcasses observed (Cj) b/	Population estimate (N) c/
2	0	--	--	--	--	0	72	72
3	1	8	--	--	--	9	182	404
4		2	10	--	--	12	247	862
5		3	9	19	--	31	491	1,364
6		5		7	30	42	353	832
Total recovered (Ri):	1	18	19	26	30		Total:	3,534
Total carcasses marked (Mi):	4	36	72	63	72			
						Adjusted estimate d/:		**3,291**

a/ Surveys were conducted from 30 October through 11 December 1996.

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. 3,534 - 243 = 3,291.

(26 in.) and female fish with a FL ≥ 63 cm (24.8 in.) were considered adults. Natural-origin males with a FL ≥ 69 cm (27.1 in.) and females with a FL ≥ 65 cm (25.6 in.) were considered adults. Based on these length criteria, the in-river run consisted of 26.1% male adults, 35.3% female adults, 26.6% male grilse, and 12.0% female grilse.[18/] Salmon which entered Merced River Hatchery consisted of 34.6% adults (FL ≥ 61 cm [24 in]) and 65.4% grilse (FL < 61 cm).

The 1996 Merced River fall run of 4,432 salmon was an increase of 52% from previous year's run size, and 70% greater than the average population size from 1986 through 1995 (Appendix 2).

[18/] Loudermilk, W., W.G. Neillands, and S.J. Baumgartner. Sportfish Restoration Act Annual Report, 1996-1997. Grant F-51-9-9, Project 5, Job 2. CDFG-SJVSSR, Fresno office.

SUMMARY

The total estimated 1996 Central Valley chinook salmon spawner population was 367,695 fish (Table 12). This was 13% higher than the 1995 total of 325,973 salmon (Kano 1999).

All of the late-fall, winter, and spring runs, and 95% of the fall run were in the Sacramento River system. In the upper mainstem, the winter run showed a decrease of 17% from the 1995 population, and the spring run increased 19%. In the Yuba River, the fall run almost doubled over the previous year with the highest population since 1982.

The total fall run in San Joaquin River tributaries was 71% higher than that of 1995, despite one of the lowest runs recorded in the Stanislaus Rivers. However, this system still only contributed a small portion (4.5%) of the total Central Valley escapement.

TABLE 12. Summary of the 1996 Sacramento-San Joaquin river system chinook salmon spawner populations.

Spawning area	Late-fall run	Winter run	Spring run	Fall run	Total
Sacramento mainstem	48 a/	1,024	378	83,560	85,010
Sacramento tributaries	1,337 b/	325	8,704	255,582	265,948
San Joaquin tributaries	--	--	--	16,737	16,737
Totals:	**1,385**	**1,349**	**9,082**	**355,879**	**367,695**

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

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APPENDIX 1. 1996 chinook salmon spawner population estimates for the Central Valley river system.

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/	b/	1,024	378	71,206	72,608
Transferred from Keswick to CNFH c/	48	0	--	--	48
Clear Creek	d/	--	0	5,922	5,922
Cottonwood Creek	d/	--	6	d/	6
Battle Creek					
Coleman National Fish Hatchery	1,337	--	--	21,178	22,515
Upstream of hatchery	--	325	34	--	359
Downstream of hatchery	d/	--	--	52,409	52,409
(Totals for tributary):	(1,337)	(325)	(34)	(73,587)	(75,283)
Totals for area:	**1,385**	**1,349**	**418**	**150,715**	**153,867**
Red Bluff to Princeton Ferry					
Sacramento River mainstem					
Red Bluff to Tehama Bridge	d/	b/	b/	7,012	7,012
Tehama Bridge to Woodson Bridge	d/	b/	b/	2,922	2,922
Woodson Br to Hamilton City	d/	--	--	2,003	2,003
Hamilton City to Ord Bend	d/	--	--	417	417
Ord Bend to Princeton Ferry	d/	--	--	0	0
(Totals for tributary).				(12,354)	(12,354)
Antelope Creek	--	--	1	d/	1
Mill Creek	--	--	253	d/	253
Deer Creek	--	--	614	d/	614
Totals for area:			**868**	**12,354**	**13,222**
Big Chico Creek to American River					
Big Chico Creek	--	--	2	d/	2
Butte Creek	--	--	1,413	500	1,913
Feather River					
Feather River Hatchery	--	--	6,381	8,107	14,488
In-river	--	--	d/	57,170	57,170
(Totals for tributary):			(6,381)	(65,277)	(71,658)
Yuba River	--	--	d/	27,900	27,900
American River					
Nimbus Hatchery	--	--	--	7,651	7,651
Nimbus Basin	--	--	--	8,841	8,841
In-river	--	--	--	65,904	65,904
(Totals for tributary):				(82,396)	(82,396)
Totals for area:			7,796	176,073	183,869
Sacramento River System Totals:	**1,385**	**1,349**	**9,082**	**339,142**	**350,958**
San Joaquin River System:					
Mokelumne River					
Mokelumne River Fish Installation	--	--	--	3,883	
In-river	--	--	--	3,892	
(Totals for tributary).				(7,775)	
Stanislaus River	--	--	--	168	
Tuolumne River	--	--	--	4,362	
Merced River					
Merced River Hatcheryr	--	--	--	1,141	
In-river	--	--	--	3,291	
(Totals for tributary):				(4,432)	
San Joaquin River System Totals:				**16,737**	

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

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

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

d/ Tributary was not surveyed for this run.

APPENDIX 2. Chinook salmon spawner population estimates from 1986 through 1996 in California's Central Valley tributaries.

Tributary / Race	Estimated number of fish											1986-1995
	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	**1996**	average
Sacramento River mainstem upstream of Red Bluff												
Late-fall run	7,811	15,393	11,324	11,351	7,136	6,721	9,733	739	a/	a/	**a/**	7,021
Winter run	2,394	1,978	2,075	527	437	190	1,177	333	147	1,230	**1,024**	1,049
Spring run	15,824	10,972	9,568	5,139	3,856	762	372	386	740	318	**378**	4,794
Fall run	67,940	75,958	68,623	50,679	33,024	22,937	25,391	33,824	19,669	27,678	**71,206**	42,572
Battle Creek												
Fall run b/	31,252	24,249	67,475	31,048	21,088	17,241	12,708	18,616	43,265	83,192	**73,587**	35,013
Sacramento River mainstem downstream of Red Bluff												
Fall run	34,372	32,588	21,250	10,056	16,127	9,936	8,101	12,895	7,106	5,469	**12,354**	15,790
Feather River												
Spring run c/	1,433	1,213	6,833	5,078	1,893	4,303	1,497	4,672	3,641	5,414	**6,381**	3,598
Fall run b/	55,471	77,846	49,036	48,119	6,126 c/	42,062	40,545	42,914	53,584	72,061	**65,277**	53,515 d/
Yuba River												
Fall run	19,328	18,518	9,000	7,622	e/	14,008	6,362	6,703	10,890	14,237	**27,900**	11,852
American River												
Fall run b/	55,067	46,143	33,514	28,923	10,239	25,211	11,267	39,410	39,817	86,828	**82,396**	37,642
Mokelumne River												
Fall run b/	7,167	1,630	528	281	499	410	1,645	3,157	3,421	5,417	**7,775**	2,416
Stanislaus River												
Fall run	6,497	6,292	10,212	1,510	480	394	255	677	1,031	619	**168**	2,797
Tuolumne River												
Fall run	7,404	14,751	5,779	1,275	96	77	132	471	506	827	**4,362**	3,132
Merced River												
Fall run b/	7,439	4,126	4,592	427	82	119	986	1,678	3,589	2,922	**4,432**	2,596

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.

APPENDIX 3. 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

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