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ANADROMOUS SALMONID SPAWNING ESCAPEMENTS IN THE UPPER TRINITY RIVER, CALIFORNIA, 1969

by

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Bay-Delta Fishery Project

Anadromous Fisheries Branch

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ABSTRACT

A mark and recapture program was conducted on the anadromous salmonid escapement in the Trinity River in 1969. Escapements were estimated at 48,478 king salmon (Oncorhynchus tshawytscha) and 3,220 silver salmon (O. kisutch). Too few tagged steelhead (Salmo gairdnerii gairdnerii) were recovered to estimate their escapement. Data on length frequencies, sex ratios, and spawning success for naturally-spawning and Trinity River Hatchery fish and on degradation of river spawning habitat are also presented.

1/ Anadromous Fisheries Branch Administrative Report No. 75-7. Submitted for publication September 1974.

INTRODUCTION

The Trinity River is a large and important spawning tributary for king salmon, silver salmon, and steelhead trout in the Klamath River system, California. Proposed water projects and changes that have occurred since construction of Trinity and Lewiston dams on the Trinity River make it essential to obtain information about anadromous salmonid escapements in the Trinity. A tag and recovery program was conducted in fall 1969 on the Trinity and several of its tributaries from Del Loma to Lewiston Dam (Figure 1) to obtain this information. Emphasis was placed on the king salmon escapement.

Objectives of this study were to determine the:

1) size of salmon and steelhead spawning escapements in the upper Trinity River in 1969,
2) sex composition of the escapement,
3) percentage of each species which spawned successfully,
4) spawning area utilization, and
5) feasibility of trapping migrating fish with a temporary weir and fish trap.

METHODS AND MATERIALS

Trapping and Tagging

Fish were captured in two temporary weirs and traps. Each weir was composed of a series of overlapping panels wired to metal fence posts driven into the streambed, forming a "V" pointing upstream with the fish trap at the apex of the "V". Panel frames were 1.22 m (4 ft) high by 3.05 m (10 ft) long and were constructed of unfinished 5.08 by 5.08-cm (2 by 2-inch) fir. Twenty gauge galvanized sheet metal gussets reinforced the corners. The panels were covered with galvanized 5.08 by 5.08-cm (2 by 2-inch), 16 gauge fencing. The trap was 1.22 m (4 ft) high and 3.05 m (10 ft) square. Panels similar to the weir panels served as the upstream and side walls, and four 1.52 by 3.05-m (5 by 10-ft) panels served as the cover and bottom. The downstream panel was similar to a fyke net entrance. The trap panels were covered with galvanized 5.08 by 5.08-cm (2 by 2-inch), 11 gauge chain link fencing.

The first trap was placed in operation near Del Loma on August 5, 1969. A second trap, which was to function as a recovery trap, was installed 11.3 km (7 miles) upstream, near Big Bar on August 25. These traps were operated until rising waters forced their removal October 17. On October 20, another tagging trap was installed near Junction City to replace the Del Loma trap. This trap was kept in operation until high water forced its removal December 19. It was again placed in operation January 5, 1970, but high water permanently halted all trapping January 10.

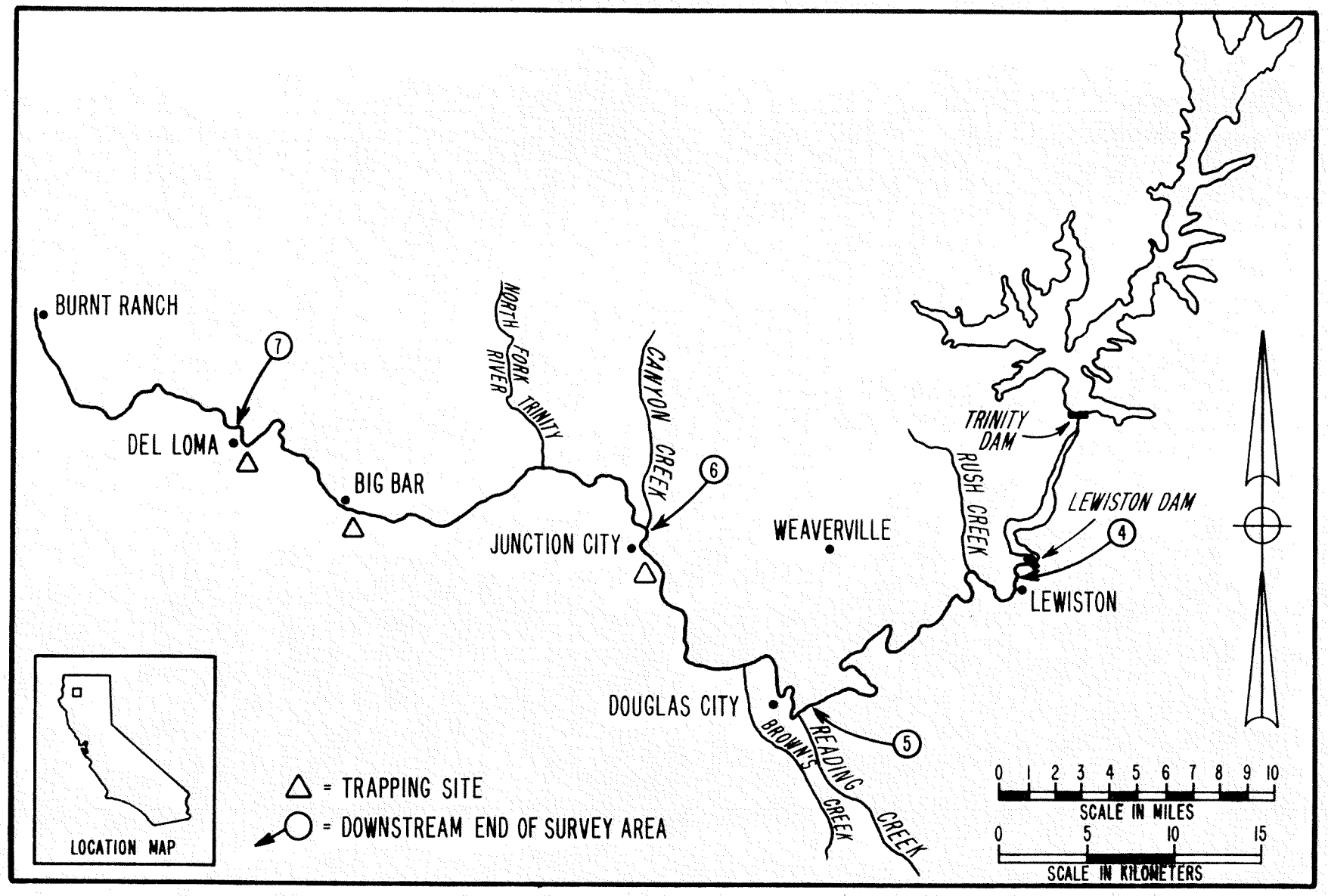

Figure 1. Upper Trinity River sections and tributary streams surveyed, 1969.

Each fish trapped was tagged with a Model FD-67 Floy tag. Beginning September 30, king salmon were also tagged with spaghetti tags to permit estimating Floy tag loss. This procedure continued until October 3, when tagging with Floy tags only was resumed. A second series of double tagging was initiated November 22, during which all species were double tagged. This procedure continued until termination of tagging. All silver salmon and steelhead were double-tagged throughout the study. Floy tags and method of application are described by Thorsen (1967). Spaghetti tags were inserted through the fishes' backs immediately behind the dorsal fin, and were secured by a double figure-eight knot.

To reduce handling stress, no attempt was made to measure fish during tagging operations, except that males were categorized as "small" or "large". In the remainder of the text, these terms refer to king salmon either less- or greater-than 60.64 cm (23-7/8 inches) FL, and silver salmon either less- or greater-than 59.69 cm (23-1/2 inches) FL. These size categories roughly separate grilse and adult fish. They also roughly correspond to the 1969 minimum commercial size limits (25 and 26 inches TL, respectively for silver and king salmon. Other data recorded were tag type, date, sex, and general condition of the fish.

Recovery

A survey was conducted in four sections of the Trinity River and five major tributaries to recover king salmon carcasses (Figure 1). The three sections between Lewiston Dam and Junction City have the same boundaries as those of La Faunce (1965), Rogers (1970), Gibbs (1956), and Weber (1965). Weber and Gibbs also surveyed areas above the dam site. My downstream section, below Junction City, extended as far downstream as 0.4 km (1/4 mile) downstream from Del Loma; earlier surveys ended at North Fork Trinity. Most of my survey effort in this downstream section was concentrated between Junction City and the North Fork Trinity.

Recovery surveys were conducted in the river from mid-October to mid-December. Sampling effort was concentrated in sections having the greatest density of fish in order to see as many carcasses as possible. Each section was surveyed completely before beginning the next survey and all sections were sampled numerous times. All fish recovered during the surveys were examined for sex, size, spawning success, and the presence of tags. Recovery area and date were also recorded for each fish. All fish recovered were cut in half so their gonads could be examined and to avoid recounting carcasses. Fish with empty or virtually empty gonads were considered to have spawned successfully.

The first 50 king salmon counted each day were measured to the nearest 2.54 cm (1 inch) FL. All others were recorded as either "large" or "small". Salmon which had deteriorated to a point where sex could not be determined were recorded as "sex undeterminable"; no attempt was made to measure these fish.

All fish entering Trinity Hatchery were examined, and sex, length category for male salmon, presence of tags, and recovery date were recorded.

To aid in determining the relative use of various river sections by king salmon, an aerial count of redds was made on the Trinity between North Fork Trinity River and Lewiston Dam on October 31, 1969. Also, each spawning riffle was subjectively rated as to use and size by the same method used by La Faunce (unpublished) and Rogers (1970). The aerial counts and subjective riffle ratings were not conducted simultaneously.

All escapement estimates are made by the Petersen method (Ricker 1958). Both spring- and fall-run fish are included in the king salmon recovery data and estimate.

RESULTS

King Salmon

During this study, 1,345 king salmon were tagged; 1,067 with single Floy tags and 278 with both Floy and spaghetti tags. The 1,345 total consisted of 439 large males, 353 small males and 553 females (Table 1).

On the spawning grounds, 1,054 large males, 453 small males, 1,791 large females, 125 small females, and 293 fish of undeterminable sex were examined. An additional 624 large males, 1,130 small males, and 832 females were examined as they entered Trinity Hatchery (Tables 1 and 3). All fish entering the hatchery were examined. Female king salmon entering the hatchery, however, were not divided into small and large categories.

Thirty-six tagged fish were recovered during the carcass survey. Of these, 16 had been tagged with single Floy tags and 20 with Floy and spaghetti tags. Eleven of the double-tagged fish had lost their Floy tags. A total of 129 tagged fish was recovered at the hatchery, 98 with Floy tags only, 29 with Floy and spaghetti tags, and two with spaghetti tags only (Table 2).

Fork lengths of 1,106 male and 1,316 female king salmon examined in the river were measured to the nearest 2.54 cm (1 inch). Mean fork length of males was 69.37 cm (27.31 inches) (95% C.I. 68.40-70.33 cm) and females was 73.03 cm (28.75 inches) (95% C.I. 72.52-73.53 cm) (Table 4).

Examination of the carcasses recovered in the river indicated that 92.6% of the males and 98.8% of the females had spawned.

During this study, 36.4% of the carcasses examined were recovered in river section 4, 39.1% in section 5, 20.8% in section 6, 3.5% in section 7 and 0.3% in the tributaries (actual numbers appear in Table 3).

Table 1

King Salmon Sampled at Three Locations in the Upper Trinity River and Trinity River Hatchery, 1969

	Tagging trap Number	(%)	Examined during carcass surveys Number	(%)	Examined in the hatchery Number	(%)
Large males	439	(32.6%)	1,054	(28.4%)	624	(24.1%)
Small males	353	(26.2%)	453	(12.2%)	1,130	(43.7%)
Females	553	(41.1%)	1,916	(51.5%)	832	(32.2%)
Sex undeterminable	-	-	293	(7.9%)	-	-
TOTAL	1,345		3,716		2,586	

Table 2

Number and Type of King Salmon Tags Recovered in Each Upper Trinity River Section and Trinity Hatchery, 1969

	River recovery							
	Section number				Combined tributaries	River recovery total	Hatchery recovery	Total recoveries
	4	5	6	7				
Single Floy tags	7	3	6	0	0	16	98	114
Double tagged with spaghetti and Floy tags	7	5	8	0	0	20	31	51
Floy tag intact	1	2	6	0	0	9	29	38
Floy tag lost	6	3	2	0	0	11	2	13
TOTAL	14	8	14	0	0	36	129	165

TABLE 3

King Salmon Carcasses Examined for Size and Spawning Success, Upper Trinity River, 1969

Sex	Size (FL)	River sections 4	5	6	7	Rush Creek	Reading Creek	Brown's Creek	Canyon Creek	North Fork	Total	Percent sex determinabl
Male	Over 60.64 cm											
	Spent	371	404	224	45	0	0	0	2	1	1,047	30.6
	Unspawned	1	0	6	0	0	0	0	0	0	7	0.2
	Under 60.64 cm											
	Spent	71	163	101	13	0	0	0	0	0	348	10.1
	Unspawned	24	42	38	1	0	0	0	0	0	105	3.1
Total Male		467	609	369	59	0	0	0	2	1	1,507	
Female	Over 60.64 cm											
	Spent	786	632	303	59	0	0	0	2	2	1,784	52.1
	Unspawned	2	1	3	1	0	0	0	0	0	7	0.2
	Under 60.64 cm											
	Spent	17	62	29	1	0	0	0	0	0	109	3.2
	Unspawned	10	5	1	0	0	0	0	0	0	16	0.5
Total Female		815	700	336	61	0	0	0	2	2	1,916	
Total, Sex Determined		1,282	1,309	705	120	0	0	0	4	3	3,423	100.0
Sex Undeterminable		69	144	67	9	0	0	0	4	0	293	
Grand Total		1,351	1,453	772	129	0	0	0	8	3	3,716	

TABLE 4

Length Frequency of King Salmon Carcasses Measured, Upper Trinity River, 1969

Fork length (cm)	Frequency		
	Males	Females	Total
27.94	3	0	3
30.48	0	0	0
33.02	7	2	9
35.56	14	5	19
38.10	20	2	22
40.64	19	7	26
43.18	33	8	41
45.72	52	8	60
48.26	39	7	46
50.80	39	13	52
53.34	38	11	49
55.88	21	17	38
58.42	45	32	77
60.96	37	38	75
63.50	34	52	86
66.04	44	79	123
68.58	48	119	167
71.12	50	135	185
73.66	60	160	220
76.20	94	208	302
78.74	66	125	191
81.28	76	121	197
83.82	71	70	141
86.36	67	48	115
88.90	32	22	54
91.44	48	17	65
93.98	14	7	21
96.52	13	2	15
99.06	16	0	16
101.60	4	1	5
104.14	1	0	1
106.68	1	0	1
Totals	1,106	1,316	2,422
Mean Lengths	69.37	73.03	71.12

On October 31, 1,763 redds were counted from Lewiston Dam to the North Fork Trinity River during the aerial survey. Of these, 1,418 were in river sections 4 and 5, and 345 in sections 6 and 7 (Table 5).

Table 5

King Salmon Redds and Carcasses
Counted in Upper Trinity River, 1969a/

River section	Redd count	Carcass count
4	525 (29.8%)	1,351 (36.5%)
5	893 (50.7%)	1,453 (39.2%)
6	281 (15.9%)	772 (20.8%)
7	64 (3.6%)	129 (3.5%)
TOTAL	1,763	3,705

a/ Does not include recovery data from tributaries.

Subjective ratings assigned to the major spawning riffles showed a general decrease in quality of the riffles since 1963 (Table 7). Although Lewiston Riffle is still the most utilized riffle rated, aquatic plant encroachment has caused gradual decrease in use of the riffle since 1963 (David Rogers, Calif. Dept. Fish and Game, pers. comm.). The decrease in quality of most riffles was primarily due to siltation.

Silver Salmon

All silver salmon were tagged between November 3, 1969 and January 9, 1970. During this period, a total of 82 was trapped and tagged. Of these, 39 were large males, 20 small males, and 23 females (Table 6).

Table 6

Silver Salmon Tagged and Recovered
in the Upper Trinity River, 1969

	Number tagged	Total number examined in the hatchery
Large males (greater than 59.69 cm FL)	39 (47.6%)	153 (7.7%)
Small males (less than 59.69 cm FL)	20 (24.4%)	1,711 (85.7%)
Females	23 (28.0%)	132 (6.6%)
TOTAL	82	1,996

Table 7

Relative Values and Cause of Degradation, Trinity River Riffles

Riffles[a]	Rating[b] 1963	1967	1968	1969	Cause of degradation
Hatchery	25	25	25	25	Aquatic plant encroachment
Lewiston[c]	100	100	100	100	Aquatic plant encroachment
Rush Creek	25	15	1	1	Inundation
Salt Flat	-	-	-	5	Aquatic plant encroachment
Grass Valley Creek	75	15	10	10	Inundation-siltation
Reo Stott's	25	5	1	1	Siltation
Below Reo Stott's	15	25[d]	20	5	Siltation
Above End of Steel Bridge Road	15	15	10	1	Siltation
End of Steel Bridge Road	25	15	15	20	Siltation
Above Badel Hole[e]	15	-	5	5	Siltation
Above Johnson Hole[e]	15	-	10	10	Siltation
Above Floyd Jackson[e]	15	-	0	0	Siltation, gravel compaction, aquatic plant encroachment
Indian Creek	15	15	5	5	Unknown
Hunt's	25	75	50	50	Aquatic plant encroachment
First Riffle Below Hunt's[f]	-	25	15	15	Unknown
Second Riffle Below Hunt's[f]	-	25	5	5	Inundation
Douglas City	25	5	0	0	High water velocities
Above Reading Creek[e]	15	-	1	1	Unknown

[a] Listed in order going downstream.
[b] Ratings for 1963, 67 and 68 from Rogers (1970).
[c] Use of Lewiston Riffle has gradually decreased since 1969.
[d] Minor stream changes made in this area increased water velocity and improved riffle.
[e] These riffles were not observed in 1967.
[f] These riffles were relatively unimportant in 1963.

Trinity Hatchery was virtually the only source for silver salmon recovery. A total of 1,996 silver salmon, 49 of which had been tagged, entered the hatchery. This total was comprised of 153 large males, 1,711 small males, and 132 females (Table 6). Other recoveries consisted of two tagged and five untagged carcasses which drifted against the weir at the Junction City trapping site. No silvers were recovered during our river surveys.

Steelhead

Eighty-six steelhead were tagged between August 14, 1969, and January 9, 1970. Of these, 29 appeared to be males and 57 females (secondary sex characteristics were not greatly developed when these fish were tagged). One tagged fish and 240 untagged fish (171 males and 70 females) entered Trinity Hatchery (Table 8). No steelhead were recovered during the river surveys or at the tagging facilities.

The male-to-female ratio of steelhead entering the hatchery was 2.6 to 1, compared to 0.5 to 1 for the steelhead tagged.

Table 8

Steelhead Tagged and Recovered
in the Upper Trinity River, 1969

	Number tagged	Total number examined in the hatchery
Males	29 (33.7%)	171 (71.8%)
Females	57 (66.3%)	70 (28.2%)
TOTAL	86	241

DISCUSSION

King Salmon

Tag loss is a potential source of error. Eleven of the 20 double-tagged fish (55%) recovered during the carcass survey had lost their Floy tags. Due to the method of spaghetti tag attachment and the short duration of the study, I assumed 100% retention of spaghetti tags. Because of the excessive Floy tag shedding rate, I estimated the escapement using only spaghetti tag data.

The tag-to-untagged ratios for river and hatchery returns were significantly different at the 0.5% level when tested with Chi-square. Thus, I estimated the river escapement using river data only.

Hatchery recoveries included 31 spaghetti-tagged fish. Hence, of the 278 originally tagged, 247 presumably remained in the river. Using Petersen's model, the 20 river-recovered tags and the 3,716 king salmon recovered in the river produce a point estimate of 45,893 fish in the river. Adding the 2,586 fish entering the hatchery results in a total escapement estimate of 48,479 king salmon. The 95% confidence interval (formula 55 In Chapman 1948) is 27,572 to 70,950.

Other potential sources of error include any aspects of the trapping, tagging, or of the recovery procedures which may cause marked and unmarked fish to be recovered at different rates. Trapping and tagging procedures may cause changes in behavior which influence the probability of subsequent recovery. Also, trapping or carcass recovery procedures may be selective for size or sex categories.

Many of the problems I experienced with this study might be reduced by the use of numbered tags. This would allow comparison of the time of tagging with the time of recovery. It would also allow separate estimates for the different size and sex categories.

Only 7.7% of the estimated escapement was recovered during the carcass count. Flood flows occurred frequently during the study, and it is probable that with lower and more constant flows the river recovery percentage would have been greater. If the fish that entered the hatchery are included in the recovery percentage, the resultant 13.0% is somewhat less than the 14.7% reported by Gibbs (1956) and Weber (1965).

Trinity Hatchery was not in existence when Gibbs and Weber conducted their studies. The difference between the 1969 recovery rates and those of Gibbs and Weber suggests a need for further examination of the techniques for estimating spawning escapement under current conditions.

Small males displayed an uneven distribution in the river; they comprised 26.2% of the fish tagged, 12.2% of the fish recovered in the river survey, and 43.7% of the fish entering Trinity Hatchery. When the river and hatchery data are pooled, however, the resultant percentage (25.1) is quite similar to the composition of fish tagged (26.2%). When these data were tested with Chi-square, the distribution of small males was significantly different beyond the 0.05% significance level. A possible explanation for this is that in areas of high spawning densities, large males harass the small males and keep them away from the redds; whereupon the small males continue upstream (Rogers 1970). An alternative explanation is that spawning, rearing and/or release methods employed at Trinity Hatchery may be promoting an early return of their fish (Roger Lanse, Unpublished).

A reduction in the percentage of king salmon returning to the Trinity as grilse would be beneficial. Few 2-year old king salmon contribute to ocean fisheries, and grilse are not spawned at the hatchery.

The available literature shows the percentage of returns to Pacific Coast hatcheries which are small males is variable, but there are some indications that the percentage returning to Trinity River Hatchery may be higher than at most areas (Table 9).

Table 9

Percentages of Small Male King Salmon
Observed at Several Pacific Coast Sampling Locations

Sampling location	Sampling years	% small males	Source
Trinity Hatchery (Trinity River, Calif.)	1962-1968	20.4-69.1 (range)	Murray (1968)
Iron Gate Hatchery (Klamath River, Calif.)	1964-1968	12.0 (average)	Roger Lanse (unpublished)
Bonneville Dam pool area hatcheries	1945-1960	4.8-14.6 (range)	Maltzeff and Zimmer (1963)
Winchester Dam counts (Umpqua River, Oregon)	1957-1967	22.3 (average)	Bauer and McDivitt (1967)
Gold Ray Dam counts (Rogue River, Oregon)	1942-1967	16.0 (average)	Haight and Riikula (1967)

This suggests the need for examining hatchery techniques to determine factors which may have an effect on grilsing rates.

Nearly 93% of the males and 99% of the females spawned successfully. There was, however, a difference in spawning success between small and large fish. Only 76.8% of the small males had spawned successfully, whereas 99.3% of the large males had done so. Of the females, 87.2% of the small, and 99.6% of the large fish had spawned successfully. The difference in degree of success between small and large fish of the same sex was significant at the 0.5% significance level for both sexes when tested with Chi-square.

King salmon were distributed unevenly on the spawning grounds. Thirty-seven percent of the carcasses were recovered in the 3.22 km- (2 mile-) long area immediately below Lewiston Dam, and 39% in the stretch of river between Old Lewiston Bridge and Douglas City (river sections 4 and 5, respectively). River sections 6 and 7 received minimal use, as did the tributaries examined. These findings are substantiated by the distribution of the redds counted during the aerial survey.

Reduced flows in the Trinity River due to Lewiston and Trinity Dams have resulted in a 95% reduction of the sediment-carrying capacity of the river (California 1970). Several creeks carrying large sediment loads enter the Trinity in section 5 and low river flows allow these sediments to settle on the spawning riffles, rather than flushing them downstream. Riparian vegetation and rooted aquatic plants are encroaching on the riffles, causing further deterioration of the habitat. Due to this degradation, an estimated 28% of the spawning area between Lewiston and Douglas City has been destroyed (California 1970) and the degradation is continuing. Although spawning habitat has been most seriously harmed in Section 5, habitat degradation is not limited to this area. Many riffles in sections 4, 6, and 7 are deteriorating as well. The results of the subjective riffle rating (Table 7) indicate that 14 riffles, including Lewiston Riffle, have decreased while two have increased in quality since 1963. If the trend continues the result could be a reduction of the spawning escapement.

Silver Salmon

All silver salmon were tagged with both Floy and Spaghetti tags, therefore it was not necessary to make a correction for the number of Floy tags lost, although one silver was recovered with its Floy tag missing.

The Petersen method, using the hatchery returns of marked and unmarked silver salmon, produces a population estimate of 3,200 fish. The ratio of tagged-to-untagged king salmon recovered at the hatchery was much different than that of king salmon recovered in the river. If this were also true of silver salmon, this estimate would be severly biased. Because no silver salmon were recovered during the carcass recovery surveys, it is impossible to judge whether or not the hatchery silver salmon tagged-to-untagged ratios are representative of the population.

The male-to-female ratio of fish entering Trinity Hatchery was 14.1:1. This ratio is greatly different than the sex ratio of tagged fish (2.6:1) and is due to the large percentage of small males entering the hatchery. Excluding the small males, the ratio is 1.2:1. Possible causes for the occurrence of so many small fish in the hatchery are discussed in the king salmon section of this report.

Steelhead

Because only one tagged steelhead was recovered no population estimate was made. Since almost equal numbers of steelhead and silvers were tagged (86 and 82, respectively), and a greater proportion of silvers than steelhead entering the hatchery was tagged, the steelhead escapement appears to be larger than the silver salmon escapement. Most of the steelhead entered the hatchery from January through March (Bedell, 1970), after tagging operations had ceased. Consequently, probably a greater portion of the silver escapement than the steelhead escapement was tagged. Since the steelhead escapement apparently was the larger of the two, and fewer steelhead than silvers entered the hatchery, the data suggest that steelhead utilize natural spawning habitat to a greater extent than do silvers in the upper Trinity.

Trap Efficiency

The number of fish captured during trapping operations on the Trinity River indicates the weir and fish trap employed during this study provide an efficient means of capturing fall-run king salmon. The weir and trap proved to be susceptible to high water, however, and their efficiency at capturing silver salmon and steelhead are limited, since these species normally migrate during periods of high flows.

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