

State of California  
The Resources Agency  
DEPARTMENT OF FISH AND GAME

ANNUAL REPORT  
CHINOOK SALMON SPAWNER STOCKS IN  
CALIFORNIA'S CENTRAL VALLEY, 1988

Edited by

Robert M. Kano  
Inland Fisheries Division

Inland Fisheries  
Administrative Report No. 97-10  
1997

CHINOOK SALMON SPAWNER STOCKS IN  
CALIFORNIA'S CENTRAL VALLEY, 1988<sup>1/</sup>

Edited by

Robert M. Kano

Inland Fisheries Division

ABSTRACT

This report covers the 36th 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 1988 total escapement of chinook salmon in the Central Valley was 302,811 fish. This total consisted of 269,143 fall-, 18,895 spring-, 2,803 winter- and 11,970 late-fall-run spawners. All of the spring-, late-fall-, and winter-run salmon were estimated to be in the Sacramento River system, while 21,211 fish of the fall run were in the San Joaquin River system.

Due to decreases of spawner populations in most Central Valley tributaries, the total 1988 salmon stock was smaller than in 1987. However, larger populations occurred in the Stanislaus River fall run, and a record high fall run in Battle Creek and spring run in the Feather River also were present. The winter run in the mainstem Sacramento River also increased slightly from the 1987 level, but was still critically low.

---

<sup>1/</sup> Inland Fisheries Administrative Report No. 97-10.  
Submitted for publication October 1997. California  
Department of Fish and Game, 1416 Ninth Street, Sacramento,  
California 95814.

## 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 significantly to the ocean fisheries of Oregon and Washington. This report is the 36th 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 described as follows:

- 1) Late-fall run. These fish 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 are usually larger in physical size than the fall- and winter-run fish spawning in the same area.
- 2) Winter run. These fish spawn almost entirely in the Sacramento River and its tributaries upstream of Red Bluff, arriving 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.

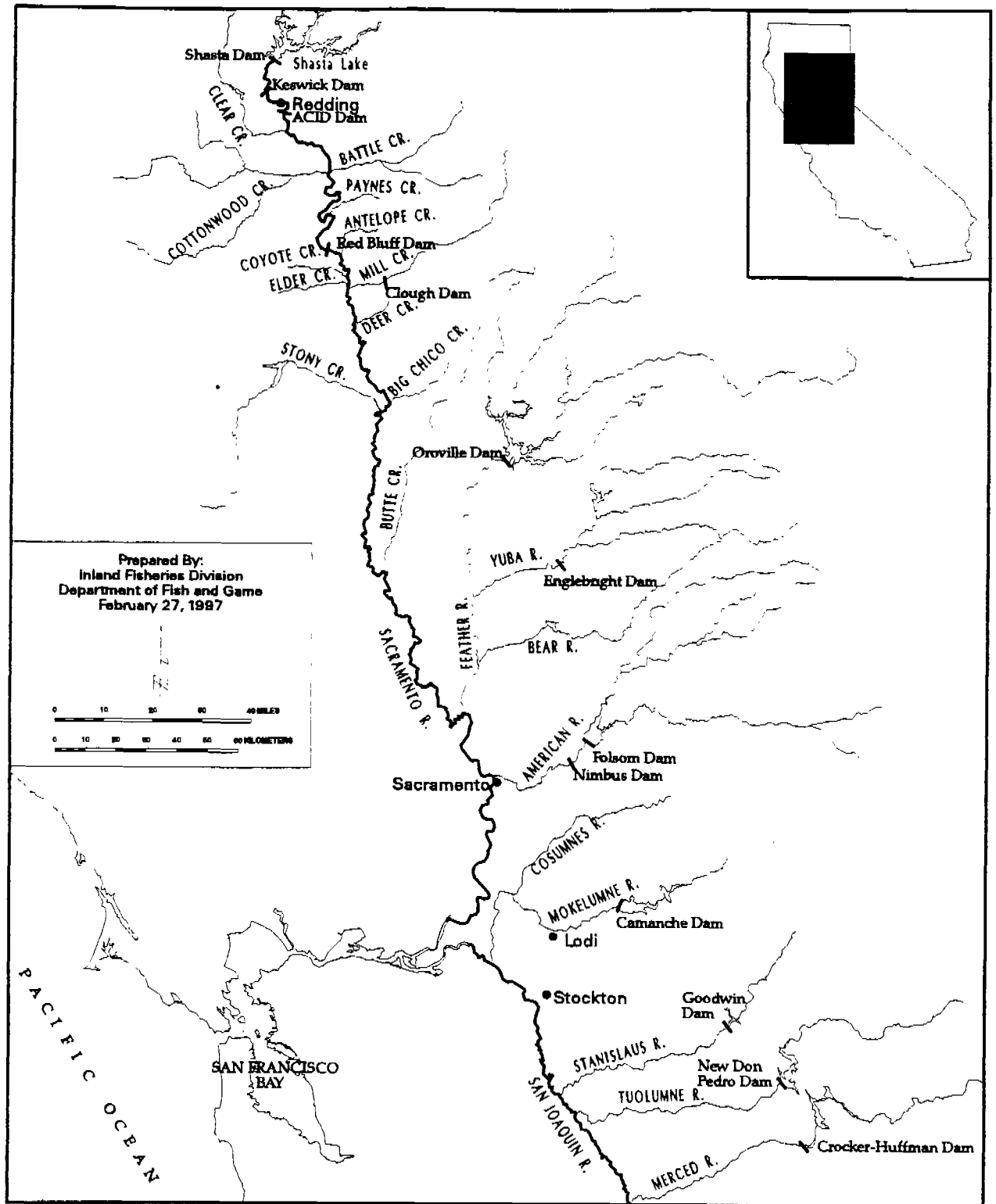


FIGURE 1. Sacramento-San Joaquin river system of California's Central Valley.

## GENERAL METHODS

During 1988, 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 a spawner population size; in some such cases, a decision of the number of spawners present was arrived at by "best professional judgement".

Calculated estimates of spawner populations most often employed an expansion of data based on marking and recovering salmon carcasses. Estimates for some tributaries were derived directly from counts of carcasses based on a surveying efficiency. The proportion of carcasses marked during a single previous survey that were recovered in following surveys (recovery rate) was used to expand the number of carcasses observed during the season in a tributary; all counted carcasses were cut in half to prevent recounting.

In other streams, carcasses were marked throughout a series of surveys. Upon recovery during subsequent trips, discrete marks applied to the carcasses allowed identification with individual surveys. All counted carcasses were again 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). Battle Creek was the only tributary in this area for which individual late-fall- and fall-run population estimates were made. Spawning distribution in the mainstem was determined from aerial redd counts.

In 1988, 159,118 salmon were estimated for the Sacramento River system between Keswick Dam and Red Bluff, consisting of 136,098 fall-, 11,377 late-fall-, 2,075 winter- and 9,568 spring-run fish (Appendix 3). The Battle Creek portion of the fall run was 67,475 fish. Since other tributaries in this area were not surveyed during the spring- and winter-run spawning periods, numbers of fish for these runs were included in the mainstem totals.

Sacramento River Mainstem - by Richard E. Painter

Estimates of the total numbers of salmon using the Sacramento River system upstream from RBDD during 1988 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 from the dam's east-bank trapping facility; salmon were assigned to a run based on their 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, 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

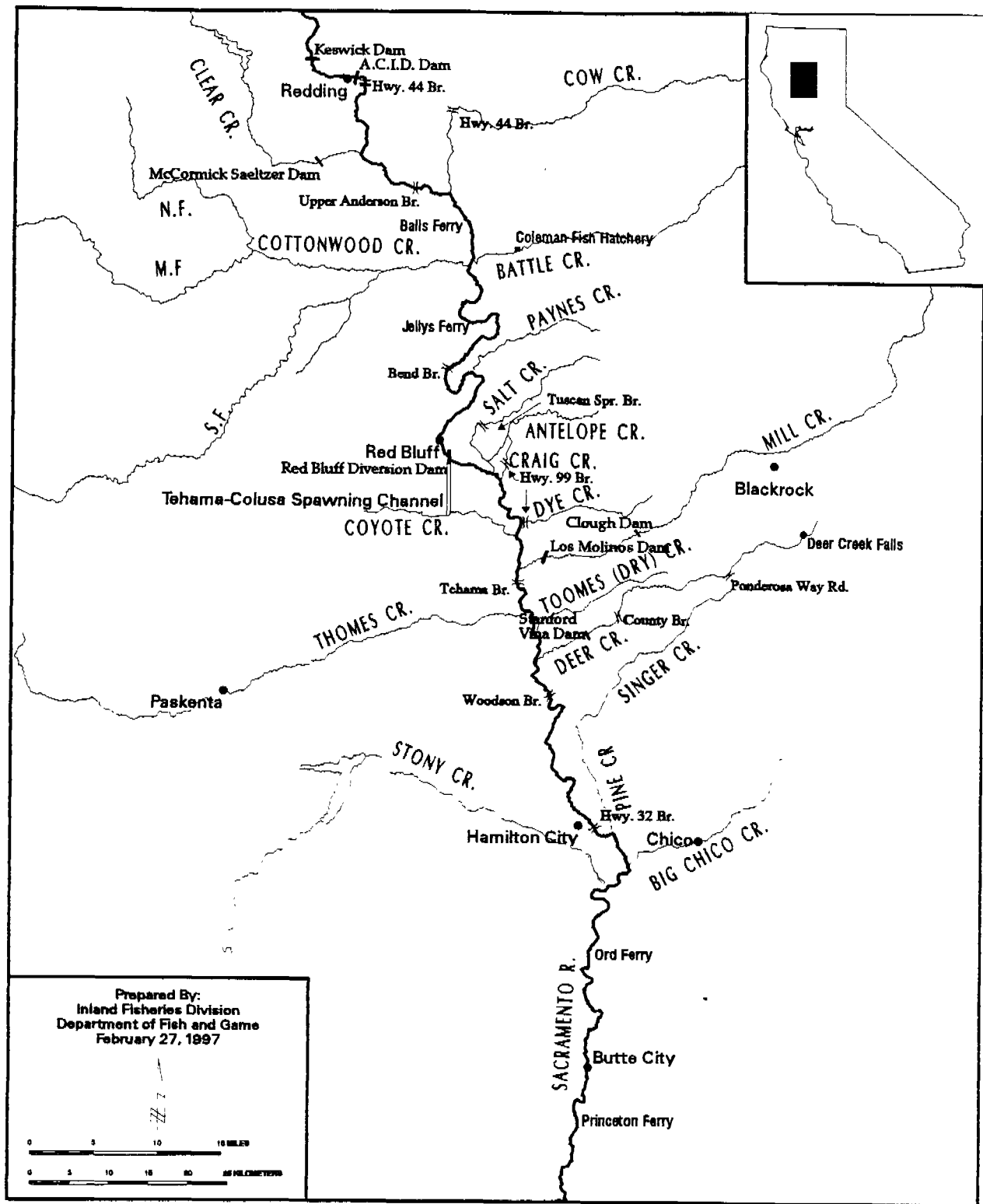


FIGURE 2. Sacramento river system from Keswick Dam downstream to Princeton Ferry.

with the smaller part of the following winter run at the end of the year. The total 1988 potential spawners for each of these two runs was obtained by adding the appropriate estimated numbers of fish from the 1987 calendar year that would spawn in 1988, and not including that portion of the 1988 calendar year estimated numbers that would spawn in 1989.

The RBDD gates were raised during periods from 3 December 1987 through 9 March 1988 to facilitate upstream migration of the winter run of chinook salmon. Since counts for most of the 1988 late-fall- and winter-run spawners passing the dam were not possible when the gates were open, estimated numbers of these runs for these periods were calculated based on historical data. The number of 1988 late-fall-run salmon estimated from counts when the gates were closed in December 1987 was expanded to determine the remainder of the run, using the average of proportional distributions seen in the 1968-1985 late-fall runs. Likewise, expansion of winter-run salmon numbers was made from counts after the gates were closed in March 1988 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. Estimated numbers of sport-caught salmon were also determined from historical data. Late-fall-, spring-, and fall-run 1988 catches were calculated using the average percentage caught of each respective run during the 1977-1986 period. The 1988 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 31 January through 30 March 1988).

To obtain the late-fall and fall-run population for only the mainstem upper Sacramento River, the number of potential spawners of these runs was reduced by the estimated population in Battle and Clear creeks. The 1988 mainstem estimates included all of the winter- and spring-run salmon, as well as some late-fall-run fish for unsurveyed tributaries.

Late-fall run. An estimated 11,598 late-fall 1988 potential spawners passed RBDD in 1987 and 1988 (Appendix 2). The late-fall sport-catch was estimated to be 221 salmon, leaving 11,377 fish (Table 1) as a spawner population upstream of Red Bluff. Fifty-three late-fall salmon entered Coleman National Fish Hatchery (CNFH) through Battle Creek leaving 11,324 fish as the mainstem spawner population (Appendix 3). 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 with the upper mainstem

**TABLE 1.** Calculation of the 1988 spawner population for each run of chinook salmon upstream of Red Bluff Diversion Dam.

Run	Number of fish passing dam in calendar year:		Number of potential spawners	Estimated sport catch	Estimated 1988 spawner population
	1987	1988			
Late-fall a/	7,827	+ 3,771 b/	= 11,598	- 221	= 11,377
Winter a/	37	+ 2,059 b/	= 2,096	- 21	= 2,075
Spring	-- c/	9,771	= 9,771	- 203	= 9,568
Fall	-- c/	139,976	= 139,976	- 3,878	= 136,098
<b>Totals:</b>	<b>7,864</b>	<b>+155,577</b>	<b>= 163,441</b>	<b>- 4,323</b>	<b>= 159,118</b>

a/ Estimated numbers of these runs from 1 Dec. 1987 through 12 Mar. 1988 were calculated using the historical (1968-1985) average proportional distribution.

b/ Totals of 5,971 late-fall- and 9 winter-run salmon passed RBDD in the latter part of 1988 (Appendix 2), and were not included in these counts; these fish were considered 1989 spawners.

c/ No 1988 spawners passed Red Bluff in 1987.

population, along with 404 late-fall-run salmon trapped at Keswick Dam that were hauled to CNFH for spawning. The estimated late-fall spawner population of the upper Sacramento River of 11,324 fish was 26% lower than the 1987 population of 15,393 fish, but 17% higher than the race's average run size from 1978 through 1987 (Appendix 5).

Winter run. An estimated 2,096 winter-run potential spawners passed RBDD in 1987 and 1988 (Appendix 2). The winter-run sport-catch was estimated to be 21 salmon, leaving a spawner population of 2,075 fish (Table 1) upstream of Red Bluff. The winter-run population has been critically low for the past six years, and while the 1988 run size was about 5% higher than the 1987 population, it was still only 34% of the average run size for the previous 10 years (Appendix 5).

Spring run. An estimated 9,771 spring-run potential spawners passed RBDD in 1988 (Appendix 2). The spring-run sport-catch was estimated to be 203 salmon, leaving 9,568 fish as a spawner population upstream of Red Bluff (Table 1). The 1988 spring-run spawner population was a decrease of 13% from the 1987 population, and 87% of the average run size for the previous 10 years (Appendix 5).

Fall run. An estimated 139,976 fall-run potential spawners passed RBDD in 1988 (Appendix 2). The fall-run sport-catch was estimated to be 3,878 salmon, leaving 136,098 fish as a spawner population upstream of Red Bluff (Table 1). A total of 71,928

fish was estimated for Battle and Clear creeks, so 64,170 salmon was the upper mainstem population (Appendix 3). This population included fall-run salmon which used other tributaries to the mainstem that were not surveyed. The fall run in the mainstem Sacramento River upstream of Red Bluff was a decrease of about 15% from the 1987 population, but was still  $1\frac{1}{2}$  times the average 1978-1987 population (Appendix 5).

Mainstem spawning distribution. The 1988 relative redd distribution of the four runs of salmon in the mainstem Sacramento River from Keswick Dam downstream to Red Bluff (Figure 2) was determined from data collected by airplane during each run's spawning season. Nearly all the mainstem late-fall- (95%) and spring-run (97.3%), and the majority of the winter (75%) and fall-run (77.8%) spawning occurred upstream from RBDD (Table 2).

#### Battle Creek - by Richard E. Painter

Late-fall, winter, and spring runs. Small numbers of these three runs have been known to spawn in Battle Creek. However, no spawner surveys were conducted during 1988, and the only available spawner data were for late-fall-run salmon which entered CNFH (53 fish) from the creek.

Fall run. Salmon carcass mark-and-recovery surveys were conducted from 10 October through 27 December 1988. Surveys covered the 5.6 km (3.5 mi) stretch of river between CNFH and the old hatchery location, and Gover's Ditch, an irrigation diversion about 1 km (0.6 mi) long located 1.6 km (1.0 mi) downstream from CNFH. An estimated spawner population for this area of 51,923 salmon was calculated (Table 3), using the mark-and-recovery data with the Schaefer equation (Appendix 1.B). An additional 15,552 fish entered CNFH, 1,937 of which were released to spawn upstream of the hatchery.

The composition of fall-run salmon in Battle Creek was 43.7% male adults (fork length (FL) > 65 cm [25.6 in]), 52.8% female adults, and 3.5% grilse (FL ≤ 65 cm), based on an examination of 14,850 carcasses. In comparison, fish entering CNFH consisted of 49.5% male adults, 43.0% female adults, and 7.5% grilse.

The total 1988 fall run-size for Battle Creek of 67,475 fish was the largest recorded in this tributary, and was almost three times larger than the 1987 population (Appendix 5).

TABLE 2. Chinook salmon relative redd distribution during 1988 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/	128	23.6%	12	0.9%	0	0.0%	0	0.0%
A.C.I.D. Dam to Highway 44	68	12.5%	375	28.2%	39	25.8%	2,535	14.4%
Highway 44 to Upper Anderson Bridge	174	32.1%	335	25.2%	88	58.3%	5,019	28.6%
Upper Anderson Bridge to Balls Ferry	103	19.0%	88	6.6%	12	7.9%	2,216	12.6%
Balls Ferry to Jellys Ferry	30	5.5%	51	3.8%	5	3.3%	2,443	13.9%
Jellys Ferry to Bend Bridge	6	1.1%	111	8.3%	3	2.0%	1,215	6.9%
Bend Bridge to Red Bluff Dam	6	1.1%	25	1.9%	0	0.0%	238	1.4%
Red Bluff Dam to Tehama Bridge	15	2.8%	210	15.8%	3	2.0%	2,400	13.7%
Tehama Bridge to Woodson Bridge	12	2.2%	123	9.2%	1	0.7%	1,045	6.0%
Woodson Bridge to Hamilton City (Hwy. 32)	0	0.0%	0	0.0%	0	0.0%	312	1.8%
Hamilton City to Ord Ferry	0	0.0%	0	0.0%	0	0.0%	111	0.6%
Ord Ferry to Princeton Ferry	0	0.0%	0	0.0%	0	0.0%	19	0.1%
Totals:	542		1,330		151		17,553	

a/ Counts made during aerial surveys on 20 January, 11 February, and 16 March 1988.

b/ Counts made during aerial surveys on 13 April and 28 July 1988.

c/ Counts made during aerial surveys on 1 and 21 September 1988.

e/ Counts made during aerial surveys from 5 October through 4 November 1988.

d/ Anderson-Cottonwood Irrigation District Dam.

TABLE 3. Chinook salmon carcass mark-and-recovery data used to estimate the 1988 fall-run spawner population in Battle Creek from Coleman National Fish Hatchery downstream to the old hatchery site. a/

Recovery period (j)	Number of marked carcasses recovered from marking period (i):											Total marked carcasses recovered (Rj)	Total carcasses observed (Cj) b/	Population estimate (N) c/
	1	2	3	4	5	6	7	8	9	10	11			
2	50	--	--	--	--	--	--	--	--	--	--	50	3,511 d/	8,812
3	1	53	--	--	--	--	--	--	--	--	--	54	3,606	15,290
4	0	2	75	--	--	--	--	--	--	--	--	77	6,027	18,732
5	0	0	3	58	--	--	--	--	--	--	--	61	1,316	4,384
6	0	0	0	0	12	--	--	--	--	--	--	12	637	2,176
7	0	0	0	0	0	7	--	--	--	--	--	7	362	672
8	0	0	0	0	0	0	4	--	--	--	--	4	498	1,743
9	0	0	0	0	0	0	0	5	--	--	--	5	112	470
10	0	0	0	0	0	0	0	0	3	--	--	3	38	105
11	0	0	0	0	0	0	0	0	1	9	--	10	64	197
12	0	0	0	0	0	0	0	0	0	0	3	3	35	152
Total recovered (Ri):	51	55	78	58	12	7	4	5	4	9	3	Total: 52,733		
Total carcasses marked (Mi):	128	235	240	194	41	13	14	21	11	28	13	Adjusted estimate a/: 51,923		

a/ Surveys were conducted from 10 October to 27 December 1988.

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

c/ Schaefer (1951) estimate equation:  $N = (R_{ij} \times (M_i/R_i) \times (C_j/R_j))$ .

d/ Includes carcasses observed during the first marking period, for purposes of calculating the second period population estimate.

e/ 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.  $52,733 - 810 = 51,923$ .

Clear Creek - by Richard E. Painter

Late-fall and spring runs. No spawner surveys were conducted for these runs in this tributary during 1988.

Fall run. Eight mark-and-recovery surveys of Clear Creek were made between 8 November and 28 December 1988, in the 6.4 km (4 mi) stretch of river from McCormick-Saeltzer Dam downstream to within 0.8 km (0.5 mi) of the Hwy.273 bridge. Totals of 1,142 salmon carcasses, 906 live fish, and 512 redds were counted. Thirty-nine of the carcasses were marked, 10 of which were subsequently recovered. Applying the Petersen equation (Appendix 1.A.1) to this data resulted in an estimated 4,453 salmon as the 1988 spawner population.

Cottonwood Creek - by Richard E. Painter

Late-fall and spring runs. No spawner surveys were conducted for these runs in this tributary during 1988.

Fall run. Aerial surveys of Cottonwood Creek were made on 12 and 19 October 1988, and 60 redds were counted. No spawner population estimate was made. Stream flow was extremely low in this tributary during the surveys.

Paynes Creek - by Richard E. Painter

Fall run. Five surveys were conducted on the lower 6.4 km (4 mi) of Paynes Creek between 18 November and 14 December 1988. Six live and one dead salmon were observed near man-made spawning structures built downstream of the bridge. No spawner population estimate was made.

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, Craig, Dry, Mill, and Deer creeks. Population estimates were possible only for the mainstem, and Mill and Deer creeks.

A total of 25,262 chinook salmon spawners was estimated for the Sacramento River system between Red Bluff and Princeton Ferry in 1988 (Appendix 3). This total consisted of 593 late-fall-, 728 winter-, 1,204 spring-, and 22,737 fall-run salmon.

Due to the RBDD gates being opened, the Tehama-Colusa Spawning Channel was not operated, and no salmon were counted entering

that facility. Precipitation and runoff in the upper Sacramento valley were low during the entire 1988 fall spawning season. Stream flows were low in most tributaries until early December.

Sacramento River Mainstem - by Richard E. Painter

Late-fall run. Based on aerial surveys made on 20 January, 11 February, and 16 March 1988, an estimated 593 late-fall-run spawners were in the mainstem Sacramento River downstream of Red Bluff.

Winter run. Based on weekly aerial surveys between 13 April and 28 July 1988, an estimated 728 winter-run salmon were in the mainstem Sacramento River downstream of Red Bluff.

Spring run. Based on aerial surveys made on 1 and 21 September 1988, 261 spring-run salmon were estimated for the Sacramento River mainstem between Red Bluff and Tehama Bridge.

Fall run. Based on aerial surveys from 5 October through 4 November 1988, 21,250 fall-run salmon were estimated for the mainstem Sacramento River between RBDD and Princeton Ferry. This run size was 34% lower than the 1987 population, and 56% of the average run size from 1978 to 1987 (Appendix 5).

Mainstem spawning distribution. Redd counts made during the aerial surveys in 1988 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 2). In proportion to the entire mainstem (including upstream of RBDD) spawning activity, 5% of the late-fall-, 25% of the winter-, 2.5% of the spring-, and 22.2% of the fall-run redds were observed in this section of the river. However, none of the late-fall-, winter-, or spring-run redds were observed downstream of Hwy.32.

Salt Creek

Fall run. No survey was made of this tributary.

Antelope Creek - by Richard E. Painter

Spring run. Spring-run salmon are known to enter Antelope Creek, but no surveys were conducted in 1988.

Fall run. Surveys between 11 November and 20 December 1988, were made in the stretch of Antelope Creek reaching 1.2 km (0.75 mi) upstream from Cone Grove Park. Only one salmon carcass, and two redds were observed. A spawner population estimate was not made.

Craig Creek - by Richard E. Painter

Late-fall run. Late-fall-run salmon are known to enter Craig Creek, but no surveys were conducted in 1988.

Fall run. Surveys of Craig Creek were made on 2 and 9 December 1988 from the Hwy.99-E bridge to 0.8 km (0.5 mi) upstream. No salmon carcasses, live fish, nor redds were observed. A spawner population estimate was not made.

Dye Creek

Fall run. No survey was made of this tributary.

Mill Creek - by Richard E. Painter and Colleen Harvey

Late fall run. Some fish of this race have been known to spawn in this stream, but no surveys were made in 1988.

Spring run. In 1988, the spring-run salmon population was monitored immigrating past Clough Dam. Passage through a 1.2-m long by 0.45-m diameter (4-ft L x 1.5-ft D) tunnel located at the upstream end of the fish ladder, was recorded by a Smith-Root Model 602 electronic fish counter. During two days each week, an observer made visual counts of fish to check the counter's accuracy.

A total of 446 upstream-passages was counted from 2 May through 15 June 1988. Since this period covered an estimated 78% of the historic (1954-1963) spring-run migration past the dam<sup>2/</sup>, an expansion (466/.78) to account for the entire run resulted in an estimated 572 salmon for 1988.

Fall run. Between 10 November and 28 December 1988, eight surveys were made of lower Mill Creek from 0.8 km (0.5 mi) upstream of the Los Molinos Mutual Water Company's upper diversion dam to the confluence with the Sacramento River. A total of 476 salmon carcasses was recovered, and based on a 32% recovery rate, the fall run was estimated to be 1,487 spawners.

The composition of the fall run, based on examination of 394 carcasses, was 35% male adults (FL > 60.7 cm [23.9 in], 58.4% female adults, and 6.6% grilse (FL ≤ 60.7 cm). Prespawning mortality was 9.0%.

---

<sup>2/</sup> Memorandum to Eldon Hughes from W. VanWoert, Mill Creek Counting Station. California Department of Fish and Game, Central Valley Project Office. May 1964. 7p.

Toomes (Dry) Creek - by Richard E. Painter

Fall run. Four surveys were made for this run between 2 and 21 December 1988 from the Tehama-Vina Road crossing to 2.4 km (1.5 mi) upstream. No salmon carcasses, live fish, or redds were observed. A population estimate was not made.

Deer Creek - by Richard E. Painter and Colleen Harvey

Late-fall Run. Late-fall-run salmon are known to enter Deer Creek, but no surveys were conducted in 1988.

Spring run. In August 1988, spring-run salmon were counted by snorkeling a section of Deer Creek from Hwy.32 downstream to the A-Line Road crossing. This stream section was the same "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<sup>3/</sup>. Assuming that previously defined relationship, where the indicator reach count represented 31% of the run, the total snorkeling count of 115 salmon was expanded to 371 fish for the 1988 run<sup>4/</sup>.

Fall run. Six surveys were made in lower Deer Creek between 16 November and 21 December 1988, covering the area between the monastery and the Leininger Bridge, a stretch of 7.7 km (4.8 mi). Twenty-two live salmon and 13 carcasses were observed. No fall-run population estimate was made.

Singer Creek

Fall run. No surveys were conducted in Singer Creek during 1988.

---

<sup>3/</sup> File report of 1986 and 1987 spring-run salmon surveys, from Emil Eckman, U.S. Forest Service, to the Lassen National Forest Resource Office, 17 November 1987.

<sup>4/</sup> File report of 1988 spring-run salmon surveys, from Emil Eckman, U.S. Forest Service, to the Almanor District Ranger Office, 31 March 1989.

## Big Chico Creek to the American River

Chinook salmon spawner population estimates for the Feather, Yuba, and American rivers (Figure 3) were made from weekly mark-and-recovery surveys of salmon carcasses. The only other tributary in this area that was surveyed was Butte Creek.

A total of 99,673 chinook salmon was estimated for the Sacramento River tributaries from Butte Creek to the American River in 1988. This total consisted of 8,123 spring-run and 91,550 fall-run fish (Appendix 3).

### Big Chico Creek

Fall run. Fall-run salmon are known to enter Big Chico Creek, but no surveys were conducted in 1988.

### Butte Creek - by Richard Flint

Spring run. The 1987-88 winter was very dry resulting in extremely low runoff. While rainfall in April did not appreciably increase spring flows, it did delay diversions, and allowed salmon access to the creek. Fish rescue efforts relocated several hundred salmon upstream of Hwy.99, although many fish remained stranded downstream.

Surveys were conducted on 3 and 4 October 1988, in the river stretch from the Centerville Powerhouse to Parrott-Phelan Dam. Streamflow was about 1.7 m<sup>3</sup>/s (60 cfs), with very good visibility through the water. Totals of 540 live salmon, 177 carcasses, and 391 redds were observed.

The 1988 spring-run spawner population was about 1,290 fish. The number of salmon upstream of Centerville Powerhouse was not determined. Despite the poor flow conditions, this was the largest spring run since the 1963 population of 4600 salmon (Menchen 1964).

Fall run. Streamflows in Butte Creek during the 1988 fall-run spawning period were almost non-existent before 22 November, and were low after then until the year's end. One survey was conducted on 7 December from the Durham Mutual Diversion Dam downstream to Gorrill Dam. No live salmon, 143 carcasses, and four redds were observed. No estimated of the fall-run spawner population was made.

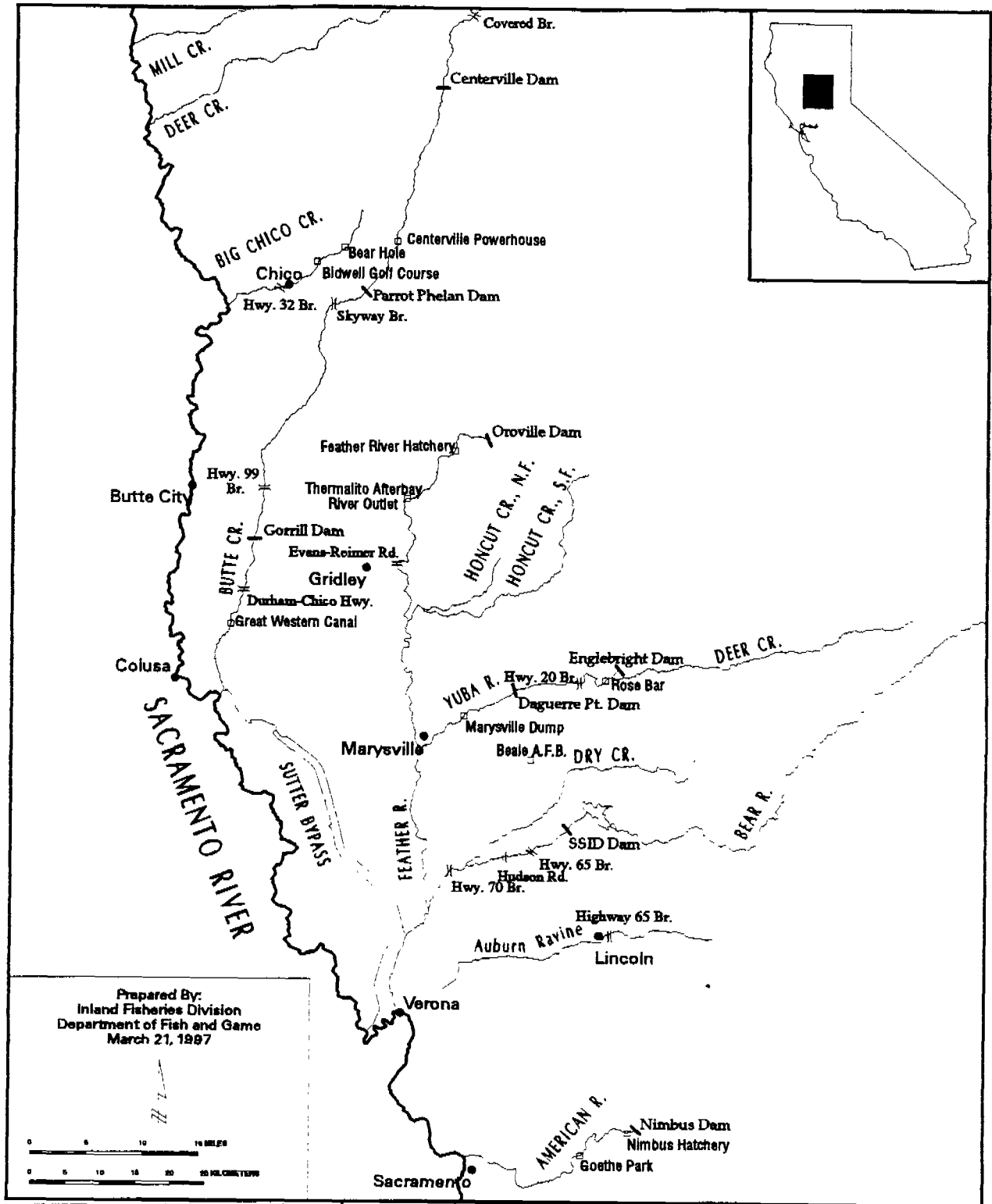


FIGURE 3. Sacramento river system from Big Chico Creek downstream to the American River.

Feather River - by Fred Meyer

Spring run. In past years salmon entering Feather River Hatchery (FRH) from 1 to 30 September were classified as spring-run. In 1988, the fish ladder into the hatchery was not opened until 7 September, and it was closed when holding pond capacity was reached before the end of the month. After pond space was freed up by spawning some of the salmon, the ladder was reopened from 3 to 6 October. For this total period, 6,833 salmon were counted as spring-run (Schlichting 1991). These fish consisted of 55% male adults (FL  $\geq$  68 cm [26.8 in]), 41% female adults, and 4% 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 6,833 spring-run salmon at FRH in 1988 was the highest ever recorded, and was almost  $6\frac{1}{2}$  times higher than the average number observed in the past 10 years (Appendix 5).

Fall run. Weekly carcass mark-and-recovery surveys of fall-run salmon were conducted in the Feather River from 4 October to 13 December 1988. Surveys covered the river reach between the hatchery barrier dam and Evans-Reimer Road. This area consisted of two sections, characterized by different flow regimes. The stream section between the hatchery barrier dam and Thermalito Afterbay Outlet, a "low-flow section", had an constant stream flow of 17.0 m<sup>3</sup>/s (600 cfs) throughout the survey period. Flow downstream of Thermalito Afterbay Outlet to Evans-Reimer Road ranged from 56.6 m<sup>3</sup>/s (2000 cfs) at the start of the surveys, to 28.3 m<sup>3</sup>/s (1000 cfs) by mid-November. For both sections, visibility through the water decreased from 1.8 to 0.9 m (6-3 ft) as surveys progressed.

This season, only adult carcasses, regardless of their state of decomposition, were marked for use in estimating the population with the Jolly-Seber calculations (Appendix 1.C). This was a change in procedure from past seasons when only fresh adult and grilse carcasses were marked for Schaefer estimates. Due to the large numbers of spawners this year it was only possible to mark an overall 25% of the adult carcasses seen.

The Jolly-Seber estimates, calculated from the mark-and-recovery data, for the upstream low-flow section were 26,460 adult salmon, and 13,755 adults for the downstream section (Table 4, Table 5). Combining these numbers and expanding for a 5.5% grilse proportion brought the total in-river estimate to 42,556 fish. A total of 6,480 fall-run salmon entered FRH (Schlichting 1991), bringing the 1988 fall run in the Feather River to 49,036 fish.

The composition of salmon in the river, based on examination of 4,066 fresh carcasses, was 35.3% male adults (FL  $\geq$  68 cm [26.8 in]), 59.2% female adults, and 5.5% grilse (FL < 68 cm). In

TABLE 4. Chinook salmon carcass mark-and-recovery data used in the calculation of a Jolly-Seber estimate of the 1988 fall-run spawner population in the Feather River from the Feather River Hatchery barrier dam to the Thermalito Afterbay Outlet. a/

Survey period	Total carcasses observed (Ci) b/	Carcasses recovered from period:									Marked carcasses recovered		Estimated number of fish	
		1	2	3	4	5	6	7	8	9	(Mi)	(Ki)	(Ni)	(Di)
1	23	--	--	--	--	--	--	--	--	--	--	--	42	510
2	291	9	--	--	--	--	--	--	--	--	9	2	--	2,625
3	1,222	2	82	--	--	--	--	--	--	--	84	32	--	5,087
4	3,067	0	26	271	--	--	--	--	--	--	297	80	--	6,675
5	3,736	0	6	63	155	--	--	--	--	--	224	56	--	4,815
6	3,399	0	0	10	39	225	--	--	--	--	274	47	--	2,835
7	2,195	0	0	1	6	33	184	--	--	--	224	25	--	1,891
8	1,102	0	0	0	0	6	14	116	--	--	136	32	--	898
9	758	0	0	0	0	1	3	19	129	--	152	39	--	851
10	890	0	0	0	0	0	1	8	28	159	196	16	--	232
11	302	0	0	0	0	0	0	0	2	14	16	--	--	--
Total recovered (Ri):		11	114	345	200	265	202	143	159	173				
Total marked (Ti):		23	270	702	521	656	494	434	371	354				
Jolly-Seber estimate c/: 26,460														

a/ Surveys were conducted from 4 October through 12 December.

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

c/  $E = N(1) + D(1) + D(2) + \dots D(j)$  (Appendix 1.C).

TABLE 5. Chinook salmon carcass mark-and-recovery data used in the calculation of a Jolly-Seber estimate of the 1988 fall-run spawner population in the Feather River from the Thermalito Afterbay Outlet to Evans-Reimer Road. a/

Survey period	Total carcasses observed (Ci) b/	Carcasses recovered from period:							Marked carcasses recovered		Estimated number of fish	
		1	2	3	4	5	6	7	(Mi)	(Ki)	(N1)	(Di)
1	116	--	--	--	--	--	--	--	--	--	402	1,690
2	538	4	--	--	--	--	--	--	4	3		2,704
3	1,337	2	42	--	--	--	--	--	44	17		2,542
4	2,530	1	16	210	--	--	--	--	227	8		2,782
5	1,682	0	0	7	147	--	--	--	154	22		1,684
6	1,125	0	0	1	14	126	--	--	141	46		1,077
7	1,137	0	0	0	6	33	169	--	208	34		741
8	899	0	0	0	1	6	25	218	250	14		133
9	184	0	0	0	0	0	2	12	14			
Total recovered (Ri):		7	58	218	168	165	196	230				
Total marked (Ti):		22	168	374	418	335	348	444				
Jolly-Seber estimate c/:											13,755	

a/ Surveys were conducted from 25 October through 13 December..

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

c/  $E = N(1) + D(1) + D(2) + \dots D(j)$  (Appendix 1.C).

comparison, salmon entering the FRH consisted of 43% male adults, 52% female adults, and 5% grilse.

The 1988 population of 49,036 salmon was 37% lower than that of the previous year, but slightly higher than the average population from 1978 to 1987 (Appendix 5).

Yuba River - by Fred Meyer

Spring Run. Salmon of this race were observed in the river during the summer of 1988, but no attempt was made to determine the run size.

Fall run. Weekly salmon carcass mark-and-recovery surveys started on 13 October and ended on 2 December 1988 in the Yuba River from the Parks Bar bridge (Hwy.20) downstream to Marysville. Surveys were not conducted upstream of Hwy.20. River flow upstream of Daguerre Point Dam was about 19.8 m<sup>3</sup>/s (700 cfs), and flow downstream of the dam was about 11.3 m<sup>3</sup>/s (400 cfs), with visibility through the water of over 1.8 m (6 ft) throughout most of the survey period. Heavy rains in late November caused flows of over 56.6 m<sup>3</sup>/s (2000 cfs), and the run could not be adequately sampled in the last two planned surveys.

Carcasses were marked using colored plastic ribbon attached to a jaw with a hog-ring. This season, only adult carcasses, regardless of their state of decomposition, were marked for use in estimating the population with the Jolly-Seber calculations (Appendix 1.C). This was a change in procedure from past seasons when only fresh adult and grilse carcasses were marked for Schaefer estimates.

Using carcass mark-and-recovery data with the Jolly-Seber calculations, 5,421 adult salmon were estimated as the spawner population between the Hwy.20 bridge and Marysville (Table 6). The estimate was expanded to include a 21% grilse proportion, for a total population of 6,862 fish in the surveyed area.

The spawner population for the area upstream of Hwy.20 to Rose Bar was calculated using the average proportion (15.5%) of the total river's population that spawners in this section constituted in past years. This section's population was assumed to be 1,259 salmon, bringing the total estimated spawner population for 1988 to 8,121 salmon. Considering that the entire run was not completely surveyed due to the high river flows, a population of 9,000 salmon for 1988 seems reasonable.

The composition of 1,056 fresh salmon carcasses examined was 33% male adults (FL ≥ 68 cm [26.8 in]), 46% female adults, and 21% grilse (FL < 68 cm).

TABLE 6. Chinook salmon carcass mark-and-recovery data used in the calculation of a Jolly-Seber estimate of the 1988 fall-run spawner population in the Yuba River from Parks Bar bridge (Hwy. 20) to Marysville. a/

Survey period	Total carcasses observed (Ci) b/	Carcasses recovered from period:						Marked carcasses recovered		Estimated number of fish	
		1	2	3	4	5	6	(Mi)	(Ki)	(Ni)	(Di)
1	92	--	--	--	--	--	--	--	--	221	700
2	335	21	--	--	--	--	--	21	9	--	771
3	671	8	130	--	--	--	--	138	32	--	1,564
4	1,084	0	20	195	--	--	--	215	72	--	1,478
5	1,541	1	10	53	342	--	--	406	60	--	687
6	882	0	1	7	52	242	--	302	0	--	--
7 d/	1	0	0	0	0	0	1	1	0	--	--
8 d/	--	--	--	--	--	--	--	--	--	--	--
Total recovered (Ri):		30	161	255	394	242	1				
Total marked (Ti):		72	294	492	685	672	267				
Jolly-Seber estimate c/:										5,421	

a/ Surveys were conducted from 13 October through 2 December.

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

c/  $E = N(1) + D(1) + D(2) + \dots D(j)$  (Appendix 1.C).

d/ High river flows occurred during the final two planned surveys.

The 1988 run of 9,000 salmon was only 45% of the previous year's population, and only 52% of the average run size from 1978 to 1987 (Appendix 5).

American River - by William L. Somer

Fall run. Weekly salmon carcass mark-and-recovery surveys were conducted between 7 November and 28 December 1988 in the 11-km (6.8-mi) reach of the American River from the Goethe Park footbridge upstream to the Nimbus Hatchery racks. River flows in this section were 14.2 m<sup>3</sup>/s (500 cfs) for the entire survey period, and visibility through the water ranged from 2.4 - 3.0 m (8-10 ft). The spawner population in the Nimbus Basin (upstream of the Nimbus racks) was also surveyed, concurrently with the downstream section, through counts of carcasses found washed up on the racks.

Carcasses were marked using colored plastic ribbon attached to a jaw with a hog-ring. This season, only adult carcasses, regardless of their state of decomposition, were marked for use in estimating the population with the Jolly-Seber calculations (Appendix 1.C). This was a change in procedure from past seasons when only fresh adult and grilse carcasses were marked for Schaefer estimates.

The adult salmon spawner population of the Goethe Park to Nimbus racks section, estimated from mark-and-recovery data using the Jolly-Seber calculations was 18,872 fish (Table 7). The adult estimate was expanded to include a 12% grilse proportion, for a total of 21,445 fish in this section. Upstream of the Nimbus racks, 3,444 spawners were estimated from an observed 2,927 carcasses, assuming an 85% recovery efficiency. The two combined estimates gave 24,889 salmon within the river. An additional 8,625 salmon entered Nimbus Hatchery (Ducey 1990), bringing the total American River 1988 fall-run population to 33,514 fish.

The composition of 908 fresh salmon carcasses examined was 47% male adults (FL ≥ 68 cm [26.8 in]), 9% male grilse (FL < 68 cm), 41% female adults, and 3% female grilse. In comparison, fall-run salmon entering the Nimbus Hatchery in 1988 consisted of 44% male adults (FL ≥ 60 cm [23.6 in]), 49% female adults, and 8% grilse (FL < 60 cm).

The 1988 run of 33,514 salmon was about 28% lower than the previous year's population, and 72% of the average run size from 1978 through 1987 (Appendix 5).

TABLE 7. Chinook salmon carcass mark-and-recovery data used in the calculation of a Jolly-Seber estimate of the 1988 fall-run spawner population in the American River from the Nimbus Hatchery racks to the Goethe Park footbridge. a/

Survey period	Total carcasses observed (Ci) b/	Carcasses recovered from period:						Marked carcasses recovered		Estimated number of fish	
		1	2	3	4	5	6	(Mi)	(Ki)	(N1)	(Di)
1	66	--	--	--	--	--	--	--	--	516	7,905
2	1,021	2	--	--	--	--	--	2	3	--	919
3	1,813	2	408	--	--	--	--	410	64	--	5,216
4	3,242	1	48	387	--	--	--	436	78	--	2,864
5	1,834	0	10	42	294	--	--	346	84	--	813
6	799	0	3	14	54	134	--	205	42	--	536
7	493	0	2	5	4	28	81	120	16	--	103
8	165	0	0	2	0	1	13	16	0	--	--
Total recovered (Ri):		5	471	450	352	163	94				
Total marked (Ti):		61	942	997	1026	628	300				
Jolly-Seber estimate c/:										18,872	

a/ Surveys were conducted from 7 November through 28 December.

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

c/  $E = N(1) + D(1) + D(2) + \dots + D(j)$  (Appendix 1.C).

CHINOOK SALMON SPAWNER POPULATIONS  
FOR THE SAN JOAQUIN RIVER SYSTEM

The Cosumnes, Mokelumne, Stanislaus, Tuolumne, and Merced rivers of the San Joaquin River system (Figure 4) were surveyed for chinook salmon spawners. A total of 21,211 salmon, consisting entirely of fall-run fish, was estimated for 1988 (Appendix 4).

Cosumnes River to the Calaveras River

Cosumnes River - by William L. Somer

Fall run. This tributary was surveyed from Michigan Bar to the Jackson Highway (Hwy.16) crossing on 2, 8, and 21 December 1988. Totals of two salmon carcasses, 18 live fish, and 31 redds were observed. The fall-run spawner population was judged to be about 100 fish.

Mokelumne River - by William L. Somer

Fall run. In 1988, six surveys were conducted from 10 November through 29 December between Camanche Dam and Mackville Road. The Mokelumne River flow was 2.8 m<sup>3</sup>/s (100 cfs) throughout the survey period, and visibility through the water was very poor.

Six salmon carcasses, 3 skeletons, and 177 live fish were observed, from which a spawner population of about 400 salmon was thought to have been present. Combined with the 128 salmon which entered the Mokelumne River Hatchery (Estey 1990), the 1988 fall-run spawner population was 528 fish. The composition of the salmon entering the hatchery was 37% male adults (FL ≥ 61 cm [24 in]), 36% female adults, and 24% grilse.

The 1988 run was only 32% of the previous year's population, and was only 9% of the average of population size estimated from 1978 through 1987 (Appendix 5).

Calaveras River

This tributary was not surveyed in 1988.

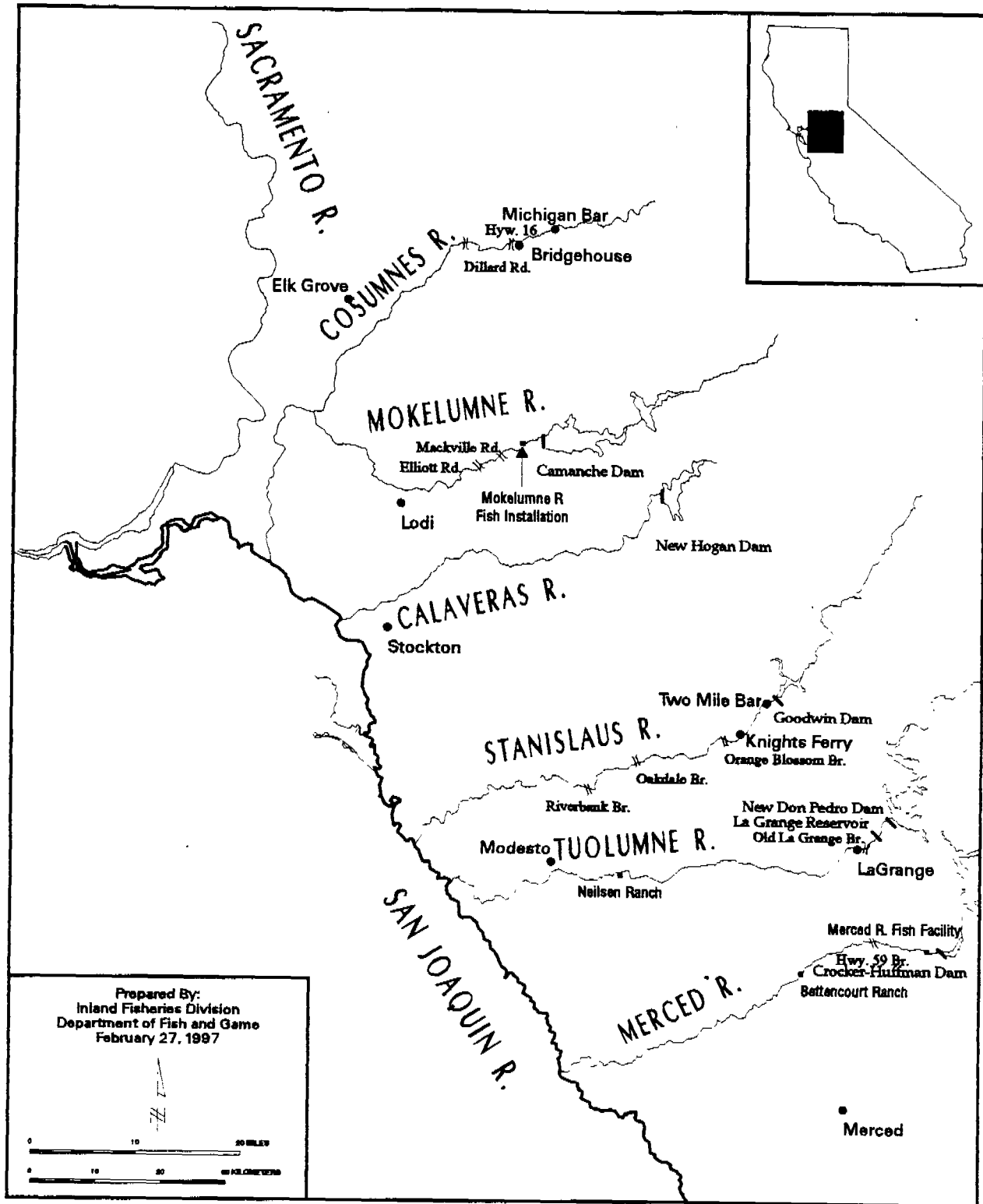


FIGURE 4. San Joaquin River system from the Merced River downstream to the Cosumnes River.

Stanislaus River to the Merced River

Stanislaus River - by Mark S. Pisano and W. George Neillands

Fall run. The 1988 fall-run salmon spawner population was estimated through carcass mark-and-recovery surveys in the Stanislaus River from 25 October through 29 December. Six surveys were conducted in the Goodwin Dam and Two Mile Bar areas. Eight surveys were made from Knights Ferry downstream to the Riverbank Bridge, a stretch of 30.9 km (19.2 mi). River flows at the Orange Blossom Bridge ranged from 11.2 to 12.3 m<sup>3</sup>/s (395-435 cfs), while water temperatures ranged from 13.5°C (56.3°F) in late October to 9°C (48.2°F) in late December. Visibility through the water was often greater than 3.0 m (10 ft) except during late November when storm runoff reduced visibility to about 1.8 m (6 ft).

Carcasses were marked using colored plastic ribbon attached to a jaw with a hog-ring. This season, only adult carcasses, regardless of their state of decomposition, were marked for use in estimating the population with the Jolly-Seber calculations (Appendix 1.C). This was a change in procedure from past seasons when only fresh adult and grilse carcasses were marked for Schaefer estimates.

The salmon population of the Knights Ferry to Riverbank Bridge section was estimated at 8,940 adult fish using the Jolly-Seber calculations with the mark-and-recovery data (Table 8). The estimate was expanded to 9,401 fish to account for a 4.9% grilse proportion. During the surveys at Goodwin Dam, 67 salmon carcasses were observed, of which 49 were marked, and 14 recovered, and at Two Mile Bar, 205 carcasses were seen, 135 were marked, and 47 were recovered. Petersen (Appendix 1.A.2) estimates of 227 fish and 584 fish, respectively, were calculated for these areas.

The 1988 run consisted of 35.4% male adults (FL ≥ 61 cm [24 in]), 59.7% female adults, 0.6% male grilse (FL < 61 cm), and 4.3% female grilse, based on examination of 395 fresh salmon carcasses.

The total estimated Stanislaus River 1988 fall-run spawner population of 10,212 salmon was 62% larger than the previous year's population, and more than 2½ times the average run size for the past ten years (Appendix 5).

TABLE 8. Chinook salmon carcass mark-and-recovery data used in the calculation of a Jolly-Seber estimate of the 1988 fall-run spawner population in the Stanislaus River from Knights Ferry to the Riverbank Bridge. a/

Survey period	Total carcasses observed (Ci) b/	Carcasses recovered from period:						Marked carcasses recovered		Estimated number of fish	
		1	2	3	4	5	6	(Mi)	(Ki)	(N1)	(Di)
1	117	--	--	--	--	--	--	--	--	270	1,559
2	732	33	--	--	--	--	--	33	11	--	1,017
3	873	6	248	--	--	--	--	254	98	--	2,134
4	1,468	5	69	220	--	--	--	294	94	--	1,990
5	1,679	0	24	56	393	--	--	473	145	--	1,094
6	1,531	0	0	14	122	457	--	593	70	--	858
7	879	0	0	0	7	48	292	347	92	--	16
8	247	0	0	0	2	13	77	92	0	--	--
Total recovered (Ri):		44	341	290	524	518	369				
Total marked (Ti):		110	682	607	1110	1179	862				
Jolly-Seber estimate c/:										8,940	

a/ Surveys were conducted from 25 October through 29 December.

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

c/  $E = N(1) + D(1) + D(2) + \dots D(j)$  (Appendix 1.C).

Tuolumne River - by Mark S. Pisano and Maurice Fjelstad

Fall run. The 1988 fall-run chinook salmon spawner surveys in the Tuolumne River were conducted from 25 November through 28 December. The run started later than in past seasons, partially due to low flow conditions in the river. Poor water quality in the south Sacramento-San Joaquin Delta may also have delayed immigration. River flows downstream of LaGrange Dam ranged from 1.6 m<sup>3</sup>/s (55 cfs) in early October to 3.2 m/s (113 cfs) in early November, averaging 2.5 m<sup>3</sup>/s (89 cfs) during the surveys. Visibility through the water was usually greater than 5 m (1.6 ft) throughout the survey period. Water temperature decreased from 13.1°C (55.5°F) in October to 8.6°C (47.5°F) in late December.

Carcass mark-and-recovery surveys were conducted in the river stretch from Old LaGrange Bridge downstream to Neilsen Ranch near Waterford, a distance of 27.3 km (17 mi). Redd surveys during the peak spawning period were also made of that entire stretch, and also from Old LaGrange Bridge upstream to LaGrange Dam (1.6 km [1 mi]), and from Neilsen Ranch downstream to Geer Avenue (12.9 km [8 mi]).

Carcasses were marked using colored plastic ribbon attached to a jaw with a hog-ring. This season, only adult carcasses, regardless of their state of decomposition, were marked for use in estimating the population with the Jolly-Seber calculations (Appendix 1.C). This was a change in procedure from past seasons when only fresh adult and grilse carcasses were marked for Schaefer estimates.

The population in the river section between Old LaGrange Bridge and Neilsen Ranch was estimated to be 4,388 adult salmon, using the mark-and-recovery data with the Jolly-Seber calculations (Table 9). The estimate was expanded to include a 4% grilse proportion, bringing the total for this section of river to 4,571 fish.

The populations for the two sections up- and down-stream of the mark-and-recovery area were determined from their redd proportions relative to the entire surveyed reaches. The number of redds in these areas constituted 20.9% of the total redds from LaGrange Dam to Geer Avenue bridge. Assuming that the estimated 4,571 spawners in the mark-and-recovery area represented 79.1% of the run, then 1,215 salmon were in the other areas, and the total estimated 1988 fall-run spawner population for the Tuolumne River was 5,779 salmon.

The run consisted of 37.2% male adults (FL ≥ 61 cm [24 in]), 2% male grilse (FL < 61 cm), 58.9% female adults, and 2% female grilse. The lengths used to separate adults from grilse were determined from length frequency distributions of 401 fresh salmon carcasses.

TABLE 9. Chinook salmon carcass mark-and-recovery data used in the calculation of a Jolly-Seber estimate of the 1988 fall-run spawner population in the Tuolumne River from Old LaGrange Bridge to Neilsen Ranch. a/

Survey period	Total carcasses observed (Ci) b/	Carcasses recovered from period:							Marked carcasses recovered		Estimated number of fish	
		1	2	3	4	5	6	7	M(i)	(Ki)	(N1)	(Di)
1	1	--	--	--	--	--	--	--	--	--	1	30
2	30	0	--	--	--	--	--	--	0	0	--	399
3	136	0	7	--	--	--	--	--	7	7	--	824
4	421	0	3	43	--	--	--	--	46	37	--	836
5	608	0	3	23	113	--	--	--	139	119	--	1,167
6	886	0	1	8	55	159	--	--	223	193	--	1,041
7	820	0	0	2	38	94	136	--	270	349	--	-133
8	915	0	0	0	12	21	246	182	461	160	--	223
9	510	0	0	0	3	23	44	90	160	0	--	--
Total recovered (Ri):		0	14	76	221	297	426	272				
Total marked (Ti):		1	30	128	375	466	651	516				
Jolly-Seber estimate c/:											4,388	

a/ Surveys were conducted from 25 November through 28 December.

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

c/  $E = N(1) + D(1) + D(2) + \dots + D(j)$  (Appendix 1.C).

The 1988 run of 5,779 fall-run salmon was only 39% of the previous year's population, and about 50% of the average run size for 1978 to 1987 (Appendix 5); salmon populations during the past ten years have ranged from a low of 559 fish in 1980 to the record high of 40,322 fish in 1985.

Merced River - by Sharon S. Shiba and Cynthia J. Chadwick

Fall run. Weekly carcass mark-and-recovery surveys were conducted in the 16.1 km (10 mi) river stretch from Crocker-Huffman Dam downstream to the Hwy.59 bridge, from 9 November through 30 December 1988. A single redd survey also covered this section, as well as 12.1 km (7.5 mi) of the river stretch downstream from Hwy.59 to the Santa Fe bridge; the entire length of the river downstream of Hwy.59 (24.2 km [15 mi]) was not accessible.

River flows during the survey period ranged from 5.1 to 5.7 m<sup>3</sup>/s (180-200 cfs), and water temperatures decreased from 20°C (68°F) in late October to 7.8°C (46°F) in December. Visibility through the water was greater than 2 m (6.6 ft), except during one survey in December when it was reduced to 1 m (3.3 ft) by rain runoff.

Carcasses were marked using colored plastic ribbon attached to a jaw with a hog-ring. This season, only adult carcasses, regardless of their state of decomposition, were marked with the intent of estimating the population with the Jolly-Seber calculations. Post-season analysis of the data indicated that the Petersen equation (Appendix 1.A.2) was a more appropriate estimation.

A total of 974 adult salmon was examined, of which 594 were marked, and 273 subsequently recovered. From these data, 2,117 adult salmon were estimated in the river stretch from the Crocker-Huffman Dam to Hwy.59. This estimate was expanded to include an 6.9% grilse proportion, bringing the total population in this section to 2,274 fish.

The spawner population downstream of Hwy.59 to the Santa Fe bridge was estimated from the relative redd distribution between that section of the river and the mark-and-recovery survey section upstream. One-hundred-twenty-two redds were counted in half of the entire stream length downstream of Hwy.59. Assuming that this count was a representative sample, then 244 redds were present. Three-hundred-two redds, or 55% of the total (244+302) were counted upstream of Hwy.59. Assuming that the estimated 2,274 fish in the upstream section represented 55% of the run, then 1,861 salmon were downstream of Hwy.59, and the estimated in-river population was 4,135 salmon. An additional 457 salmon were observed during Merced River Fish Facility (MRFF) operations (Cozart 1991), for a total 1988 fall-run spawner population of 4,592 salmon.

Based on 173 fresh carcasses examined during the surveys, the run was composed of 45.1% male adults, 48% female adults, 1.7% male grilse, and 5.2% female grilse. In comparison, salmon which entered the MRFF consisted of 35.9% male adults, 55.6% female adults, 6.8% male grilse, and 1.7% female grilse.

The 1988 Merced River fall-run population of 4,592 salmon was 11% larger than that of the previous year, but only 48% of the average run size for 1978 through 1987 (Appendix 5).

SUMMARY

The total estimated 1988 Central Valley chinook salmon spawner population was 302,811 fish (Table 10). This was almost 10% lower than the 1987 total of 334,362 salmon (Kano and Reavis 1997), due to decreased run in most of the tributaries. The Battle Creek fall run and the Feather River spring run, however, were at record high levels. As in the past, the most of the 1988 salmon run occurred in the Sacramento River system, with only 21,211 fall-run fish in the San Joaquin River system; the Stanislaus River run constituted almost half of this system's spawners. The winter run in the mainstem Sacramento River remained at a critically low level.

TABLE 10. Summary of the 1988 Sacramento-San Joaquin river system chinook salmon spawner populations.

Spawning area	Late-fall run	Winter run	Spring run	Fall run	Total
Sacramento mainstem	11,917	2,803	9,829	85,420	109,969
Sacramento tributaries	53a/	--	9,066b/	162,512c/	171,631
San Joaquin tributaries	--	0	--	21,211	21,211
<b>Totals:</b>	<b>11,970</b>	<b>2,803</b>	<b>18,895</b>	<b>269,143</b>	<b>302,811</b>

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

REFERENCES

- Boydston, L.B. 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(1)). 13 p.
- Cozart, Michael D. 1991. Annual report, Merced River Fish Facility, 1988-89. Calif. Dept of Fish and Game, Inland Fish. Admin. Rep. No. 91-10. 17 p.
- Ducey, Ronald D. 1990. Annual report, Nimbus Salmon and Steelhead Hatchery, 1988-89. Calif. Dept of Fish and Game, Inland Fish. Admin. Rep. No. 90-7. 12 p.
- Estep, Don F. 1990. Annual report, Mokelumne River Hatchery, 1988-89. Calif. Dept of Fish and Game, Inland Fish. Admin. Rep. No. 90-6. 9 p.
- Hoopaug, David A. (ed.). 1978. King (Chinook) salmon spawning stocks in California's Central Valley, 1976. Calif. Dept. of Fish and Game, Anad. Fish. Br. Admin. Rep. No. 78-19. 33 p.
- Kano, R.M. and R. Reavis (eds.). 1997. Annual report, chinook salmon spawner stocks in California's Central Valley, 1987. Calif. Dept. of Fish and Game, Inland Fish. Br. Admin. Rep. 97-4. 54 p.
- Menchen, R.S. (ed.). 1964. King salmon spawning stocks in California's Central Valley, 1963. Calif. Dept. of Fish and Game, Anad. Fish. Admin. Rep. No. 64-3. 16 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.
- Schlichting, Donald L. 1991. Annual report, Feather River Hatchery, 1988-89. Calif. Dept of Fish and Game, Inland Fish. Admin. Rep. No. 91-12. 11 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 and those recovered with marks, and

R = number of marked carcasses recovered.

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

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

where N = the estimated spawner population,

$R_{ij}$  = carcasses marked in the *i*th marking period which were recovered in the *j*th recovery period,

$M_i$  = carcasses marked in the *i*th marking period,

$R_i$  = total marked carcasses recovered from the *i*th marking period,

$R_j$  = total marked carcasses recovered during the *j*th recovery period,

$C_j$  = total carcasses observed in the *j*th 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):

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

$E$  = the estimated spawner population

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

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

Three basic quantities are first calculated:

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

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

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

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

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

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

and,

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

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

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

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

In the above equations, the variables are defined as:

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

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

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

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

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

$D_i$  can then be calculated:

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

and,

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

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

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

APPENDIX 2. Adjusted chinook salmon counts and estimated numbers of each run at Red Bluff Diversion Dam from 18 October 1987 through 31 December 1988. a/

Count period	Adjusted salmon count b/	Number of salmon examined c/	Run distributions							
			Late-fall		Winter		Spring		Fall	
			% of fish examined	Estimated number d/	% of fish examined	Estimated number d/	% of fish examined	Estimated number d/	% of fish examined	Estimated number d/
18 Oct '87 - 2 Jan '88 e/	--	--	--	7,827	--	37	--	--	--	--
1988										
03-Jan - 09-Jan	--	--	--	719 f/	--	32 f/	--	--	--	--
10-Jan - 16-Jan	--	--	--	727 f/	--	32 f/	--	--	--	--
17-Jan - 23-Jan	--	--	--	357 f/	--	7 f/	--	--	--	--
24-Jan - 30-Jan	--	--	--	346 f/	--	27 f/	--	--	--	--
31-Jan - 06-Feb	--	--	--	393 f/	--	46 f/	--	--	--	--
07-Feb - 13-Feb	--	--	--	451 f/	--	60 f/	--	--	--	--
14-Feb - 20-Feb	--	--	--	283 f/	--	75 f/	--	--	--	--
21-Feb - 27-Feb	125	8	62.5	78	37.5	47	--	--	--	--
28-Feb - 05-Mar	213	22	63.6	135	36.4	78	--	--	--	--
06-Mar - 12-Mar	--	--	--	138 e/	--	91	--	--	--	--
13-Mar - 19-Mar	51	4	50.0	26	50.0	26	--	--	--	--
20-Mar - 26-Mar	176	24	37.5	66	62.5	110	--	--	--	--
27-Mar - 02-Apr	349	24	12.5	44	87.5	305	--	--	--	--
03-Apr - 09-Apr	289	22	0.0	0	95.5	276	4.5	13	--	--
10-Apr - 16-Apr	178	23	4.3	8	87.0	155	8.7	15	--	--
17-Apr - 23-Apr	270	22	Total: 11,598 g/b/		68.2	184	31.8	86	--	--
24-Apr - 30-Apr	261	9	--	--	53.1	139	46.9	122	--	--
01-May - 07-May	175	21	--	--	38.1	67	61.9	108	--	--
08-May - 14-May	129	9	--	--	22.2	29	77.8	100	--	--
15-May - 21-May	245	19	--	--	52.6	129	47.4	116	--	--
22-May - 28-May	801	108	--	--	16.7	134	83.3	667	--	--
29-May - 04-Jun	429	43	--	--	2.3	10	76.7	329	21.0	90
05-Jun - 11-Jun	228	11	--	--	0.0	0	81.8	187	18.2	41
12-Jun - 18-Jun	649	--	--	--	Total: 2,096 g/		b/	531	b/	118
19-Jun - 25-Jun	751	3	--	--	--	--	100.0	751	0.0	0
26-Jun - 02-Jul	267	19	--	--	--	--	42.1	112	57.9	155
03-Jul - 09-Jul	602	2	--	--	--	--	100.0	602	0.0	0
10-Jul - 16-Jul	1,873	21	--	--	--	--	33.3	624	66.7	1,249
17-Jul - 23-Jul	1,439	54	--	--	--	--	24.1	347	75.9	1,092
24-Jul - 30-Jul	967	12	--	--	--	--	8.3	80	91.7	887
31-Jul - 06-Aug	1,253	6	--	--	--	--	16.7	209	83.3	1,044
07-Aug - 13-Aug	3,780	45	--	--	--	--	20.0	756	80.0	3,024
14-Aug - 20-Aug	7,953	21	--	--	--	--	4.8	382	95.2	7,571
21-Aug - 27-Aug	15,198	101	--	--	--	--	7.9	1,201	92.1	13,997
28-Aug - 03-Sep	6,112	102	--	--	--	--	6.9	422	93.1	5,690
04-Sep - 10-Sep	2,064	31	--	--	--	--	0.0	0	100.0	2,064
11-Sep - 17-Sep	4,873	57	--	--	--	--	12.3	599	87.7	4,274
18-Sep - 24-Sep	17,996	101	--	--	--	--	5.9	1,062	94.1	16,934
25-Sep - 01-Oct	14,589	41	--	--	--	--	2.4	350	97.6	14,239
02-Oct - 08-Oct	15,790	44	--	--	--	--	0.0	0	100.0	15,790
09-Oct - 15-Oct	13,324	44	--	--	--	--	Total: 9,771 g/		100.0	13,324
16-Oct - 22-Oct	9,817	45	--	--	--	--	--	--	100.0	9,817
23-Oct - 29-Oct	7,105	68	1.5	107	--	--	--	--	98.5	6,998
30-Oct - 05-Nov	8,698	75	2.7	235	--	--	--	--	97.3	8,463
06-Nov - 12-Nov	4,708	56	19.6	923	--	--	--	--	80.4	3,785
13-Nov - 19-Nov	3,308	70	28.6	946	--	--	--	--	71.4	2,362
20-Nov - 26-Nov	1,601	--	i/	458	--	--	--	--	i/	1,143
27-Nov - 03-Dec	--	--	--	--	--	--	--	--	--	--
04-Dec - 10-Dec	--	--	--	--	--	--	--	--	--	--
11-Dec - 17-Dec	--	--	--	3,301 f/	--	9 f/	--	--	--	5,825 f/
18-Dec - 24-Dec	--	--	--	--	--	--	--	--	--	--
25-Dec - 31-Dec	--	--	--	--	--	--	--	--	--	--
Total: 139,976 g/										
Total for 3 Jan. - 31 Dec. '88 j/:	148,636	1,387	9,742		2,068		9,771		139,976	

a/ Red Bluff Diversion Dam gates were open during the periods 18 Oct. 1987 through 9 Mar. 1988, and during 1 through 31 Dec. 1988.

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

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

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

e/ Estimated numbers represent salmon passing the dam during this period in 1987 that were expected to spawn in 1988 (Kano and Reavis 1997).

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

g/ Total estimated number of potential spawners during the 1988 calendar year.

h/ Includes a total of 404 fish trapped at Keswick Dam and trucked to Coleman National Fish Hatchery.

i/ Trap not operated. Proportion assumed to be the same as for the previous week.

j/ Including late-fall- and winter-run 1989 potential spawners.

APPENDIX 3. Chinook salmon spawner population estimates for Sacramento River system tributaries in 1988.

River area Tributary	Number of fish				Total
	Late- fall run	Winter run	Spring run	Fall run	
<b>Keswick Dam to Red Bluff</b>					
Sacramento River mainstem a/	11,324 b/	2,075	9,568	64,170	87,137
Clear Creek	c/	--	c/	4,453	4,453
Cottonwood Creek	c/	--	c/	d/	--
Paynes Creek	--	--	--	d/	--
Battle Creek					
Coleman National Fish Hatchery	53	--	--	13,579	13,632
Upstream of hatchery	--	--	--	1,973	1,973
Downstream of hatchery	c/	c/	c/	51,923	51,923
(Totals for tributary):	( 53 )	( 0 )	( 0 )	( 67,475 )	( 65,555 )
Totals for area:	11,377	2,075	9,568	136,098	159,118
<b>Red Bluff to Princeton Ferry</b>					
<b>Sacramento River mainstem</b>					
Red Bluff to Tehama Bridge	332	425	237	13,143	14,137
Tehama Bridge to Woodson Bridge	261	303	24	5,327	5,915
Woodson Br. to Ord Bend	--	0	0	2,461	2,461
Ord Bend to Princeton Ferry	0	0	0	319	319
Tehama-Colusa Spawning Channel	c/	c/	c/	c/	--
(Totals for tributary):	( 593 )	( 728 )	( 261 )	( 21,250 )	( 22,832 )
Salt Creek	--	--	--	c/	--
Antelope Creek	--	--	c/	d/	--
Craig Creek	c/	--	--	d/	--
Dye Creek	--	--	--	d/	--
Mill Creek	c/	--	572	1,487	2,059
Toomes (Dry) Creek	--	--	--	d/	--
Deer Creek	d/	--	371	d/	371
Singer Creek	--	--	--	c/	--
Totals for area:	593	728	1,204	22,737	25,262
<b>Butte Creek to American River</b>					
Big Chico Creek	--	--	--	c/	--
Butte Creek	--	--	1,290	d/	1,290
Feather River					
Feather River Hatchery	--	--	6,833	6,480	13,313
Downstream of hatchery	--	--	c/	42,556	42,556
(Totals for tributary):	--	--	( 6,833 )	( 49,036 )	( 55,869 )
Yuba River	--	--	c/	9,000	9,000
American River					0
American River Hatchery	--	--	--	24,889	24,889
Downstream of hatchery	--	--	--	8,625	8,625
(Totals for tributary):	--	--	--	( 33,514 )	( 33,514 )
Totals for area:	--	--	8,123	91,550	99,673
<b>Sacramento River system totals:</b>	11,970	2,803	18,895	250,385	284,053

a/ Includes numbers of fish for tributaries not surveyed in the river area.

b/ Includes 404 fish from Keswick Dam that were transported to and spawned at Coleman Hatchery.

c/ Not surveyed.

d/ No estimate made.

e/ Due to the Red Bluff Diversion Dam gates being raised, the spawning channel was not operated.

APPENDIX 4. Chinook salmon spawner population estimates for  
San Joaquin River system tributaries in 1988.

<u>Tributary</u>	<u>Numbers of fall-run fish</u>
<u>Cosumnes River</u>	100
<u>Mokelumne River</u>	
Mokelumne River Fish Installation	128
Downstream of installation	400
Total for tributary:	528
<u>Calaveras River</u>	a/
<u>Stanislaus River</u>	10,212
<u>Tuolumne River</u>	5,779
<u>Merced River</u>	
Merced River Fish Facility	457
In-river	4,135
Total for tributary:	4,592
<u>San Joaquin River system total:</u>	21,211

a/ Tributary was not surveyed.

APPENDIX 5. Chinook salmon spawner population estimates from 1978 through 1988 in California's Central Valley tributaries.

Tributary	Estimated number of fish											1978-1987
Race	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	average
<u>Sacramento River system</u>												
<u>upstream of Red Bluff</u>												
<u>(excluding Battle Creek)</u>												
Late-fall run	12,479	10,284	9,361	6,423	4,899	14,984	7,140	8,136	7,811	15,393	11,324	9,691
Winter run	24,735	2,339	1,142	19,795	1,233	1,827	2,662	3,684	2,394	1,978	2,075	6,179
Spring run	5,669	2,856	9,363	20,655	23,156	3,854	7,823	10,200	15,824	10,972	9,568	11,037
Fall run	35,500	47,758	21,961	33,289	20,567	27,326	41,805	52,820	67,940	75,958	64,170	42,492
<u>Battle Creek</u>												
Fall run	3,652	13,159	14,443	17,205	26,795	13,983	29,893	39,808	31,252	24,249	67,475	21,444
<u>Sacramento River</u>												
<u>mainstem downstream</u>												
<u>of Red Bluff</u>												
Fall run	47,973	67,388	30,453	42,724	23,833	32,018	19,166	46,780	34,372	32,588	21,250	37,730
<u>Feather River</u>												
Spring run a/	202	250	269	469	1,910	1,702	1,562	1,632	1,433	1,213	6,833	1,064
Fall run	37,759	32,505	35,295	53,020	55,519	30,522	51,056	56,002	55,471	77,846	49,036	48,500
<u>Yuba River</u>												
Fall run	7,416	12,430	12,406	14,025	39,367	13,756	9,665	13,042	19,328	18,518	9,000	15,995
<u>American River</u>												
Fall run	21,091	47,666	49,802	64,055	43,898	35,300	39,696	65,213	55,067	46,143	33,514	46,793
<u>Cosumnes River</u>												
Fall run	100	150	200	b/	b/	200	1,000	220	b/	b/	100	187
<u>Mokelumne River</u>												
Fall run	1,086	1,507	3,231	4,954	9,372	15,861	8,298	7,682	7,167	1,630	528	6,079
<u>Stanislaus River</u>												
Fall run	50	110	100	1,000	b/	500	11,439	13,473	6,497	6,292	10,212	3,946
<u>Tuolumne River</u>												
Fall run	1,300	1,183	559	14,253	7,126	14,836	13,689	40,322	7,404	14,751	5,779	11,542
<u>Merced River</u>												
Fall run	625	2,147	3,006	10,415	3,263	18,248	29,749	16,052	7,439	4,126	4,592	9,507

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

b/ No estimate made.