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**1992 Fall-Run Chinook Salmon
Spawning Escapement in the Yuba River**

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INTRODUCTION

Background

From 1953 to 1989, the California Department of Fish and Game (DFG) conducted annual surveys on the lower Yuba River to estimate fall-run chinook salmon escapement (i.e., number of adult salmon returning to spawn). However, surveys were not conducted on the lower Yuba River in 1990, and DFG informed Yuba County Water Agency (YCWA) that surveys were not planned for the lower Yuba River in 1991. YCWA contracted with Jones & Stokes Associates to conduct the 1991 surveys (Jones & Stokes Associates 1992). In 1992, YCWA agreed to participate with DFG in conducting 1992 spawning escapement surveys.

Since 1973, DFG estimated annual chinook salmon spawning escapement in the lower Yuba River using a modified Schaefer method (Schaefer 1951). The Schaefer method is a mark-recapture technique designed to estimate the number of fish in a population consisting of a series of spatially or temporally distinct units. DFG estimated the weekly number of salmon arriving and spawning in the Yuba River based on the number of salmon carcasses that are tagged and subsequently recovered during weekly carcass surveys. The ratio of recovered tagged carcasses to total carcasses examined provides the basis for estimating weekly spawning populations throughout the spawning season.

Objective

The primary objective of the 1992 spawning escapement surveys was to estimate total chinook salmon run size in the lower Yuba River. An effort was made to follow DFG's survey methods and population estimation techniques so that the spawning escapement estimate would be comparable to past estimates. Additional information obtained from the surveys included run timing, spawning distribution, and age and sex composition.

METHODS

Streamflows and Water Clarity

Streamflows and water clarity were monitored during the spawning escapement surveys to evaluate potential effects on sampling efficiency. YCWA telemetered daily flow data directly from the U.S. Geological Survey (USGS) gage below Englebright Dam near Smartville, California (Station 11418000), and from the USGS gage near Marysville, California (Station 11421000). Water clarity was visually estimated during the field surveys.

Sampling Methods

Sampling was conducted in the same manner described for the 1991 surveys (Jones & Stokes Associates 1992). In contrast, however, only adult carcasses were tagged, and estimates of grilse were based on the proportion of grilse observed among fresh carcasses; in 1991, both adult and grilse carcasses were tagged to obtain independent estimates of adult and grilse populations.

Field Surveys

Twelve spawning escapement surveys were conducted at weekly intervals from October 6 through December 15, 1992 from the State Highway 20 Bridge near Parks Bar to the Feather River confluence near Marysville. Weekly surveys were conducted over a 2-day period; the reach from the State Highway 20 Bridge to Daguerre Point Dam (approximately 7.5 miles) was surveyed on the first day, and the reach from Daguerre Point Dam to the Feather River confluence (approximately 11 miles) was surveyed on the second day (Figure 1). Because few or no carcasses were observed during the first 3 weeks, the first three surveys were conducted in Reach 1 only. Weekly surveys were not conducted in the reach above the State Highway 20 Bridge.

A three-person crew, consisting of staff members from DFG and Jones & Stokes Associates, surveyed the river from a boat and on foot. Two surveyors walked downstream on opposite riverbanks and searched for carcasses along the shore and in the river. A boat operator assisted in retrieving salmon in deep pools and transporting the surveyors around unwadable reaches. As needed, one of the surveyors helped the boat operator retrieve carcasses from deep pools. Gaffs were used to handle carcasses and retrieve them from deep water.

Untagged carcasses were classified as fresh or decomposing. Fresh carcasses were identified by the presence of at least one clear eye, firm flesh, and shiny appearance, while decomposing carcasses were identified by milky or opaque eyes, soft flesh, and fungus attached to the body. Each fresh or decomposing carcass was recorded as an adult (age 3 and older) or grilse (age 2) based on the size criteria provided by DFG; salmon greater than 26 inches in fork length (measured from the tip of the snout to the fork of the tail) were classified as adults and salmon less than 26 inches in fork length were classified as grilse. The sex of each fresh carcass was also recorded.

A hog ring with a short strip of colored surveying tape was secured to the lower jaw of each fresh adult carcass. A different color of tape was used each week to trace carcasses to a specific tagging week. After tagging, fresh carcasses were returned to the river by placing them in running water to disperse downstream. Fresh grilse carcasses and all decomposing carcasses were not tagged; they were recorded and chopped in half with a machete. Beginning with the second survey, all recovered tagged carcasses were identified as male or female, recorded by tag color, and chopped in half.

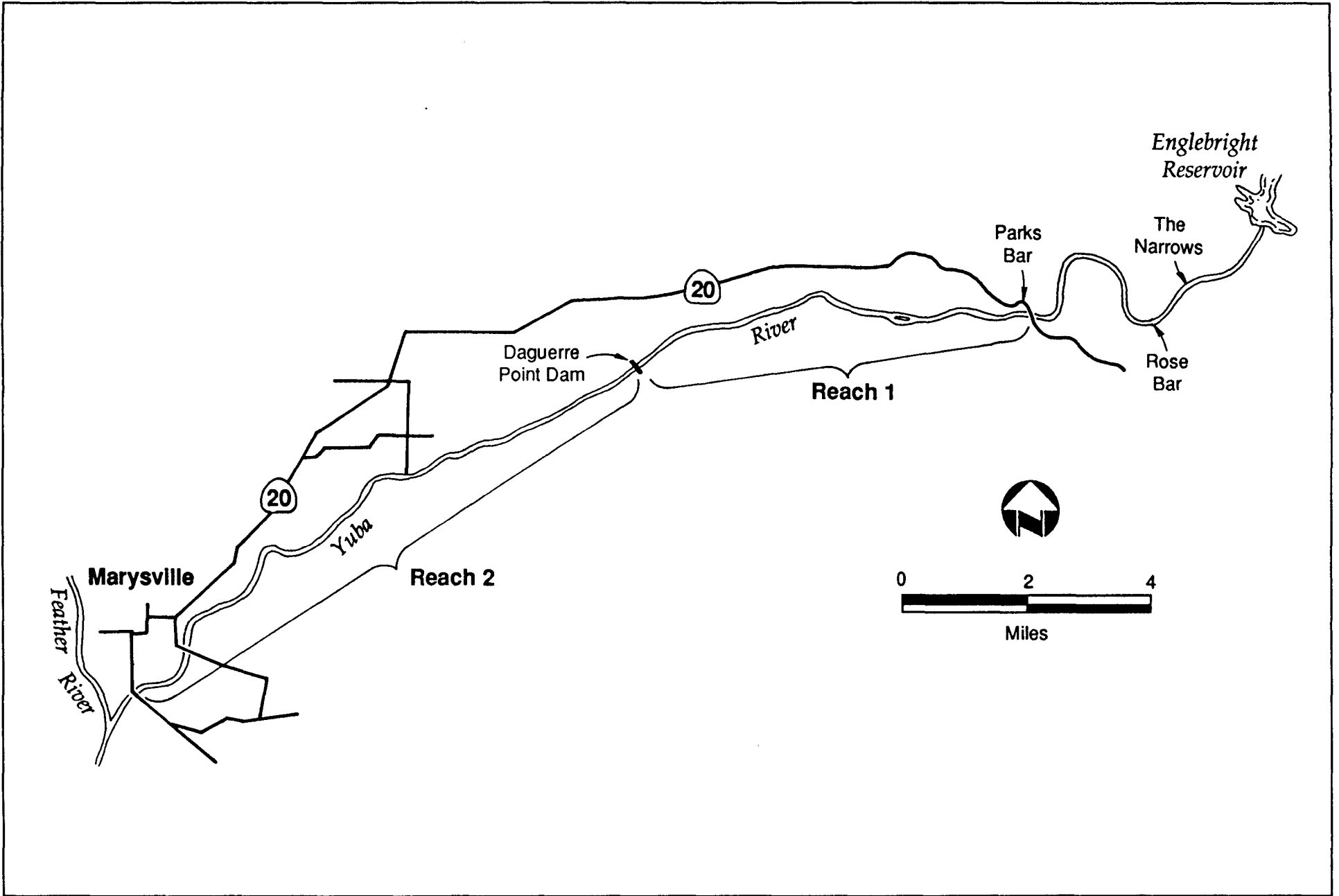


Figure 1. 1992 Lower Yuba River Chinook Salmon Spawning Escapement Survey Reaches

On December 4, 1992, two Jones & Stokes Associates fisheries biologists conducted a survey of the lower Yuba River from Englebright Dam to the State Highway 20 Bridge (approximately 5.5 miles) to determine the extent of spawning above the principal survey reach (Figure 1). A canoe was used because of poor access and the need to portage around a portion of the Narrows reach. DFG conducted only partial surveys of this reach in the past and has typically assumed that 15% of the run spawns in this reach based on the average number of adults estimated during 1966-1971 (Konnoff 1988).

Age and Sex Composition

The proportion of grilse and adult salmon in the run was estimated from the total number of fresh grilse and adult carcasses observed during the surveys. Similarly, the sex composition of adult salmon was estimated from the total number of males and females observed during the surveys. Distinguishing male and female grilse based on external characteristics was difficult, although the majority of grilse were age 2 males.

Coded Wire-Tagged Carcasses

All fresh carcasses were examined to determine the presence or absence of an adipose fin. A missing adipose fin indicates the presence of a coded wire-tag, which is implanted in the snout of hatchery-reared salmon before they are released as juveniles. These tags contain information such as race, hatchery of origin, and planting date. If the adipose fin was absent, the location, fork length, and sex of the carcass were recorded. The snout of the carcass was removed by making a vertical cut through the head and just behind the eye, leaving the lower jaw intact. Adult carcasses were then tagged with a hog ring and released back into the river. The snout was placed in a plastic bag with the recorded information and returned to DFG for tag detection, extraction, and reading.

Population Estimation

The Schaefer model, as modified by DFG, is expressed using the terms of Ricker (1975) as follows:

$$N = \sum N_{ij} = \sum (R_{ij} \times \frac{M_i}{R_i} \times \frac{C_j}{R_j}) - \sum \frac{i}{2} M_i$$

where i = week of tagging (starting with week 1),

j = week of recovery (starting with week 2),

- N = total population estimate,
- N_{ij} = weekly population estimate,
- R_{ij} = number of fish tagged in the i th tagging period that are recaptured in the j th recovery period,
- M_i = number of fish tagged in the i th tagging period,
- C_j = number of fish examined in the j th recovery period,
- R_i = total recoveries of fish tagged in the i th period, and
- R_j = total recoveries of tagged fish in the j th period.

The modified Schaefer model includes an additional term that is subtracted from the original estimate to compensate for replacement of tagged fish back into the population; Schaefer's original model was based on sampling without replacement because tagging and sampling for tags were geographically separated. This term is the total number of fish tagged, beginning with the second week of tagging. The total number of grilse salmon in the run was estimated from the proportion of fresh grilse carcasses among total fresh carcasses.

RESULTS

Streamflows and Water Clarity

Yuba River flows and water clarity during most of the 1992 salmon escapement surveys provided excellent conditions for sampling and recovery of carcasses throughout the river. Mean daily discharge from October 6 to December 8 ranged from 619 cubic feet per second (cfs) to 810 cfs at the Smartville gage and from 405 cfs to 538 cfs at the Marysville gage. Flows increased sharply during the week preceding the last survey, reaching a maximum mean daily discharge of 2,800 cfs at the Smartville gage on December 11. During the last survey on December 14 and 15, flows were declining and mean daily discharge in the lower Yuba River was 1,170 cfs at the Smartville gage and 865 cfs at the Marysville gage. Water clarity during the survey period ranged from 5 to 15 feet.

Run Timing

The condition of tagged carcasses recovered 1 or 2 weeks after tagging indicated that fresh carcasses represented fish that had died within a week before tagging. Therefore,

weekly counts of fresh carcasses provided the best approximation of the number of fish spawning weekly in the lower Yuba River.

Weekly counts of fresh carcasses indicated that spawning started in early to mid-October, peaked in mid-November, and continued until mid-December (Figure 2). No spawning activity or carcasses were observed between the State Highway 20 Bridge and Daguerre Point Dam on October 6, 1992, and only one carcass was found on October 12. During subsequent surveys, the weekly count of fresh carcasses above Daguerre Point Dam increased, reached a peak on November 16, and declined thereafter (Figure 3).

Few carcasses were observed below Daguerre Point Dam during the first two surveys on October 27 and November 3 (Figure 4). The number of fresh carcasses observed below the dam first increased on November 10 and reached a peak on November 30, 2 weeks after carcass numbers peaked above the dam. Fresh carcass numbers had dropped to low levels, and no spawning activity was observed on December 14-15.

Spawning Escapement

During the 1992 surveys, a total of 1,934 (1,457 adults and 477 grilse) chinook salmon carcasses was examined between the State Highway 20 Bridge and the Feather River confluence. Of these, 464 adult carcasses were tagged and 157 of these were recovered for an overall recovery rate of 34%.

Recovery rates of tagged carcasses were different for each survey reach, averaging 37% for the reach above Daguerre Point Dam and 28% for the reach below the dam. Because this difference could bias the population estimate if data from both reaches were combined, separate estimates were developed for each reach and then summed to obtain a total population estimate.

The estimated escapement was 3,286 salmon (2,333 adults and 953 grilse) between the State Highway 20 Bridge and Daguerre Point Dam and 2,089 salmon (1,483 adults and 606 grilse) between Daguerre Point Dam and the Feather River confluence for a total of 5,375 salmon. Assuming 15% of the run spawned above the State Highway 20 Bridge, the total chinook salmon escapement estimate was 6,323 salmon (4,489 adults and 1,834 grilse) (Table 1).

Weekly mark-recapture data and estimates are summarized in the Appendix (Tables A1 through A4).

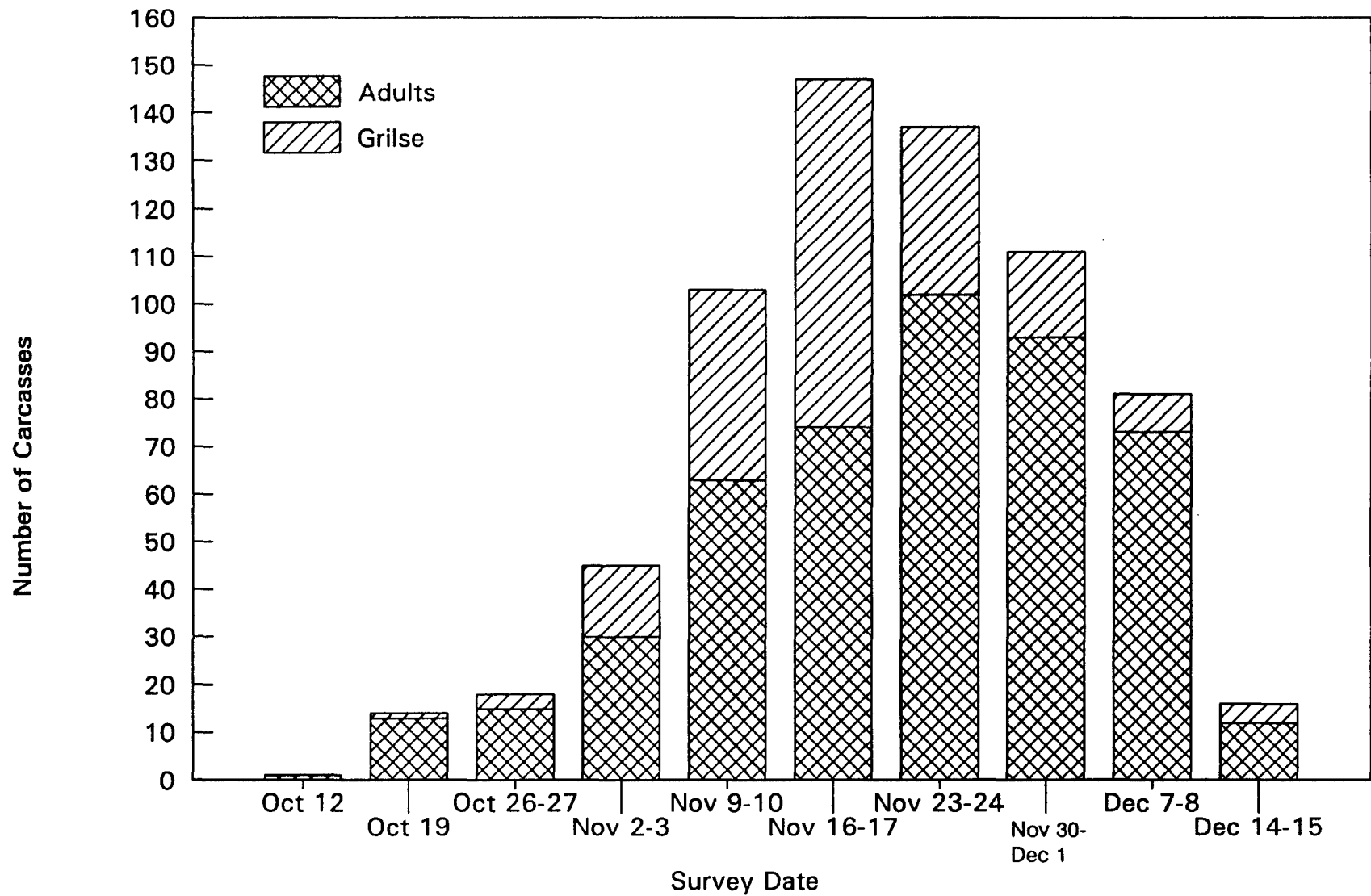


Figure 2. Numbers of Fresh Chinook Salmon Carcasses Counted Weekly during 1992 Spawning Escapement Surveys on Yuba River between Highway 20 Bridge and the Feather River Confluence

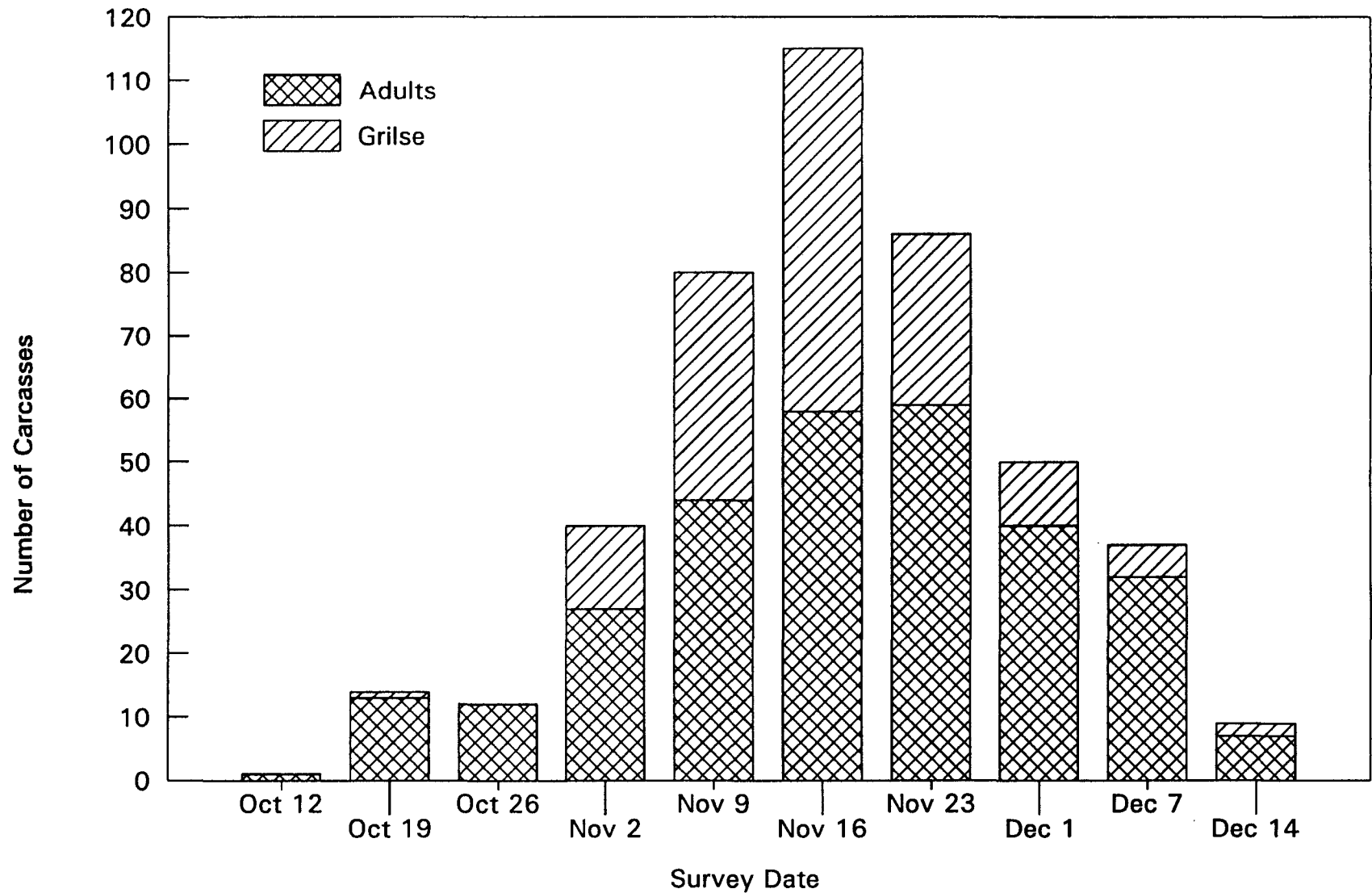


Figure 3. Numbers of Fresh Chinook Salmon Carcasses Counted Weekly during 1992 Spawning Escapement Surveys on Yuba River between Highway 20 Bridge and Daguerre Point Dam

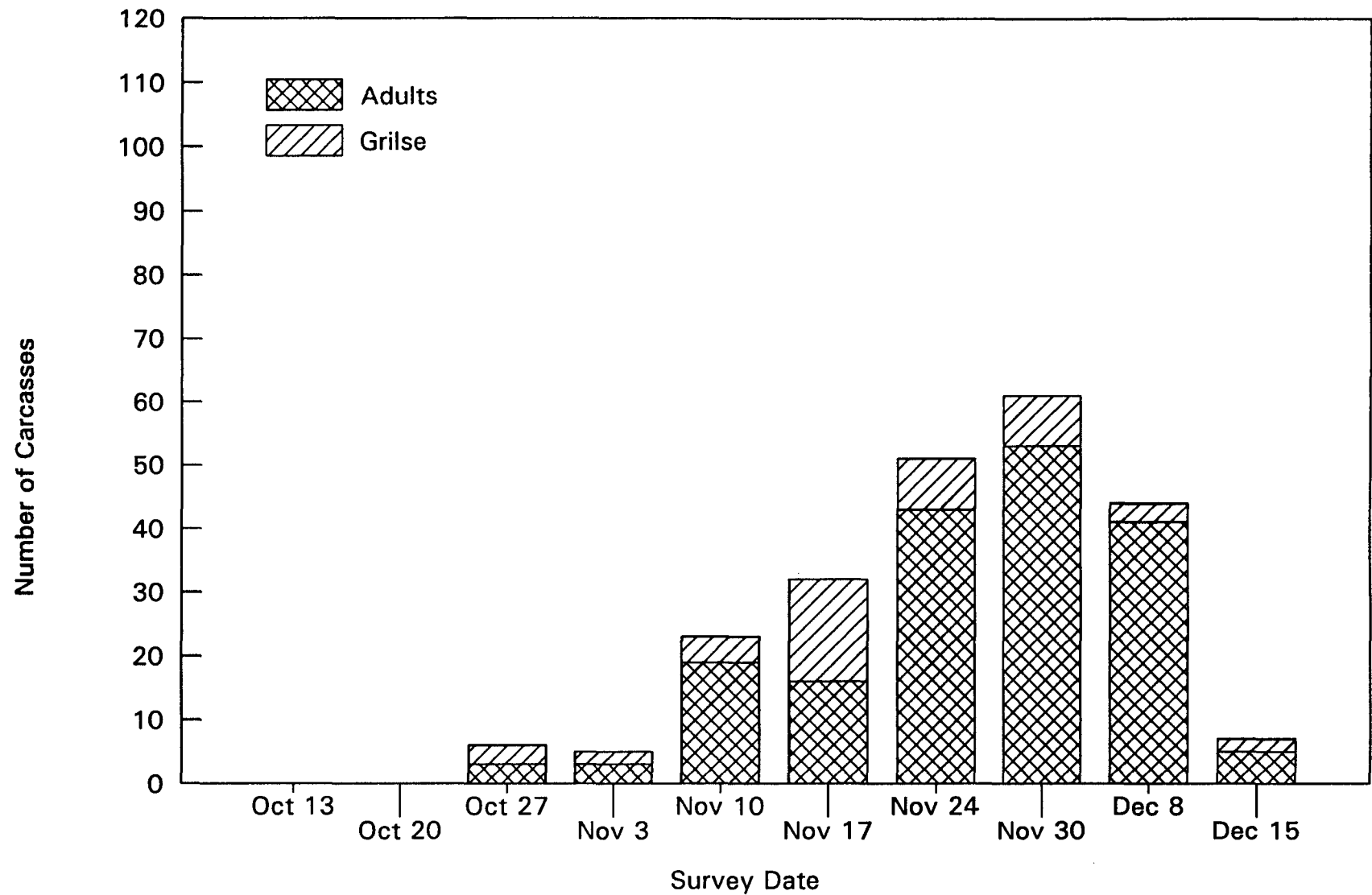


Figure 4. Numbers of Fresh Chinook Salmon Carcasses Counted Weekly during 1992 Spawning Escapement Surveys on Yuba River between Daguerre Point Dam and the Feather River Confluence

Table 1. 1992 Yuba River Fall-Run Chinook Salmon Spawning
Escapement Estimates by Survey Reach

Reach	Adult	Grilse	Total
Rose Bar to Highway 20 Bridge ^a	673	275	948
State Highway 20 Bridge to Daguerre Point Dam	2,333	953	3,286
Daguerre Point Dam to Feather River confluence	<u>1,483</u>	<u>606</u>	<u>2,089</u>
Total	4,489	1,834	6,323

^a Assumes 15% of run spawned between Rose Bar and the State Highway 20 Bridge.

Spawning Distribution

Assuming that 15% of the chinook salmon run spawned above the State Highway 20 Bridge, 52% of the run spawned between the State Highway 20 Bridge and Daguerre Point Dam, and 33% of the run spawned below Daguerre Point Dam. No spawning activity or redds were observed in the 3- to 4-mile reach upstream of the Feather River confluence.

Similar to last year's observations, few salmon were seen above the Narrows during the December 4, 1992 survey from Englebright Dam to the State Highway 20 Bridge. The first significant amount of spawning activity was observed below the Narrows reach at Rose Bar, which marks the first major spawning riffle below Englebright Dam (Figure 1).

Sex and Age Composition

The sex and age composition of fresh carcasses was 30% adult males, 41% adult females, and 29% grilse.

Coded Wire Recoveries

One coded wire-tagged salmon was recovered in the reach below Daguerre Point Dam on November 10, 1992: a male grilse (22 inches) from the Mokelumne River Fish Installation, which was planted in the Mokelumne River on April 23, 1991 (Nelson pers. comm.).

SUMMARY AND DISCUSSION

Run Timing

The timing of upstream migration and spawning of the 1992 chinook salmon run in the lower Yuba River typified the general pattern observed since 1973. Spawning started in early to mid-October, peaked in mid-November, and declined to low levels by mid-December.

A distinct difference in the timing of spawning was observed between the two survey reaches. Fresh carcass counts indicated that the onset of spawning and date of peak spawning above Daguerre Point Dam occurred 1-2 weeks earlier than that observed below the dam, suggesting that salmon entering the lower Yuba River during the early part of the run continued their migration and did not spawn until reaching spawning areas above the

dam. Later arrivals tended to spawn in the lower reaches soon after entering the lower Yuba River. The apparent differences in the timing of spawning probably reflect differences in the degree of maturity of early- and late-run salmon as well as behavioral selection of suitable water temperatures for spawning and egg incubation.

Spawning Escapement

Assuming that 15% of the population spawned above the State Highway 20 Bridge, the estimated 1992 fall-run chinook salmon spawning escapement in the Yuba River was 6,323 fish (4,489 adults and 1,834 grilse). Although recovery rates of grilse could not be determined this year, lower recovery rates of grilse observed during last year's surveys demonstrated a need to develop separate estimates of adults and grilse. Lower recovery rates probably reflect the tendency for surveyors to overlook grilse during carcass recovery efforts. Because this year's grilse estimates were simply based on the proportion sampled among fresh carcasses, the number of grilse was potentially underestimated.

Spawning Distribution

Assuming again that 15% of the run spawned above the State Highway 20 Bridge, the distribution of spawning in 1992 was similar to that observed last year with about half of the run spawning between the State Highway 20 Bridge and Daguerre Point Dam and a third of the run spawning below Daguerre Point Dam.

Hatchery Fish

Although stray hatchery fish likely contribute to Yuba River spawning runs in every year, the contribution in 1992 appears to be small based on the occurrence of only one coded wire-tagged fish among all carcasses examined this year.

Historical Perspective

The 1992 Yuba River chinook salmon spawning run of 6,323 fish was a below-average spawning escapement compared to the historical estimates; from 1953 to 1992, run size ranged from 1,000 salmon in 1957 to 39,000 salmon in 1982 and averaged about 13,000 salmon annually.

CITATIONS

Printed References

- Jones & Stokes Associates, Inc. 1992. 1991 Fall-run chinook salmon spawning escapement in the Yuba River. June. (JSA 91-219.) Sacramento, CA. Prepared for Yuba County Water Agency, Marysville, CA.
- Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish populations. (Bulletin of the Fisheries Research Board of Canada 191.) Department of the Environment, Fisheries and Marine Service. Ottawa, Ontario.
- Schaefer, M. B. 1951. Estimation of size of animal populations by marking experiments. Volume 52. (Fishery Bulletin 69.) U.S. Fish and Wildlife Service. Washington, DC.

Personal Communications

- Konhoff, D. L. Fishery biologist. California Department of Fish and Game, Rancho Cordova, CA. January 27, 1988 - memorandum to DFG files regarding 1987 Yuba River chinook salmon spawning stock estimate.
- Nelson, J. Fishery biologist. California Department of Fish and Game, Rancho Cordova, CA. March 31, 1993 - memorandum to Nick Villa regarding 1992 Yuba River chinook salmon spawning stock estimate.

**Appendix A. Weekly Recoveries of Tagged Carcasses and
Weekly Population Estimates of Fall-Run Chinook Salmon in
the Yuba River, 1992**

Table A1. Weekly Numbers of Adult Chinook Salmon Carcasses Recovered in the Yuba River between the Highway 20 Bridge and Daguerre Point Dam
October 19 - December 14, 1992

Week of Recovery (j)	Week of Tagging (i)									Tagged Carcasses Recovered (Rj)	Total Carcasses Recovered (Cj)
	Oct. 12	Oct. 19	Oct. 26	Nov. 2	Nov. 9	Nov. 16	Nov. 23	Dec. 1	Dec. 7		
Oct. 19	0									0	18
Oct. 26	0	3								3	45
Nov. 2		1	4							5	68
Nov. 9		0	1	9						10	150
Nov. 16		1	0	1	15					17	139
Nov. 23					1	15				16	190
Dec. 1					1	7	21			29	203
Dec. 7							7	15		22	112
Dec. 14								3	2	5	48
Tagged carcasses recovered (Ri)	0	5	5	10	17	22	28	18	2	107	973
Total carcasses tagged (Mi)	1	13	12	27	44	58	59	40	32	286	
Mi/Ri	--	2.60	2.40	2.70	2.59	2.64	2.11	2.22	16.00	2.7	

Table A2. Weekly Estimates of Adult Chinook Salmon in the Yuba River between the Highway 20 Bridge and Daguerre Point Dam
October 19 - December 14, 1992

Week of Recovery (j)	Week of Tagging (i)									Total
	Oct. 12	Oct. 19	Oct. 26	Nov. 2	Nov. 9	Nov. 16	Nov. 23	Dec. 1	Dec. 7	
Oct. 19	--									0
Oct. 26	--	117								117
Nov. 2		35	131							166
Nov. 9		0	36	365						401
Nov. 16		21	0	22	317					360
Nov. 23					31	470				501
Dec. 1					18	129	310			457
Dec. 7							75	170		245
Dec. 14								64	307	371
Total	--	173	167	387	366	599	385	234	307	2,618
Adjusted total										<u>-285</u> 2,333

Table A3. Weekly Numbers of Adult Chinook Salmon Carcasses Recovered in the Yuba River between the Daguerre Point Dam and the Feather River Confluence November 3 - December 15, 1992

Week of Recovery (j)	Week of Tagging (i)							Tagged Carcasses Recovered (Rj)	Total Carcasses Recovered (Cj)
	Oct. 27	Nov. 3	Nov. 10	Nov. 17	Nov. 24	Nov. 30	Dec. 8		
Nov. 3	0							0	6
Nov. 10	0	2						2	32
Nov. 17	0	0	4					4	45
Nov. 24	0		2	3				5	85
Nov. 30	0			0	17			17	118
Dec. 8	1			1	2	9		13	132
Dec. 15					1	2	6	9	59
Tagged carcasses recovered (Ri)	1	2	6	4	20	11	6	50	477
Total carcasses tagged (Mi)	3	3	19	16	43	53	41	178	
Mi/Ri	3.00	1.50	3.17	4.00	2.15	4.82	6.83	3.6	

Table A4. Weekly Estimates of Adult Chinook Salmon in the Yuba River between the Daguerre Point Dam and the Feather River Confluence November 3 - December 15, 1992

Week of Recovery (j)	Week of Tagging (i)							Total
	Oct. 27	Nov. 3	Nov. 10	Nov. 17	Nov. 24	Nov. 30	Dec. 8	
Nov. 3	-							0
Nov. 10	0	48						48
Nov. 17	0	0	143					143
Nov. 24	0		108	204				312
Nov. 30	0			0	254			254
Dec. 8	30			41	44	440		555
Dec. 15					14	63	269	346
Total	30	48	251	245	312	503	269	1,658
Adjusted total								<u>-175</u> 1,483