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CHINOOK SALMON SPAWNER STOCKS IN CALIFORNIA'S CENTRAL VALLEY, 1990

Edited by

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Inland Fisheries Division

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ABSTRACT

This report covers the 38th 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 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 1990 total escapement of chinook salmon in the Central Valley was 104,158 fish. This total consisted of 87,761 fall-, 7,557 spring-, 472 winter-, and 8,368 late-fall-run spawners. All of the spring-, late-fall-, and winter-run salmon were estimated to be in the Sacramento River system, while 1,195 fish of the fall run were in the San Joaquin River system.

Due to decreases of spawner populations in all Central Valley tributaries, the total 1990 salmon stock was 49% lower than in 1989; however, fall run populations in the Feather and Yuba rivers, two of the larger tributaries, were not surveyed. The winter run in the mainstem Sacramento River was at a record low level.

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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 38th 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 enter the river 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 sex composition of spawner populations, and to recover coded-wire-tagged salmon. Any changes in spawning distribution and habitat conditions that may adversely affect salmon are noted to determine if corrective action is necessary.

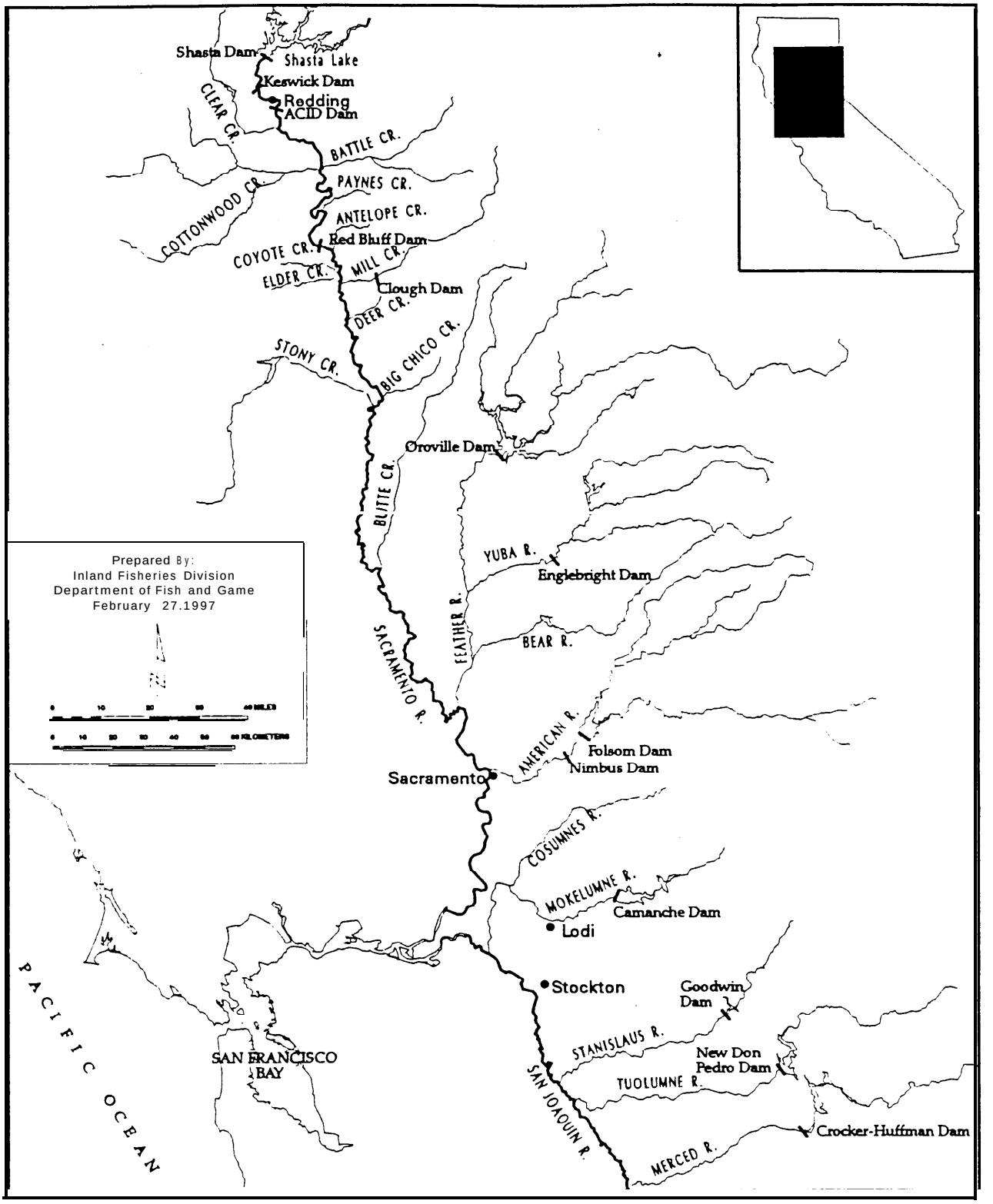

FIGURE 1. Sacramento-San Joaquin River system of California% Central Valley.

GENERAL METHODS

During 1990, spawner stock data were collected in most 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, 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

Spawner population sizes were estimated for all four runs of chinook salmon in the Sacramento River mainstem (Figure 2) upstream of Red Bluff Diversion Dam (RBDD). Clear and Battle creeks were the only tributaries in this area for which individual fall-run population estimates were made. Spawning distribution in the mainstem was determined from aerial redd counts.

In 1990, 65,635 salmon were estimated for the Sacramento River system between Keswick Dam and Red Bluff, consisting of 54,112 fall-, 7,228 late-fall-, 437 winter and 3,858 spring-run fish (Appendix 2). The mainstem portions of the fall- and late-fall-run spawner population were 32,013 and 7,136 fish, respectively. All winter-run, and almost all of the spring-run salmon (3,856 fish) were in the mainstem. The mainstem totals which are reported include fish from tributaries in which a run might have occurred, but where no surveys were made; e.g. the late-fall run in Clear Creek, and the late-fall, winter, and spring runs in Battle Creek.

Sacramento River Mainstem - by Richard E. Painter

Estimates of the total numbers of salmon using the Sacramento River system upstream from RBDD during 1990 were based on daily counts made by the U.S. Fish and Wildlife Service (USFWS) and CDFG at the dam. Counts were obtained through closed-circuit television monitoring of salmon passing through the RBDD fishways.

Total 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 their relative degree of ripeness (an indication of when it was believed that they would spawn).

The numbers of spring- and fall-run salmon passing RBDD in a calendar year account for the entire annual run of these races.

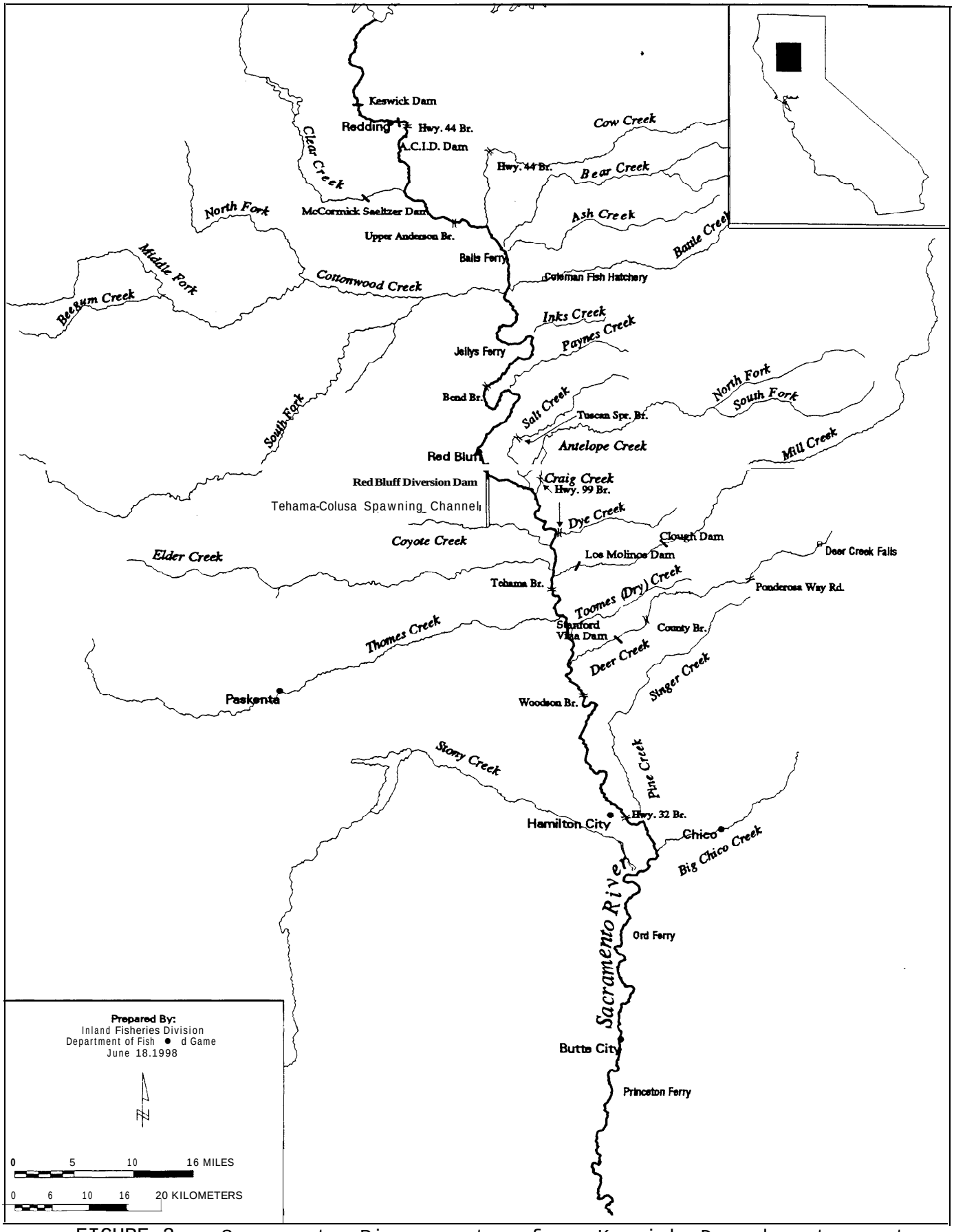

FIGURE 2. Sacramento River system from Keswick Dam downstream to Princeton Ferry.

However, the late-fall and winter runs for 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. The total 1990 potential spawners for each of these two runs was obtained by adding the appropriate estimated numbers of fish from the 1989 calendar year that would spawn in 1990, and not including that portion of the 1990 calendar year estimated numbers that would spawn in 1991.

The RBDD gates were raised during periods from 1 December 1989 through 1 April 1990 to facilitate upstream migration of the winter run of chinook salmon. When the dam gates are open the fishways are essentially inoperable, and counts are not possible. Estimated numbers of late-fall- and winter-run salmon for these periods were calculated based on historical data. The number of 1990 late-fall-run salmon estimated from counts made when the gates were closed was expanded to determine the remainder of the run, using the average of proportional distributions seen in the 19684985 late-fall runs (when the gates were closed year-round). Likewise, expansion of winter-run salmon numbers, from counts with the gates closed, was made using that run's 1968-1985 average proportional distribution.

For each of the four runs, the estimated spawner population upstream of RBDD was further defined by reducing the number of potential spawners by the estimated number of fish landed 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 numbers of sport-caught salmon were also estimated from historical data. Late-fall-, spring-, and fall-run 1990 catches were calculated using the average percentage caught of each respective run during the 1977-1986 period. The 1990 winter-run catch was estimated using the 1970-1975 average catch percentage. Late-fall- and winter-run estimated catches were also adjusted to account for a shortened sport fishing season (an angling closure for salmon was in effect from 15 January through 31 March 1990).

To obtain the late-fall-, spring and fall-run populations for only the mainstem upper Sacramento River, the numbers of potential spawners was reduced by the numbers for the appropriate run in Battle and Clear creeks.

Late-fall run. An estimated 7,305 late-fall 1990 potential spawners passed RBDD in 1989 and 1990 (Table 1). The late-fall sport-catch was estimated to be 77 salmon, leaving 7,228 fish (Table 2) as a spawner population upstream of Red Bluff. Ninety-two late-fall salmon entered Coleman National Fish Hatchery

TABLE 1. Adjusted chinook salmon counts and estimated numbers of each run at Red Bluff Diversion Dam from 22 October through 29 December 1990. 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 d/	Spring % of fish examined	Spring Estimated number d/	Fall % of fish examined	Fall Estimated number d/
22 Oct-30 Dec '89 e/	--	--	--	3,788	--	8	--	--	--	--
1990										
31-Dec-89 – 06-	--	--	--	475 f/	--	74				
07-Jan – 13-Jan	--	--	--	462 f/	--	8 f/				
14-Jan – 20-Jan	--	--	--	224 f/	--	2 f/				
21-Jan – 27-Jan	--	--	--	213 f/	--	6 f/				
28-Jan – 03-Feb	--	--	--	261 f/	--	10 f/				
04-Feb – 10-Feb	--	--	--	298 f/	--	14 f/				
11-Feb – 17-Feb	--	--	--	306 f/	--	14 f/				
18-Feb – 24-Feb	--	--	--	320 f/	--	4 f/				
25-Feb – 03-Mar	--	--	--	240 f/	--	284				
04-Mar – 10-Mar	--	--	--	156 f/	--	34P				
11-Mar – 17-Mar	--	--	--	127 f/	--	41 f/	--	0 f/		
18-Mar – 24-Mar	--	--	--	248 f/	--	34 f/	--	4 f/		
25-Mar – 31-Mar	--	--	--	152 f/	--	22 f/	--	9 f/		
01-Apr – 07-Apr	--	--	--	30 f/	--	48 f/	--	25 f/		
08-Apr – 14-Apr	56	7	0.0	0	42.9	24	57.1	32		
15-Apr – 21-Apr	143	27	3.7	5	22.2	32	74.1	106		
22-Apr – 28-Apr	123	33	0.0	0	242	30	75.8	93		
29-Apr – OS-May	186	55	Total g/:	7,305 h/	1.8	3	98.2	183		
06-May – 12-May	186	33			9.1	17	90.9	169		
13-May – 19-May	366	41			2.4	9	97.6	357		
20-May – 26-May	301	57			1.8	5	982	296		
27-May – 02-Jun	180	17			0.0	0	100.0	180		
03-Jun – 09-Jun	498	60			8.3	41	78.4	390	13.3	66
10-Jun – 16-Jun	323	67			0.0	0	343	391	65.7	212
17-Jun – 23-Jun	206	36			0.0	0	222	46	77.8	160
24-Jun – 30-Jun	307	45			0.0	0	20.0	61	80.0	246
01-Jul – 07-Jul	306	6			0.0	0	16.7	51	83.3	255
08-Jul – 14-Jul	913	133			0.0	0	31.6	289	68.4	624
15-Jul – 21-Jul	715	57			0.0	0	5.3	38	94.7	677
22-Jul – 28-Jul	176	48			0.0	0	2.1	4	97.9	172
29-Jul – 04-Aug	1,642	159			0.0	0	1.3	21	98.7	1,621
OS-Aug – 11-Aug	1,123	63			Total g/:	441 i/	15.9	179	84.1	944
12-Aug – 18-Aug	504	45					8.9	45	91.1	459
19-Aug – 25-Aug	3,612	136					10.3	372	89.7	3,240
26-Aug – 01-Sep	2,959	116					5.2	154	94.8	2,805
02-Sep – 08-Sep	2,400	95					6.3	151	93'7	2,249
09-Sep – 15-Sep	3,223	118					1.7	55	98.3	3,168
16-Sep – 22-Sep	5,912	177					3.4	201	96.6	5,711
23-Sep – 29-Sep	9,715	193					2.6	253	97.4	9,462
30-Sep – 06-Oct	5,197	115	1.7	88			0.9	47	97.4	5,062
07-Oct – 13-Oct	4,152	129	0.0	0			0.0	0	100.0	4,152
14-Oct – 20-Oct	4,693	70	0.0	0			Total g/:	3,923	100.0	4,693
21-Oct – 27-Oct	4,266	146	0.7	30					99.3	4236
28-Oct – 03-Nov	2,624	85	11.8	310					88.2	2,314
04-Nov – 10-Nov	1,295	111	36.9	478					63.1	817
11-Nov – 17-Nov	703	57	35.1	247					64.9	456
18-Nov – 24-Nov	561	14	50.0	281					50.0	282
25-Nov – 01-Dec	680	85	45.9	312					54.1	368
02-Dec – 08-Dec										
09-Dec – 15-Dec				1,722 f/		3 f/				1,259 f/
16-Dec – 22-Dec										
23-Dec – 29-Dec										
									Total g/:	55,710 j/
Total for 1990 calendar year k/:	**60,246**	**2,636**		**6,985**		**436**		**3,922**		55,710

a/ Red Bluff Diversion Dam gates were raised from 1 December 1989 through 1 April 1990, and from 3-30 December 1990.

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 facilitywhich 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 1989 that were expected to spawn in 1990 (Kano 1998).

f/ Due to the dam gates being raised, no counts were possible. Estimated numbers based on historical (1968-1985) average proportional run distribution.

g/ Total estimated number of potential spawners for the 1990 run.

h/ Includes 100 fish trapped at Keswick Dam and trucked to Coleman National Fish Hatchery.

i/ Includes 12 fish trapped at Keswick Dam and two fish at Red Bluff Dam that were trucked to Cdeman National Fish Hatchery.

j/ Includes 14 fish trapped at Red Bluff Dam that were trucked to Coleman National Fish Hatchery.

k/ Including late-fall- and winter-run 1991 potential spawners

TABLE 2. Calculation of the 1990 spawner population for each run of chinook salmon upstream of Red Bluff Diversion Dam.

Run	Number of fish passing dam in calendar year: 1989	1990	Number of potential spawners	Estimated sport catch	Estimated 1990 spawner population
Late-fall a/	3,788	+ 3,517 b/	= 7,305	- 77	= 7,228
Winter a/	8	+ 433 b/	= 441	4	= 437
Spring	-- c/	3,923	= 3,923	- 65	= 3,858
Fall	-- c/	55,710	= 55,710	- 1,598	= 54,112
Totals:	3,796	+ 63,583	= 67,379	- 1,744	= 65,635

a/ Estimated numbers of these runs from 2 Dec. 1989 through 1 Apr. 1990 were calculated using the historical (1968-1985) average proportional distribution.

b/ Totals of 3,468 late-fall- and 3 winter-run salmon passed RBDD in the latter part of 1990 (Appendix 2), and were not included in these counts; these fish were considered 1991 spawners.

cl No 1990 spawners of these runs passed Red Bluff in 1989.

(CNFH) through Battle Creek, leaving 7,136 fish as the mainstem spawner population (Appendix 2). Although some late-fall-run salmon may have used other tributaries of the upper Sacramento River, no spawner surveys were made in those streams. Numbers of those fish are included in the upper mainstem population, along with 100 late-fall-run salmon trapped at Keswick Dam that were hauled to CNFH for spawning.

The estimated 7,136 fish late-fall spawner population for the upper Sacramento River mainstem was 63% of the 1989 population of 11,351 fish, and 74% of the race's average run size from 1980 through 1989 (Appendix 3).

Winter run. An estimated 441 winter-run 1990 potential spawners passed RBDD in 1989 and 1990 (Table 1). The winter-run sport-catch was estimated to be four salmon, leaving a spawner population of 437 fish (Table 2) upstream of Red Bluff. Some winter-run salmon may have used Battle Creek, but no spawner surveys were made in that stream. Numbers of those fish are included in the upper mainstem population, along with 12 winter-run salmon trapped at Keswick Dam and two fish from RBDD that were hauled to CNFH for spawning. The 1990 winter-run spawner population upstream of RBDD was the lowest ever recorded, 21% lower than the 1989 population, and only 12% of the average run size for the previous 10 years (Appendix 3).

Spring run. An estimated 3,923 spring-run potential spawners passed RBDD in 1990 (Table 1). The spring-run sport-

catch was estimated to be 65 salmon, leaving 3,858 fish as a spawner population upstream of Red Bluff (Table 2). Two spring-run salmon were counted past CNFH, leaving the mainstem portion of the run as 3,856 fish (Appendix 2). Although some spring-run salmon may have spawned in Clear and Battle creeks, no surveys were made of these tributaries for this run. The 1990 spring-run spawner population upstream of RBDD was a decrease of 33% from the 1989 population, and only 33% of the average run size for the previous 10 years (Appendix 3).

Fall run. An estimated 55,710 fall-run potential spawners passed RBDD in 1990 (Table 1). The fall-run sport-catch was estimated to be 1,598 salmon, leaving 54,112 fish as a spawner population upstream of Red Bluff (Table 2). A total of 22,099 spawners was estimated to be in Battle and Clear creeks, leaving 32,013 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, as well as 14 fish transported from RBDD to CNFH. The fall run in the Sacramento River system upstream of Red Bluff was a decrease of 34% from the 1989 population, and was 71% of the average 1980-1989 population (Appendix 3).

Mainstem spawning distribution. The 1990 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 during each run's spawning season. The majority of the mainstem late-fall-, spring-, and winter-run spawning (86.3%, 92.8%, and 94.7%, respectively) occurred upstream from RBDD (Table 3). Fall-run spawning in this area constituted 66.5% of the entire mainstem.

Clear Creek - by Richard E. Painter

Late-fall. No spawner surveys were conducted for this run in this tributary during 1990.

Fall run. Seven weekly mark-and-recovery surveys of Clear Creek were made between 16 October and 30 November 1990, in the 6.4-km (4-mi) stretch of river downstream from McCormick-Saeltzer Dam. A total of 399 salmon carcasses was examined, of which 89 were marked by colored tape attached to the jaw with a hog ring. Thirty-eight of the marked carcasses were subsequently recovered. A Petersen estimate (Appendix l.A.2) of 1,011 salmon was calculated as the 1990 spawner population.

Based on examination of 370 salmon carcasses, the spawner population consisted of 38.0% male adults (fork length [FL] > 64 cm [25.2 in]), 46.0% female adults, and 16.0% grilse (FL ≤ 64 cm). Prespawning mortality was zero.

TABLE 3. Chinook salmon relative redd distribution during 1990 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/	34	16.1%	0	0.0%	0	0.0%	145	2.0%
A.C.I.D. Dam to Highway 44	77	36.5%	38	39.2%	8	21.1%	1,321	18.2%
Highway 44 to Upper Anderson Bridge	41	19.4%	45	46.4%	20	52.6%	951	13.1%
Upper Anderson Bridge to Balls Ferry	17	8.1%	5	5.2%	3	7.9%	747	10.3%
Balls Ferry to Jellys Ferry	9	4.3%	2	2.1%	5	13.2%	1,082	14.9%
Jellys Ferry to Bend Bridge	3	1.4%	0	0.0%	0	0.0%	468	6.4%
Bend Bridge to Red Bluff Dam	1	0.5%	0	0.0%	0	0.0%	112	1.5%
Red Bluff Dam to Tehama Bridge	9	4.3%	5	5.2%	2	5.3%	1,389	19.1%
Tehama Bridge to Woodson Bridge	10	4.7%	2	2.1%	0	0.0%	710	9.8%
Woodson Bridge to Hamilton City (Hwy. 32)	5	2.4%	0	0.0%	0	0.0%	214	2.9%
Hamilton City to Ord Ferry	5	2.4%	0	0.0%	0	0.0%	106	1.5%
Ord Ferry to Prince ton Ferry	0	0.0%	0	0.0%	0	0.0%	15	0.2%
Totals:	211		97		38		7,260	

a/ Total count made for four aerial surveys from 29 January through 11 April 1990.
b/ Total count made for ten aerial surveys from 3 May through 24 July 1990.
c/ Total count made for three aerial surveys from 13 September through 2 October 1990.
d/ Total count made for five aerial surveys from 11 October through 27 November 1990.
e/ Anderson-Cottonwood Irrigation District Dam.

Cow Creek - by Richard E. Painter

Spring Run. No surveys were conducted for this run in this tributary in 1990.

Fall Run. Aerial redd surveys were made of the creek on 22 October and 27 November 1990, from its mouth to 20.9 km (13 mi) upstream, following the north fork. A total of 29 redds was counted; however, it was difficult to distinguish between old and fresh redds, so some repeated counts may be in the total. No estimate of the Cow Creek fall-run population was made.

Cottonwood Creek - by Richard E. Painter

Spring run. The only survey for this run in the Cottonwood Creek drainage was made in Beegum Creek on 15 August 1990, during which no salmon were observed. A population estimate was not made.

Fall run. Two aerial redd surveys covering the 19.3-km (12-mi) stretch upstream from the creek's mouth were made on 27 October and 27 November 1990. A total of 82 redds was counted, all of which were observed downstream of the South Fork confluence; the presence of several beaver dams probably prevented salmon migration past this point. It was difficult to distinguish between old and fresh redds, so the total may represent some repeated counts. A fall-run population estimate was not made.

Battle Creek - by Richard E. Painter

Late-fall, winter, and spring runs. No spawner surveys were conducted for these runs during 1990 in Battle Creek. The only available spawner data were for 92 late-fall run salmon taken into CNFH, and two spring-run salmon which entered CNFH and were released upstream.

Fall run. Ten weekly surveys were conducted from 9 October through 10 December 1990. Surveys covered the 5.6.km (3.5-mi) stretch of river between CNFH and the old hatchery location. The first eight surveys also included 0.4 km (0.25 mi) of Gover's Ditch from the bypass entrance to the fish screen. 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 calculations (Appendix l.B), 6,453 salmon were estimated as the spawner population in Battle Creek downstream of CNFH (Table 4). Combined with an additional 14,635 fish which entered CNFH, the total Battle Creek fall-run population was 21,088 salmon.

TABLE 4. Chinook salmon carcass mark-and-recovery data used to estimate the 1990 fall-run spawner population in Battle Creek from Coleman National Fish Hatchery to the old hatchery site, including Gover's Ditch. a/

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	11	- -	- -	- -	- -	- -	- -	- -	11	306	561
3	1	57	- -	- -	- -	- -	- -	- -	58	886	1,295
4		8	61	- -	- -	- -	- -	- -	69	968	1,398
5		1	15	61	- -	- -	- -	- -	77	818	1,249
6			2	9	42	- -	- -	- -	53	689	1,177
7			1	2	15	27	- -	- -	45	376	653
8				0		1	15	- -	16	133	314
9				1		3	5	5	14	113	232
						1		1	2	60	113
Total recovered (Ri):	12	66	79	73	57	31	20	5		Total:	6,992
Total carcasses marked (Mi):	22	%	114	113	100	56	48	12			

Adjusted estimate d/: 6,453

a/ Surveys were conducted from 9 October to 10 December 1990.

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. 6,992 – 539 = 6,453.

The composition of fall-run salmon in Battle Creek was 44% male adults (FL > 64 cm [25.2 in]), 53% female adults, and 3% grilse (FL ≤ 64 cm), based on an examination of 3,816 carcasses. In comparison, fish entering CNFH consisted of 48% male adults, 44% female adults, and 8% grilse.

Pre-spawning mortality of fall-run salmon in Battle Creek averaged 1.0% in 1990.

The total 1990 fall run-size for Battle Creek of 21,088 fish was 32% lower than the 1989 run, and 71% of the average run size for 1980 through 1989 (Appendix 3).

Bear, Ash, Inks, and Pavnes creeks

Fall Run. During a normal year of rainfall, these creeks support small fall runs. However, drought conditions prevailed in 1990, with these streams remaining dry or with insufficient flow to attract salmon. No spawner surveys were conducted.

Red Bluff Diversion Dam to Princeton Ferry

Chinook salmon spawner populations in the mainstem Sacramento River downstream of RBDD to Princeton Ferry (Figure 2) were determined through aerial redd counts. Tributaries in this area that were individually surveyed were Antelope, Mill, and Deer creeks. Population estimates were made only for the mainstem, and Mill and Deer creeks.

A total of 18,858 chinook salmon spawners was estimated for the Sacramento River system between Red Bluff and Princeton Ferry in 1990 (Appendix 2). This total consisted of 1,140 late-fall-, 35 winter-, 1,556 spring-, and 16,127 fall-run salmon.

Due to the RBDD gates being opened, the Tehama-Colusa Spawning Channel was not operated, and no salmon entered that facility.

Sacramento River Mainstem - by Richard E. Painter

Late-fall run. Based on four aerial surveys between 29 January and 11 April 1990, an estimated 1,140 late-fall-run salmon were in the mainstem Sacramento River downstream of Red Bluff to Ord Ferry.

Winter run. Based on 10 aerial surveys between 3 May and 24 July 1990, an estimated 35 winter-run salmon were in the mainstem Sacramento River downstream of Red Bluff to Woodson Bridge.

Spring run. Based on three aerial surveys between 13 September and 2 October 1990, an estimated 216 spring-run salmon were in the mainstem Sacramento River downstream of Red Bluff to Tehama Bridge.

Fall run. Based on five aerial surveys from 11 October through 27 November 1990, 16,127 fall-run salmon were estimated for the mainstem Sacramento River between RBDD and Princeton Ferry. This run size was 60% -higher than the 1989 population, but only 55% of the average run size from 1980 to 1989 (Appendix 3).

Mainstem spawning distribution. Redd counts made during the aerial surveys in 1990 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 (Table 3). In proportion to the entire mainstem (including upstream of RBDD) spawning activity, 13.8% of the late-fall-, 7.3% of the winter-, 5.3% of the spring-, and 33.5% of the fall-run redds were observed this section of the river.

Antelope Creek - by Richard E. Painter

Spring run. Three surveys were made of sections of upper Antelope Creek between 3 and 9 August 1990. Snorkeling to count salmon was conducted from the confluence of the north and south forks to 3.2 km (2 mi) downstream, and in 6.4 km (4 mi) of South Fork Antelope Creek from the S.F. Antelope Campground downstream. Only one adult salmon was observed. A population estimate was not made.

Fall run. Surveys in Antelope Creek for this run were not made due to low water conditions.

Mill Creek - by Richard E. Painter

Spring run. During the spring-run spawning period, six surveys were made of upper Mill Creek from 30 July to 11 October 1990. The first survey was conducted by snorkeling pools and glides in the 5.6-km (3.5-mi) stretch downstream of Mill Creek Campground. For the remaining surveys, sections of the creek from the Hwy.36 Bridge to 3.2 km (2 mi) downstream of Blackrock were snorkeled. Totals of five salmon carcasses, 46 adult fish and 37 redds were observed.

Prior to these surveys, spring-run salmon were monitored immigrating past Clough Dam from 4 April through 30 June 1990. 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.

Through this method a total of 844 salmon was determined as the 1990 spring-run population.

Fall run. Surveys were not conducted for this run in Mill Creek during 1990. Due to low streamflows, the mouth of Mill Creek was impassable to fall-run salmon until after 31 October. It was doubtful if any salmon, which entered the creek later, were able to spawn successfully since gravel was heavily silted by runoff from a fire scar.

Deer Creek - by Richard E. Painter

Spring run. In August 1990, spring-run salmon were counted by snorkeling a section of the creek from Deer Creek Falls to 10.5 km (6.5 mi) downstream. This stream section was smaller than the "indicator reach" used to develop a relationship between snorkeling counts and Stanford-Vina dam ladder counts of salmon in 1986, and to estimate the run size in 1987 2/; in that relationship, the indicator reach count represented 31% of the run. This year's stream section was assumed to represent 28.6% of the run, and the total snorkeling count of 142 salmon was expanded to 496 fish for the 1990 spring run.

Fall run. A 1.6-km (l-mi) stretch of lower Deer Creek was surveyed on 21 November 1990, starting at the railroad trestle located 3.2 km (2 mi) upstream from its mouth. Only one grilse salmon was observed. An estimate of the spawner population was not made.

Salt, New, Craig, Dye, Coyote, Elder, Thomes, Toomes, Stoney, and Singer creeks

Fall run. During a normal year of rainfall, these creeks support small fall runs. However, drought conditions prevailed in 1990, with these streams remaining dry or with insufficient flow to attract salmon. No spawner surveys were conducted.

2/ File report of 1986 and 1987 spring-run salmon surveys, from Emil Eckman, U.S. Forest Service, to the National Forest Resource Office, 17 November 1987.

Big Chico Creek to the American River

A total of 18,508 chinook salmon was estimated in 1990 for the Sacramento River tributaries from Butte Creek to the American River (Figure 3). This total consisted of 2,143 spring-run and 16,365 fall-run fish; however, fall-run numbers of in-river spawners for the Feather and Yuba rivers were not determined (Appendix 2).

Bia Chico Creek

Spring run. A single cursory survey was conducted on 1 August 1990. Portions of the creek from Upper Bidwell Park to the Iron Canyon fish ladder, and Higgins Hole were examined by snorkeling. No salmon were observed, and an estimate of the population was not made.

Fall run. No surveys were conducted for this run in 1990.

Butte Creek - by Richard Flint

Spring run. Snorkel surveys were conducted, on 14-15 June and 15 August 1990, of spring-run salmon holding areas from the Centerville Head Dam to the Helltown Bridge. Counts of live salmon ranged from 60 to 83 fish.

A spawner survey was conducted on 1 October 1990, in the river stretch from the Centerville Powerhouse to about 1.6 km (1 mi) downstream of the Covered Bridge. Survey conditions were excellent due to low flows, with 28 salmon carcasses, 48 live fish, and 64 redds counted.

Based on these combined observations it was felt that the spring-run spawner population was about 250 salmon.

Fall run. No surveys were conducted for this run in 1990.

Feather River

Spring run. From 7 September through 1 October 1990, 1,893 salmon classified as spring-run fish (Schlicting 1993) entered Feather River Hatchery (FRH). These fish consisted of 37.8% male adults (FL $\geq$ 68 cm [26.8 in]), 31.2% female adults, and 31.0% grilse (FL < 68 cm). In the river itself, the period of spring-run spawning could not be distinguished from the fall-run spawning period, and no attempt was made to estimate numbers of in-river spring-run salmon.

The 1,893 spring-run salmon at FRH in 1990 was 63% lower than the 1989 run, and 14% lower than the average number observed in the

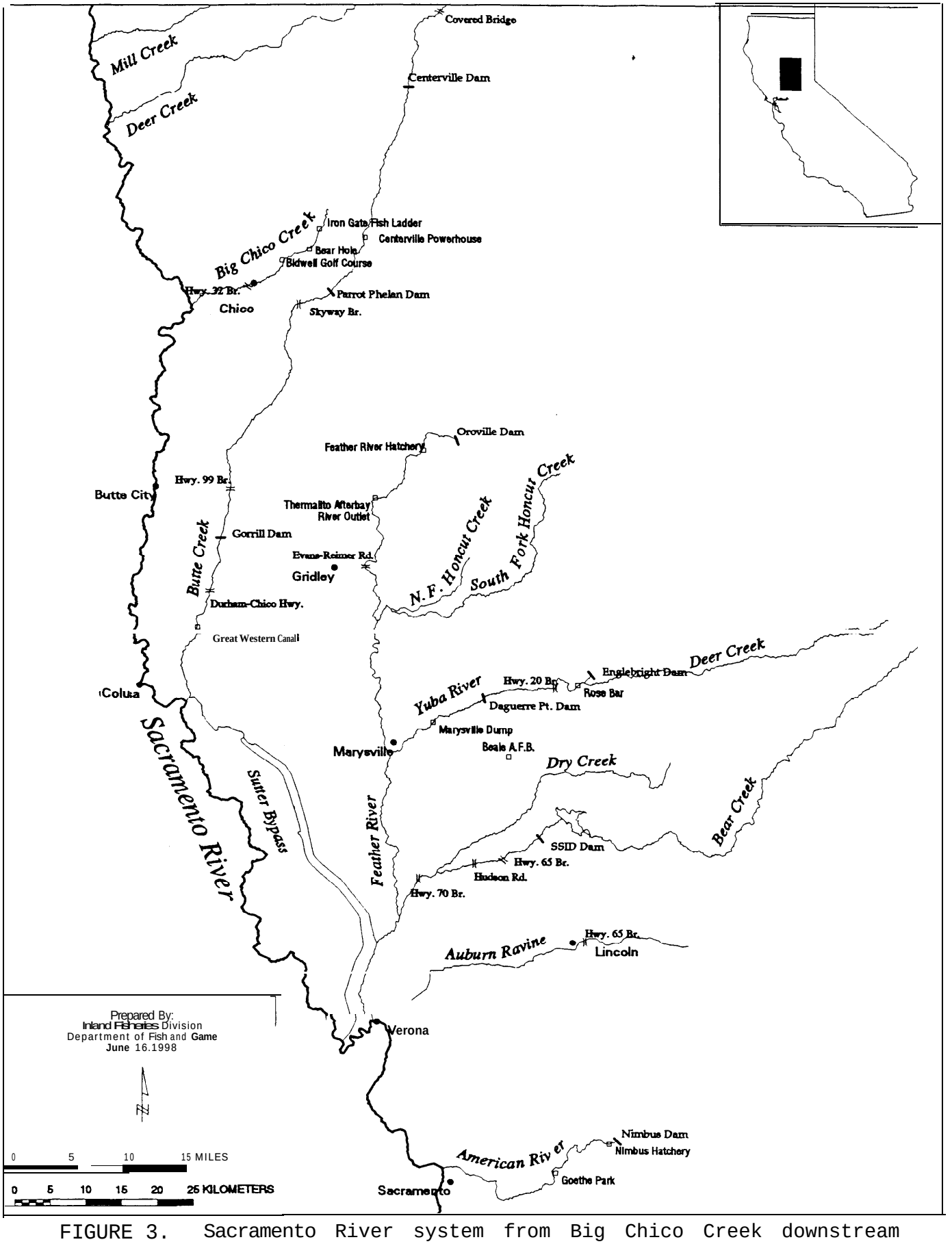

FIGURE 3. Sacramento River system from Big Chico Creek downstream to the American River.

past 10 years (Appendix 3).

Fall run. Surveys to estimate the number of in-river spawners were not conducted in 1990. A total of 6,126 fall-run salmon entered FRH (Schlicting 1993).

Yuba River

Spring Run. No surveys were conducted for this run in 1990.

Fall run. No surveys were conducted for this run in 1990.

American River - by Maury Fjelstad

Fall run. Weekly salmon carcass mark-and-recovery surveys were conducted between 15 November and 3 December 1990 in the 11.2-km (7-mi) reach of the American River from Goethe Park upstream to the Nimbus Hatchery racks. River flows averaged 25.3 m^3/s (893 cfs) during the survey period but varied greatly, ranging from 16.6 to 52.1 m^3/s (585-1840 cfs).

A single survey by boat was also made in mid-spawning season to determine salmon use of the remaining 20.9-km (13-mi) stretch of the river downstream of Goethe Park to the mouth. About 30 live salmon and nine redds were observed on 20 riffles.

This season, only adult carcasses, regardless of their state of decomposition, were marked for use in estimating the population. While all the fresh (clear-eyed) carcasses were marked, due to the large numbers of spawners at times it was only possible to mark about half of the decayed carcasses seen. Marked carcasses were either replaced into running water when possible, or left in place in backwater areas.

The adult salmon spawner population of the Goethe Park to Nimbus racks section, estimated from mark-and-recovery data using the Schaefer calculations (Appendix l.B) was 4,262 fish (Table 5). The adult estimate was expanded to include a 17% grilse proportion, for a total of 5,135 fish in this section. Upstream of the Nimbus racks, 254 spawners were estimated. The two combined estimates gave 5,389 salmon within the river. An additional 4,850 salmon entered Nimbus Hatchery (Ducey 1991), bringing the total American River 1990 fall-run population to 10,239 fish.

The composition of 333 fresh salmon carcasses examined was 37% male adults (FL $\geq$ 68 cm [26.8 in]), 46% female adults, 14% male grilse (FL < 68 cm), and 3% female grilse. In comparison, fall-run salmon entering the Nimbus Hatchery in 1990 consisted of 36.6% male adults (FL $\geq$ 60 cm [23.6 in]), 46.4% female adults, and 17.0% grilse (FL < 60 cm).

TABLE 5. Chinook salmon carcass mark-and-recovery data used to estimate the 1990 fall-run spawner population in the American River from Goethe Park to the Nimbus Hatchery racks. 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) cl
2	62	- -	- -	- -	- -	- -	- -	62	445	560
3	18	42	- -	- -	- -	- -	- -	60	469	1,123
4	0	9	45	- -	- -	- -	- -	54	425	1293
5	1		14	104	- -	- -	- -	119	504	919
6			5	10	84	- -	- -	99	319	629
7			1	2	12	68	- -	83	211	339
8			3	5	10	10	22	SO	154	339
Total recovered (Ri):	81	51	68	121	106	78	22		Total:	5,202
Total carcasses marked (Mi):	102	147	209	201	206	119	58			
								Adjusted estimate d/:		**4,262**

a/ Surveys were conducted from 15 November to 3 December 1990.

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

c/ Schaefer (1951) estimate equation: N = Σ(Rij x (Mi/Ri) x (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. 5,202 – 940 = 4,262.

The 1990 run of 10,239 salmon was 65% lower than the previous year's population, and only 22% of the average run size from 1980 through 1989 (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 1,195 salmon, consisting entirely of fall-run fish, was estimated for 1990 (Appendix 2).

Cosumnes River

Fall run. This tributary was not surveyed.

Mokelumne River

Fall run. A cooperative program (between CDFG, Woodbridge Irrigation District, and East Bay Municipal Utility District [EBMUD]) to attract fall-run salmon to the Mokelumne River was attempted during 1990. River flow was regulated by releases from Camanche Dam to maintain a constant 7.1 m^3/s (250 cfs) from 18-25 October. Flows were increased to 11.3 m^3/s (400 cfs) until 31 October, reduced back to 7.1 m^3 until 17 November, then further decreased to 1.1 - 1.4 m^3/s (40-50 cfs) for the remainder of the spawning season. Water temperatures in the spawning areas ranged from 14.4°C (58°F) in mid-October to 9.4°C (49°F) in mid-November.

Five surveys were conducted by boat of the 7.2-km (4.5-mi) stretch of river from Camanche Dam to Mackville Road between 21 November and 19 December 1990. During these surveys, a total of 35 live salmon and a maximum of 29 redds were counted. Only three salmon carcasses were recovered.

EBMUD also monitored salmon at Woodbridge Dam from 16 October through 17 December 1990 3/. A total of 431 salmon was counted migrating past the dam by using video equipment and a fish trap. Combined with the 68 salmon which entered the Mokelumne River Fish Installation (Estey 1992), the 1990 fall-run spawner population was 499 fish.

3/ J. Hagar. 1991. Upstream migration and spawning of fall run chinook salmon in the Mokelumne River, 1990. Report to EBMUD Fisheries and Wildlife Office. Orinda, CA. 2op.

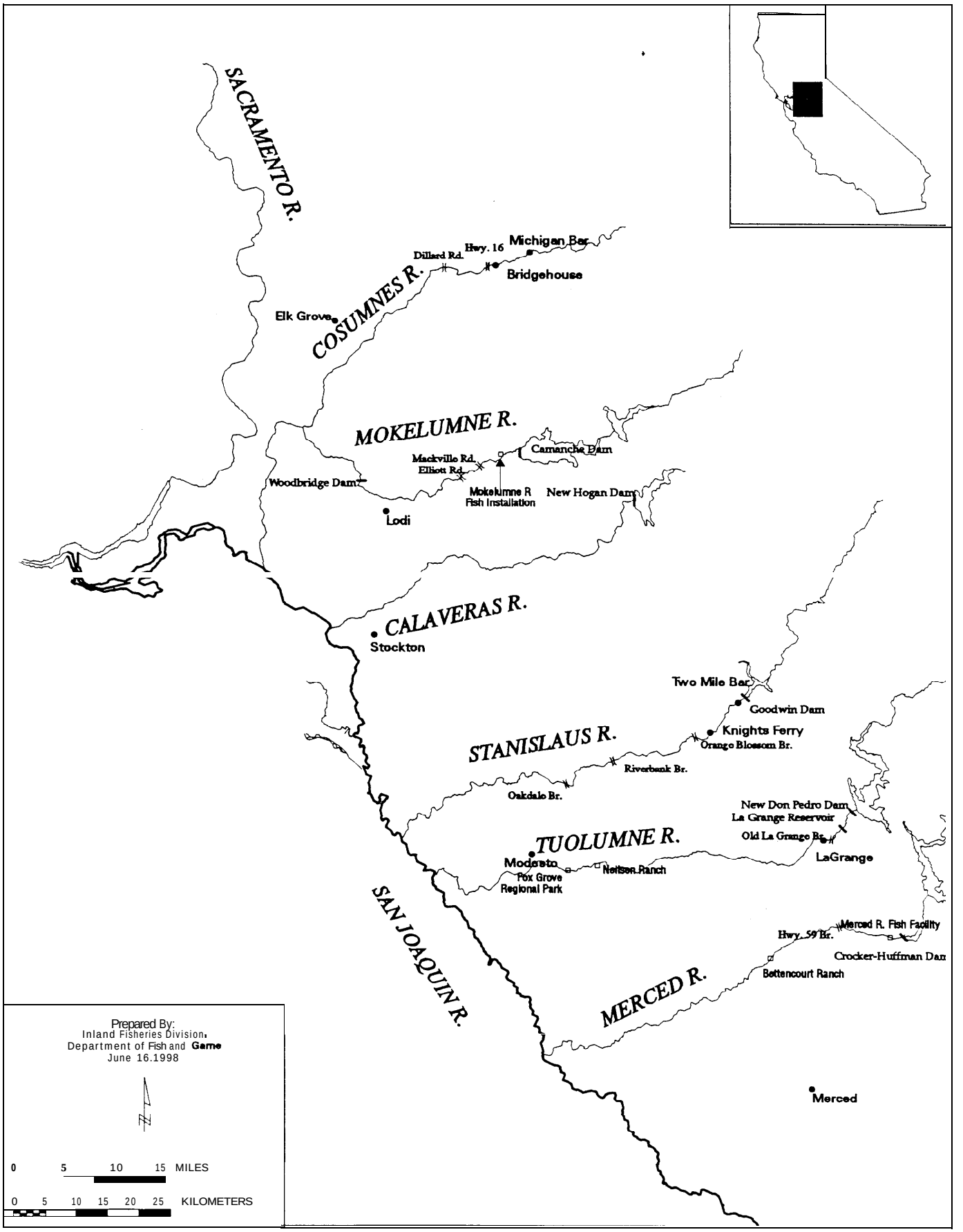

FIGURE 4. San Joaquin River system from the Merced River downstream to the Cosumnes River.

The run at Woodbridge consisted of 36% male adults (FL ≥ 61 cm [24 in]), 29% female adults, 29% male grilse (FL < 61 cm), and 6% female grilse. The composition of the salmon entering the hatchery was 23.5% male adults, 13.2% female adults, and 63.3% grilse.

The 1990 spawner population in the Mokelumne river was 77% higher than the previous year's run, which was the lowest since 1977. However, it was still only 8% of the average population size estimated from 1980 through 1989 (Appendix 3).

Calaveras River

This tributary was not surveyed in 1990.

Stanislaus River - by Steven J. Baumgartner

Fall run. A cooperative program (between CDFG, South San Joaquin and Oakdale irrigation districts, Tri-Dam, and U.S. Bureau of Reclamation) to attract fall-run salmon to the Stanislaus River was attempted during 1990. From 17 October through 7 November, water releases from Goodwin Dam kept river flows at about 4.2 m^3/s (150 cfs). An additional 5.6 m^3/s (196 cfs) was released from the South San Joaquin Irrigation District into the Stanislaus River at Riverbank. A temporary weir and fish-trap just upstream of the Orange Blossom Bridge was operated from 12 October to 7 December to collect eggs from the anticipated increased numbers of salmon.

Spawner surveys were conducted from 7 November through 28 December 1990. Surveys were made on-foot in the Goodwin Dam and Two Mile Bar areas, while the 30.9-km (19.2-mi) stretch from Knights Ferry downstream to Riverbank was covered by boat. During the surveys, river flows at the Orange Blossom Bridge were about 5.0 m^3/s (177 cfs), while water temperatures ranged from 15°C (59°F) in early November to 6°C (42.8°F) in late December. Visibility through the water was always greater than 3 m (10 ft).

This season, fresh and decayed adult salmon carcasses and only fresh grilse salmon carcasses were marked using plastic ribbon attached to a jaw with a hog-ring. Combinations of colors and patterns of ribbons differentiated categories of carcasses each week. Marked carcasses were released into running water for subsequent recovery. Carcasses of decayed grilse salmon and skeletons were only counted and chopped in half to prevent recounting.

The carcass marking protocol was intended to allow use of the data in estimating the population through several biometric models (Appendix 1). Post-season analysis of the data indicated that the Schaefer estimation was the most appropriate technique.

The salmon population of the Knights Ferry to Riverbank section was estimated at 399 fish using the fresh adult and grilse mark-and-recovery data in the Schaefer calculations (Table 6). About 25 salmon were present in the Goodwin Dam and Two-Mile Bar areas.

A total of 119 salmon was trapped at Orange Blossom Bridge from 2 November to 7 December 1990. Ninety-four of these fish (56 males and 38 females) were spawned, and the remaining 25 were released back into the river upstream of the trap to spawn in the wild. The eggs collected were transported to MRFF, raised to fry stage, then transferred to the Tuolumne River Fish Facility near LaGrange.

The combined numbers for fall-run salmon from Goodwin Dam to Riverbank and from the fish spawned at the trap gave a run of 480 fish for the Stanislaus River in 1990.

The run consisted of 34.8% male adults (FL ≥ 68 cm [26.8 in]), 35.1% female adults, 20.1% male grilse (FL < 68 cm), and 10.0% female grilse, based on examination of fresh salmon carcasses from the surveys and the trap. The length separating grilse and adults was determined from data collected in the entire San Joaquin basin surveys.

The 1990 Stanislaus River fall-run spawner population of 480 salmon was a decrease of 68% from the previous year's population, and only 9% of the average run size for the past ten years (Appendix 3).

Tuolumne River - by Mark S. Pisano

Fall run. The 1990 fall-run chinook salmon spawner surveys in the Tuolumne River were conducted from 23 October through 26 December. The run started two to three weeks later than in past seasons, maybe due to the water management program conducted in the Stanislaus River. Tuolumne flows downstream of LaGrange Dam were 6.6 m^3/s (234 cfs) through the end of October and decreased to 2.6 m^3/s (93 cfs) by mid-December. Flows averaged 3.8 m^3/s (134 cfs) during the surveys, and visibility through the water was usually not less than 5 m (16.5 ft). Water temperature decreased from 13.0°C (55.4°F) in October to 8.0°C (46.4°F) in late December.

Carcass mark-and-recovery surveys were conducted in the river stretch from Old LaGrange Bridge downstream to Fox Grove Regional Park, a distance of 38.5 km (24 mi). This season, fresh and decayed adult salmon carcasses and only fresh grilse salmon carcasses were marked using plastic ribbon attached to a jaw with a hog-ring. Combinations of colors and patterns of ribbons differentiated categories of carcasses each week. Marked carcasses were released into running water for subsequent

TABLE 6. Chinook salmon carcass mark-and-recovery data used to estimate the 1990 fall-run spawner population in the Stanislaus River from Knights Ferry to Riverbank. 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	3	- -	- -	- -	- -	- -	3	22	22
3		2	- -	- -	- -	- -	2	29	39
4		1	5	- -	- -	- -	6	33	48
5			0	0	- -	- -	0	51	51
6			1	1	4	- -	6	73	176
7						5	5	27	80
8						2	2	28	52
Total recovered (Ri):	3	3	6	1	4	7		Total:	438
Total carcasses marked (Mi):	3	4	9	5	8	13			
							Adjusted estimate d/:		**399**

a/ Surveys were conducted from 7 November to 28 December 1990.

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

c/ Schaefer (1951) estimate equatio : N = $\leq$ (Rij x (Mi/Ri) x (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. 438 – 39 = 399.

recovery. Carcasses of decayed grilse salmon and skeletons were only counted and chopped in half to prevent recounting.

The carcass marking protocol was intended to allow use of the data in estimating the population through several biometric models (Appendix 1). Post-season analysis of the data indicated that the Petersen estimation was the most appropriate technique.

The population in the river section between Old LaGrange Bridge and Fox Grove Regional Park was 88 salmon, estimated from a total of 29 marked carcasses, 14 of which were recovered. An additional eight decayed grilse carcasses were counted, but not marked. No spawning was observed by Turlock Irrigation District personnel in the river stretches up- and downstream of the mark-and-recovery survey area; the absence of spawning in these areas was a difference from past seasons. The total estimated 1990 fall-run spawner population for the Tuolumne River was 96 salmon.

The run consisted of 43.8% male adults (FL ≥ 68 cm [26.8 in]), 34.4% female adults, 21.8% male grilse (FL < 61 cm); no female grilse were among the salmon sampled for length and sex determinations. The length separating grilse and adults was determined from data collected in the entire San Joaquin basin surveys.

The 1990 run of 96 fall-run salmon was a decrease of 97% from the previous year's population (Appendix 3), and the lowest since the 1963 salmon run of 100 fish (Menchen 1964).

Merced River - by Sharon N. Shiba

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 to 1.2 **km** (0.75 mi) downstream of the Hwy.59 bridge (at Da Sylva's gate). Surveys began on 25 October and were completed on 28 December 1990; the first salmon were observed on 14 November, about three weeks later than they were seen in surveys prior to 1989. An aerial survey to count redds in the river downstream of Hwu.59 to the Santa Fe bridge was made on 17 December.

River flows prior to 2 November 1990 ranged from 2.5 to 3.1 m^3/s (85-110 cfs), while during the remainder of the surveys they ranged from 4.2 to 5.4 m^3/s (149-192 cfs). Water temperatures decreased from 17.8°C (64°F) in late October to 7.5°C (45.5°F) in late December. Visibility through the water was greater than 2 m (6.6 ft) throughout the survey period.

This season, fresh and decayed adult salmon carcasses and only fresh grilse salmon carcasses were marked using plastic ribbon attached to a jaw with a hog-ring. Combinations of colors and patterns of ribbons differentiated categories of carcasses each

week. Marked carcasses were released into running water for subsequent recovery. Carcasses of decayed grilse salmon and skeletons were only counted and chopped in half to prevent recounting.

The carcass marking protocol was intended to allow use of the data in estimating the population through several biometric models (Appendix 1). **Due to** the low number of carcasses marked, the Petersen equation was the most appropriate estimation.

A Petersen estimate of 35 fish was calculated for the river stretch from the Crocker-Huffman Dam to Da Sylva's gate, based on 15 carcasses observed, of which 13 were marked and nine subsequently recovered. An additional decayed grilse carcass was counted, but not marked. No redds were observed downstream of the survey area during the aerial survey, and the spawner population in this stretch of river was assumed to be zero. A total of 46 salmon was taken into the Merced River Fish Facility (M. Cozart, pers. comm.). The total 1990 fall-run spawner population for the Merced River was 82 salmon.

Based on 16 carcasses examined during the surveys, the run was composed of 37.4% male adults (FL ≥ 68 cm [26.8 in]), 31.3% female adults, 31.3% grilse (FL < 68 cm); except for one grilse which could not be sexed, all were males. In comparison, salmon which entered the Merced River Fish Facility consisted of 40.8% male adults (FL ≥ 61 cm [24 in]), 22.5% female adults, and 36.7% grilse (FL < 61 cm). The length separating the in-river grilse and adults was determined from data collected in the entire San Joaquin basin surveys.

One hundred-thirty-nine salmon which had strayed from the San Joaquin River were "rescued" from the San Luis Canal and Los Banos Wildlife Area bypass channel from 13 November through 14 December 1990. The total number of fish present in the western Merced County drainage system was judged to be about twice as many as rescued.

The 1990 Merced River fall run of 82 salmon was a decrease of 81% from the previous year's run size (Appendix 3), and was the lowest spawner population since 1966 (Menchen 1967).

SUMMARY

The total estimated 1990 Central Valley chinook salmon spawner population was 104,158 fish (Table 7).

This was 49% lower than the 1989 total of 205,990 salmon (Kano 1998). The lower spawner population reflected not only decreases in all runs of salmon throughout the system, but also that it was not possible to estimate the runs in the Feather and Yuba rivers (two of the larger tributaries).

As in the past, most of the 1990 salmon run occurred in the Sacramento River system. The Stanislaus, Tuolumne, and Merced rivers of the San Joaquin River system again contributed only a small portion of the fall-run spawners, with a combined total of 658 fish; this was only 20% of the combined total estimated in 1989. The winter run in the mainstem Sacramento River was a record low with only 437 salmon.

TABLE 7. Summary of the 1990 Sacramento-San Joaquin river system chinook salmon spawner populations.

Spawning area	Late-fall run	Winter run	Spring run	Fall run	Total
Sacramento mainstem	8,276	472	4,072	48,140	60,960
Sacramento tributaries	92a/	--	3,485b/	38,464c/	42,041
San Joaquin tributaries	--	--	--	1,157	1,157
Totals:	**8,360**	**472**	**7,557**	**87,761**	**104,158**

a/ Consists only of fish which entered Coleman Hatchery (Battle Creek).
b/ Includes Battle, Mill, Deer, and Butte creeks, and Feather River Hatchery only.
c/ Includes Clear and Battle creeks, the American River, and Feather River Hatchery.

REFERENCES

Boydstun, LB. 1994. Analysis of two mark-recapture methods to estimate the fall chinook salmon (Oncorhynchus tshawytscha) spawning run in Bogus Creek, California. Calif. Fish and Game. 80(l)). 13 p.

Ducey, Ronald D. 1991. Annual report, Nimbus Salmon and Steelhead Hatchery, 1990-91. Calif. Dept of Fish and Game, Inland Fish. Admin. Rep. No. 91-16. 10 p.

Estey, Don F. 1992. Annual report, Mokelumne River Hatchery, 1990-91. Calif. Dept of Fish and Game, Inland Fish. Admin. Rep. No. 92-7. 9 p.

Hoopaugh, David A. (ed.). 1978. King (Chinook) salmon spawning stocks in California% Central Valley, 1976. Calif. Dept. of Fish and Game, Anad. Fish. Br. Admin. Rep. No. 78-19. 33 p.

Kano, R.M. (ed.). 1998. Annual report, chinook salmon spawner stocks in California% Central Valley, 1989. Calif. Dept. of Fish and Game, Inland Fish. Br. Admin. Rep. 98-2. 42 p.

Menchen, R.S. (ed.). 1964. King salmon spawning stocks in California's Central Valley, 1963. Calif. Dept. of Fish and Game, Mar. Res. Br. Rep. No. 64-3. 17 p.

Menchen, R.S. (ed.). 1967. King (chinook) salmon spawning stocks in California's Central Valley, 1966. Calif. Dept. of Fish and Game, Mar. Res. Br. Rep. No. 67-13. 26 p.

Ricker, W.E. 1975. Computation and Interpretation of Biological Statistics of Fish Populations. Res. Bd. Canada, Bull. 191. 382 p.

Schaefer, M.D. 1951. Estimation of size of animal populations by marking experiments. U. S. Fish and Wildl. Serv., Fish. Bull. 52: 189-203.

Schlicting, Donald L. 1993. Annual report, Feather River Hatchery, 1990-91. Calif Dept of Fish and Game, Inland Fish. Admin. Rep. No. 93-5. 10 p.

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 but not 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);

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

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

$\sum_2^i M_i$ = 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:

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

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 ith to the ith+1 periods (S_i):

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

- to estimate survival of carcasses from period 1 to period:

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

In the above eauations, the variables are defined as:

T_i = number of carcasses marked in the ith period,

K_i = total marked carcasses recovered after the ith period that were marked before the ith period,

R_i = total recovered marked carcasses that were marked in the ith period,

M_i = total recovered marked carcasses for the ith period, and

C_i = number of carcasses examined for marks during the ith 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 Si in the denominator of the above two equations is a further modification by Frank Fisher, CDFG, personal comm.)

APPENDIX 2. 1990 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
Sacramento River System:					
Keswick Dam to Red Bluff					
Sacramento River mainstem a/	7,136 b/	437 cl	3,856	32,013	43,442
Clear Creek	-- d/	--	--	1,011	1,011
Battle Creek					
Coleman National Fish Hatchery	92	--	--	14,635	14,727
Upstream of hatchery	--	--	2	--	2
Downstream of hatchery	-- d/	-- d/	-- d/	6,453	6,453
(Totals for tributary):	(92)	--	(2)	(21,088)	(21,182)
Totals for area:	7,228	437	3,858	54,112	65,635
Sacramento River System:					
Red Bluff to Princeton Ferry					
Sacramento River mainstem					
Red Bluff to Tehama Bridge	355	25	216	9,195	9,791
Tehama Bridge to Woodson Bridge	389	10	0	4,718	5,117
Woodson Br. to Hamilton City	198	0	0	1,396	1,594
Hamilton City to Ord Bend	198	0	0	722	
Ord Bend to Princeton Ferry	0	0	0	%	96
(Totals for tributary):	(1,140)	(35)	(216)	16,127)	(17,518)
Mill **Creek**	--	--	844	-- d/	844
Deer Creek	--	--	4%	-- e/	496
Totals for area:	1,140	35	1,556	16,127	18,858
Sacramento River System:					
Butte Creek to Americn River					
Butte Creek	--	--	2.50	-- d/	250
Feather River					
Feather River Hatchery	--	--	1.893	6,126	8,019
In -river	--	--	-- d/	-- d/	--
(Totals for tributary):	--	--	(1,893)	6,126)	(8,019)
Yuba River	--	--	-- d/	-- d/	--
American River					
Nimbus Hatchery	--	--	--	4,850	4.850
In -river	--	--	--	5,389	5,389
(Totals for tributary):	--	--	--	10,239)	(10,239)
Totals for area:	--	--	2,143	16,365	18,508
Sacramento **River system totals:**	8,368	472	7,557	86,604	103,001
San Joaquin River System:					
Mokelumne River					
Mokelumne River Fish Installation	--	--	--	68	68
In – river	--	--	--	431	431
(Totals for tributary):	--	--	--	(499)	(499)
Stanislaus River	--	--	--	480	480
Tuolumne River	--	--	--	%	96
Merced River					
Merced River Fish Facility	--	--	--	46	46
In -river	--	--	--	36	36
(Totals for tributary):	--	--	--	(82)	(82)
San Joaquin River system totals:	--	--	--	1,157	1,157

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

b/ Includes 100 fiih from Keswick Dam that were transported to and spawned at Coleman Hatchery.

c/ Includes 12 fiih from Keswick Dam and 2 fiih from Red Bluff Diversion Dam that were transported to Coleman Hatchery.

d/ Tributarywas not surveyed for this run.

e/ *An* estimate of the run size was not made.

APPENDIX 3. Chinook salmon spawner population estimates from 1980 through 19% in California's Central Valley tributaries.

Tributary / Race	Estimated number of fish											1980- 1989
	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	average
Sacramento River system upstream of Red Bluff (excluding Battle Creek)												
Late-fall run	9,361	6,423	4,899	14,984	7,140	8,136	7,811	15,393	11,724	11,351	7,136	9,682
Winter run	1,142	19,795	1233	1,827	2,662	3,684	2,394	1,978	2,075	527	437	3,732
Spring run	9,363	20,655	23,156	3,854	7,823	10200	15,824	10,972	9,568	5,139	3,856	11,655
Fall run	21,961	33,289	20,567	27,326	41,805	52,820	67,940	75,958	64,170	48,526	32,013	45,436
Battle Creek												
Fall run a/	14,443	17,205	26,795	13,983	29,893	39,808	31,252	24,249	67,475	31,048	21,088	29,615
Sacramento River mainstem downstream of Red Bluff												
Fall run	30,453	42,724	23,833	32,018	19,166	46,780	34,372	32,588	21,250	10,056	16,127	29,324
Feather River												
Spring run b/	269	469	1,910	1,702	1,562	1,632	1,433	1,213	6,833	5,078	1,893	2210
Fall run a/	35,295	53,020	55,519	30,522	51,056	56,002	55,471	77,846	49,036	48,119	6,126 b/	51,189
Yuba River												
Fall run	12,406	14,025	39,367	13,756	9,665	13,042	19,728	18,518	9,000	7,622	c/	15,673
American River												
Fall run a/	49,802	64,055	43,898	35,300	39,696	65,213	55,067	46,143	33,s 14	28,923	10,239	46,161
Cosumnes River												
Fall run	200	d/	d/	200	1,000	220	d/	d/	100	c/	c/	344
Mokelumne River												
Fall run a/	3231	4,954	9,372	15,861	8,298	7,682	7,167	1,630	528	281	499	5,900
Stanislaus River												
Fall run	100	1,000	d/	500	11,439	13,473	6,497	6,292	10212	1,510	480	5,669
Tuolumne River												
Fall run	559	14,253	7,126	14,836	13,689	40,322	7,404	14,751	5,779	1,275	96	11,999
Merced River												
Fall run a/	3,006	10,415	3,263	18,248	29,749	16,052	7,439	4,126	4,592	427	82	9,732

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

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

c/ Tributary was not surveyed.

d/ No estimate made.