The Resources Agency of California
Department of Fish and Game

A KING SALMON SPAWNING SURVEY OF THE SOUTH FORK TRINITY RIVER, 1964 1/

D. A. LaFAUNCE
Region 1, Inland Fisheries

SUMMARY

Because of a lack of information on the size of spawning runs of king salmon Onchorhynchus tshawytscha in the South Fork Trinity River, a tag and recovery or Petersen-type study was performed in 1964 to obtain an estimate of the spawning populations.

The primary objective was to determine if a tag and recovery experiment would give a reliable estimate of the size of the spring-run salmon population. Secondary objectives are: (1) determine the area and time of spring-run spawning; (2) determine the area and time of fall-run spawning; (3) estimate the size of the fall-run spawning population.

Spring-run salmon were seined from pools and tagged with "spaghetti" tags prior to spawning. The tags were recovered as part of a carcass recovery survey throughout the entire river and in Hayfork Creek. The survey extended over both the spring and fall runs of salmon.

The tagged fish did not distribute themselves throughout the population, but spawned close to the resting pools from which they were tagged. The average distance traveled by all tag recoveries was 0.9 miles, ranging from no movement to 5.0 miles.

High consumption of salmon carcasses by bears and other animals reduced the efficiency of the carcass recovery.

Because of the lack of distribution of the tagged fish, the tag and recovery method was only partially successful in estimating the size of the spring-run of king salmon on the South Fork Trinity River. The population estimate obtained is 11,600 (11,604) fish.

The spring-run spawned in the South Fork from about two miles above Hyampom, upstream for 46 miles, and in Hayfork Creek from two to seven miles above its mouth. Spring-run spawning began in late September and peaked in mid-October.

The fall-run spawned in the lower 30 miles of the South Fork, from its mouth to Hyampom, and in the lower 2.7 miles of Hayfork Creek. Fall-run spawning began in mid-October and peaked around the 10th of November.

The fall-run population was estimated to be 3,300 (3,337) fish.

Refinements of tagging time and/or location and intensification of carcass recovery effort would improve the accuracy of a Peterson-type study of the South Fork Trinity River king salmon population size.

1/ Marine Resources Branch Administrative Report No. 67-10

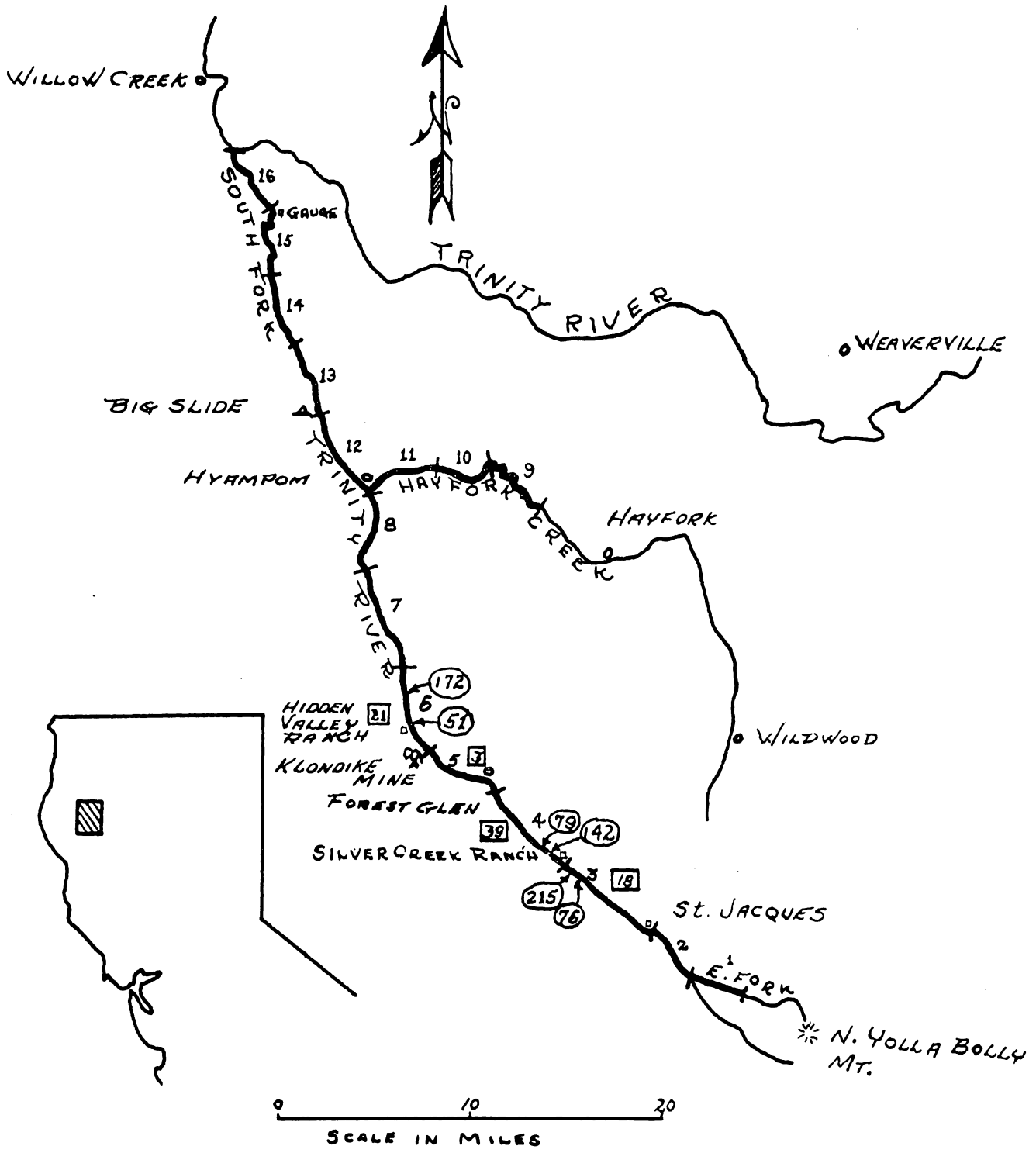

FIGURE 1. The South Fork Trinity River and Hayfork Creek. The survey sections are numbered. The figures in circles are the number of fish tagged from a particular pool. Total tag and tag-scar recoveries are shown by river section, in squares.

INTRODUCTION

An accurate estimate of the size of the fish population to be affected is of great importance when major water project developments are planned for construction on salmon and steelhead streams. This information is essential for proper planning for mitigation and/or enhancement of the threatened fisheries.

A large water development project is planned for the South Fork of the Trinity River, below Hyampom Valley, near Eltapom Creek. Although this project is several years in the future, knowledge of the present runs of anadromous fish is needed for planning future studies.

It was generally known that both a spring-run and a fall-run of king salmon Onchorhynchus tshawytscha occurred in the South Fork, but little else about these runs was known. On one aerial count of redds made by the U. S. Fish and Wildlife Service on October 30, 1958, 101 redds were counted (U.S.F.W.S., 1960). In October 1963, Healey (1963) surveyed about 30 miles of the upper South Fork. He estimated that 7,000 to 10,000 spring-run king salmon spawned in that year.

Because of the general lack of knowledge of the salmon runs in the South Fork, it was decided that a more thorough survey should be made in the fall of 1964.

The primary objective of the survey was to determine if a Peterson-type experiment would give a reliable estimate of the spring-run spawning population. Secondary objectives were: (1) determine the area and time of spring-run spawning; (2) determine the area and time of fall-run spawning; (3) estimate the fall-run spawning population.

These objectives were to be achieved by tagging spring-run salmon from pools before they spawned, then recover the tags as part of a carcass recovery survey throughout the entire river.

DESCRIPTION OF THE STUDY AREA

The South Fork is the largest tributary of the Trinity River (Figure 1). It heads in the North Yolla Bolly Mountains, which have a maximum elevation of 7,863 feet. The river flows generally northwestward for about 90 miles, to its junction with the main Trinity River near the town of Willow Creek. Hayfork Creek is the largest tributary of the South Fork, joining the river at Hyampom.

The South Fork drainage occupies 932 square miles (Cal. Dept. Water Resources, 1962), most of which is lightly populated with humans. Other than Hayfork (pop. 2,200), Hyampom (pop. 250), Wildwood (pop. 250) and Forest Glen (pop. 60), only a few scattered ranchers and miners live along the streams.

Access to the main river by car is limited to scattered points, except in Hyampom Valley and the lower three miles of the East Fork of the South Fork, where roads closely parallel the stream. A fair to good road parallels Hayfork Creek for nearly its entire length, but easy access to the creek is found only near the mouth, in Hayfork Valley and in the vicinity of Wildwood. Some of the access routes are negotiable by jeep only.

The drainage is characterized by steep, heavily forested hillsides. Douglas fir and Ponderosa pine are the main commercial timber. Digger pine-oak associations are common in the lower elevations. Considerable logging has been done in the past and this activity will continue and may increase.

For most of its length, the South Fork flows through a deep, steep-sided canyon. Hyampom Valley is the only open area along the main river. Hayfork Valley is the only open area along Hayfork Creek.

The river, in 1964, was characterized by scattered large, deep pools interspersed with shallow pools, riffles, and rapids. After the December, 1964 flood, most of the pools had disappeared. The tremendous amount of material washed into the stream had filled the pools with fine gravel. Salmon spawning areas are found from the mouth at about 500 feet elevation to about the 3,500-foot level in the East Fork, a distance of some 76 miles.

Stream flow at Forest Glen reached the minimum recorded flow of 15 cfs on September 25-27, 1964. Normal maximum winter flows are about 17,000 cfs. The peak recorded flow was estimated at 33,800 cfs in the December, 1955 flood (U.S.G.S., 1964). The peak flow in the December, 1964 flood exceeded the above, but estimates are not available.

In August 1964, a recording thermometer was installed at Forest Glen. In mid-August, the high was 72° F., with lows of 65° F. In mid-November the lowest temperatures were recorded, prior to the December flood, with a maximum of 34° and a minimum of 33°. At the gaging station near the mouth of the South Fork, the average high for August was 73° and the low 70°. The mid-November temperatures were 43° for both maximum and minimum (U.S.G.S., 1964 and unpublished).

METHODS

A preliminary survey was conducted in early August to locate suitable pools for seining and tagging salmon. The pools had to be accessible at least by jeep, contain 50 or more salmon, and be reasonably free of obstructions to seining.

Several suitable pools were located near the Silver Creek Ranch, about seven miles by jeep above Forest Glen. Two other suitable holes were located; one at the Hidden Valley Ranch, about six miles below Forest Glen, and another about three miles further downstream.

The tagging was accomplished on August 25, 26, and 27. A crew of 12, including two SCUBA divers, did the seining and tagging in the Silver Creek Ranch area. The crew was reduced to eight, including divers at the lower two pools. The tagging could not have been accomplished without the divers. All of the pools had obstructions from which the seines had to be guided or disentangled. The divers were also a great aid in herding the fish to keep them from escaping from the seines.

Three seines were used to capture the salmon and were identical, except for depth which was 10, 20, and 30 feet. All were made of No. 36 nylon twine, 3½ inch stretched measure, 75 feet long, hung in 1/3 on manila float and lead lines. The spacing of the floats was 22 inches, and the leads 12 inches.

Because of varying depths of the pools, all of the seines were used at least once.

The fish were tagged just posterior to the dorsal fin with spaghetti tags consisting of 1/2 inch yellow cellulose nitrate discs crimped on yellow "Resinite" plastic tubing.

The fish were not anesthetized for tagging, but most were quite docile when removed from the net.

The tagged fish were measured to the nearest centimeter, fork length. A few fish succumbed almost immediately from the tagging, and their tags were removed. About a week after the tagging, a check was made in the area for post-tagging mortalities. Several carcasses were found bearing tags. A few additional dead tagged fish had been found by people at the two ranches.

For carcass recovery purposes, the main river was divided into 13 sections, from four miles up the East Fork to the mouth. The lower 14.7 miles of Hayfork Creek was divided into three sections (Figure 1). Each section was a day's run for the survey crew and all but one pair of sections extended from one access point to the next. This exception was the two-day-run from the forks to the Silver Creek Ranch, which necessitated an overnight stop with a local miner. The sections varied in length from 4 to 8.2 miles. Spring-run survey sections totaled 60.5 miles; fall-run sections, totaled 32.9 miles (Table 1).

Carcass recovery began in late September, about one month after the fish were tagged. The recovery crews consisted of two, two-man teams. Wherever possible, one man stayed on each bank of the stream. The survey trips were about one week apart.

The crews counted redds on the first two survey runs. After that, superimposition of redds made counting impractical.

When a tagged carcass was encountered, the tag number, sex, spawning success (for females) and location of the tagged carcass was recorded.

Untagged fish were recorded by sex, size (whether over or under 23-7/8 inches fork length) and spawning success of the females. All carcasses were cut in two to prevent duplicate counts on later runs.

The first 25 carcasses recovered by each crew each day were measured to the nearest 0.5 inch. These measurements were later converted to centimeters. (Centimeter tapes were not available to the survey crews until late in the season).

Tag-scarred carcasses were recorded by river section, but their exact location was not recorded. Hindsight reveals that this should have been done.

RESULTS

A total of 760 salmon including 442 females (58%) and 318 males (42%) was seined and tagged. The fish were collected from four holes in the Silver Creek Ranch area, above Forest Glen, and from two pools in the Hidden Valley

TABLE 1

Salmon Carcass Recovery Summary, South Fork Trinity River, 1964

River Section 1/	Section number	Length (miles)	Number runs	Females	Males	Total 2/ Carcasses	Skeletons	Max. redds	Tags	Tag scars
SPRING RUN										
South Fork										
East Fork Trinity River	1	4.0	3	0	2	2	0	57		
Forks to St. Jacques'	2	4.5	3	21	10	31	7	219		
Silver Creek Ranch	3	5.5	3	65	28	93	11	375	13	5
Rattlesnake Creek	4	6.3	3 3/	129	62	191	4	396	29	10
Klondike Mine	5	5.5	4	98	45	143	6	310	1	2
Miller Creek	6	6.4	5	138	86	224	22	265	10	11
Total, sections 3-6				430	221	651	43	1,346	53	28
St. John's Ranch	7	8.2	5	57	22	79	3	551		
Hyampom	8	5.4	6	21	14	35	4	138		
Hayfork Creek										
Jud Creek (Highway) - Halfway Ridge Trail	9	5.6	1	0	0	0	0	0		
Halfway Ridge Trail - Grassy Flat Creek 4/	10	4.3	1	1	0	1	0	45		
Grassy Flat Creek - S. Fork Trinity River 5/	11	4.8	1	5	5	10	0	106		
Total, spring-run		60.5		535	274	809	57	2,462	53	28
FALL RUN										
South Fork										
Big Slide Camp	12	5.3	7	54	73	127	7	368		
Underwood Creek	13	4.8	6	7	8	15	1	96		
Surprise Creek	14	6.6	4 6/	8	6	14	0	77		
Stream Gauge	15	7.1	2	5	4	9	0	38		
Mouth of River	16	6.4	2 7/	2	0	2	0	25		
Hayfork Creek										
Smith Ranch (falls) - S. Fork Trinity River	8/	2.7	1	12	4	16	6	104		
Total fall-run		32.9		88	95	183	14	708		

1/ Landmarks indicated for sections 3-8 and 12-16 are located at lower end of sections.

2/ Excluding skeletons.

3/ One additional run of 1.5 miles.

4/ Spawning in lower two miles only.

5/ Spawning in upper three miles only.

6/ One complete run, two runs to Grouse Creek (1.6 miles), one run for 3.1 miles.

7/ One run of one mile only.

8/ Lower 2.7 miles of section 11.

Ranch area, (Figure 1). The total known post-tagging mortality was 14 for the upstream groups and 11 for those tagged below Forest Glen, leaving 735 tagged fish comprised of 426 females and 309 males at large.

The tagged fish ranged in length from 40 to 93 centimeters, with a mean of 69.7 cm (Figure 2).

The spring-run began spawning about September 20 in the East Fork and spawning gradually progressed downstream. The peak of spawning above Forest Glen was about October 10. Spawning began in the area below Forest Glen about October 1, peaking in the middle of the month. The spring-run was almost through spawning in Hayfork Creek on October 17.

The fall-run began spawning about October 15 and peaked about November 10. Apparently the fall-run spawned in Hayfork Creek at about the same time, as they were nearly through spawning on November 20.

There was little overlap in the spawning areas of the two runs on the South Fork. For all practical purposes, the spring-run spawned above the Hyampom Valley. The fall-run spawned mostly in the valley and downstream to Grouse Creek. Some fall-run fish spawned from Grouse Creek all the way to the mouth of the river, but turbidity and higher flows below Grouse Creek made observations and carcass recovery nearly impossible.

In Hayfork Creek, spring-run spawning was confined to a five-mile area, beginning two miles above the mouth. Some overlap in spawning area occurred in Hayfork Creek, since the fall-run spawned throughout the lower 2.7 miles of the creek. In spite of this overlap in space, the runs are easily distinguished in Hayfork Creek, since they spawn about a month apart.

The carcass recovery program began September 25 and ended on November 20. During this period, 809 spring-run and 183 fall-run carcasses (excluding skeletons) were recovered in the South Fork and Hayfork Creek (Table 1).

Spring-run recoveries consisted of 53 tagged carcasses, and 756 untagged carcasses. Tagged carcasses were comprised of 46 females and 7 males; untagged carcasses, 489 females and 267 males. Included in the totals of untagged carcasses were 28 fish which carried unmistakable tag scars. The sex of 16 of these was recorded individually (9 females; 7 males), but unfortunately, the remaining 12 were included in the totals only. Through oversight their individual identities (number of males and females) were not maintained.

Fall-run carcasses consisted of 88 females, 95 males and 14 skeletons. The proportions of male and female carcasses recovered in the two runs were markedly different. The spring-run consisted of 66 percent females and only 34 percent males. The fall-run was nearly equal, 48 percent females and 52 percent males (Table 2).

In both runs, 99 percent of the females had spawned. The spawning success of the males was also high, although no records were maintained. Interestingly, four of the seven unspawned females in the spring-run were tagged fish.

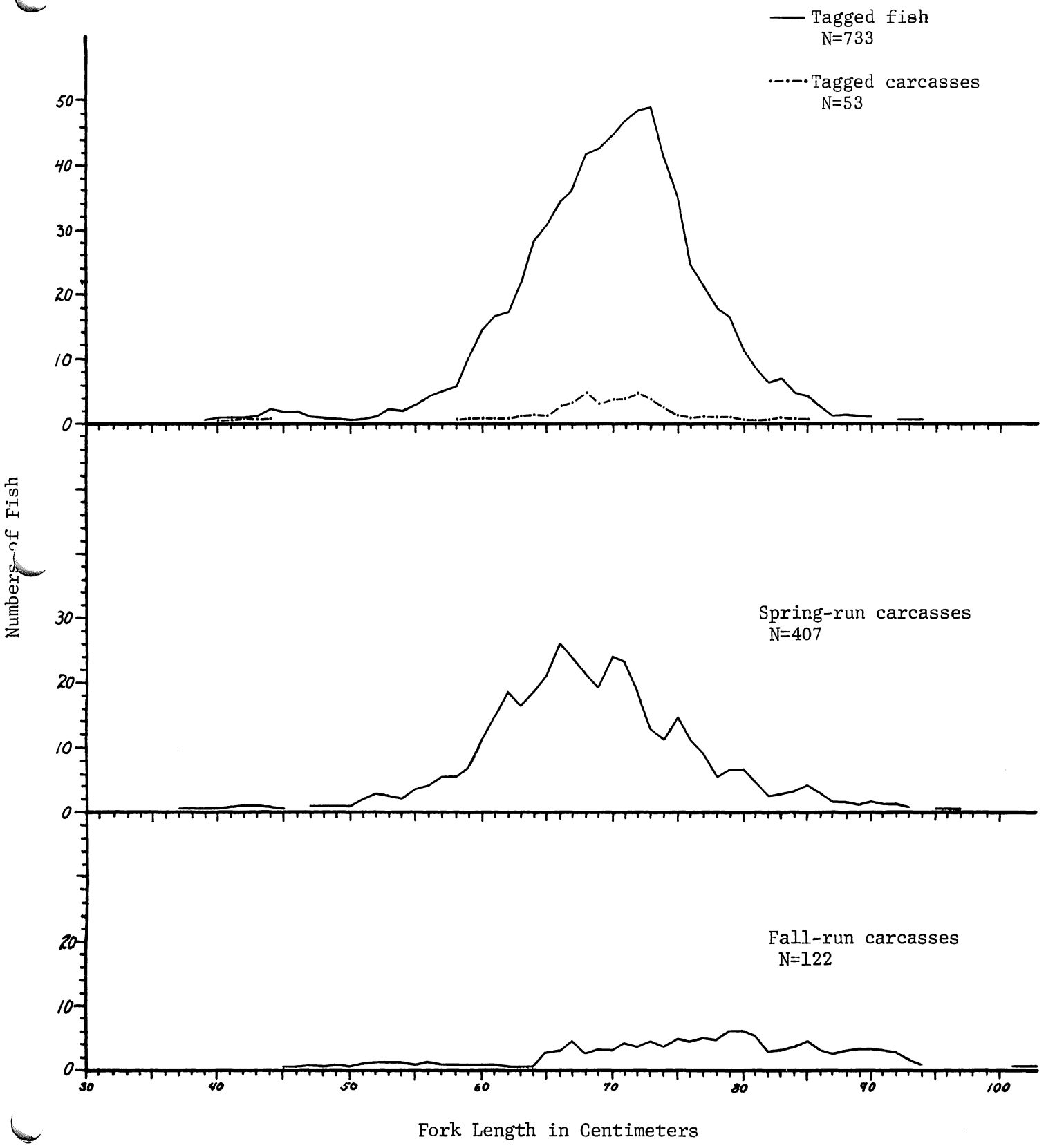

FIGURE 2. Length-frequencies of tagged and recovered king salmon, spring-run salmon carcasses and fall-run salmon carcasses; South Fork Trinity River, 1964. All curves have been smoothed by a moving average of three (3).

The tagged fish did not move extensively. The movements of all tag recoveries averaged 0.94 miles. Seven tags were recovered in the immediate area of tagging. Upstream movements of 31 fish ranged from 0.2 to 5.0 miles, averaging 1.15 miles. Downstream movements of 15 fish ranged from 0.1 to 3.7 miles, averaging 0.93 miles.

DISCUSSION

In trying to estimate the size of the spawning population in the South Fork, several problems became apparent. Tagged fish moved only a short distance from the point of tagging and did not distribute themselves throughout the population. All of the tagged and tag-scarred carcasses, and over 80% of the unmarked spring-run carcasses were recovered in the four river sections where tagging operations were conducted, i.e. sections 3-6 (Table 1).

There was a substantial difference in the sex ratio of the tagged fish and that of the 16 tag-scarred fish of known sex. A 2x2 Chi-square test indicated a significant difference at the .05 level. The most probable explanation is that the males shed tags at a higher rate than the females. I have no explanation for this result. The sex ratio of the 12 tag-scarred fish for which sex could not be determined was assumed to be the same as that of the 16 tag-scarred fish of known sex (Table 3).

To add more complications to estimating the population, the carcass recovery in sections 3-6 was apparently more efficient, for the ratio of carcasses to the maximum number of redds observed was higher (approximately 1:2) than in the non-tagging sections (approximately 1:6). Consequently, the number of carcasses collected in the non-tagging sections could not be used as an index of the population size in those sections.

These problems necessitated some modification of the standard methods for calculating populations, and reduced the overall reliability of the estimates.

Population estimates were calculated as follows: Data collected in sections 3-6 (Table 3) were used to calculate estimates of the numbers of males and females utilizing them. Calculations follow formula 3.7 of Ricker (1958).

$$\text{Number of males} = \frac{309(221 + 1)}{19 + 1} = 3,430$$

$$\text{Number of females} = \frac{426(430 + 1)}{62 + 1} = 2,914$$

Total population utilizing sections 3-6 = 3,430 + 2,914 = 6,344.

Confidence limits indicated that either sex could have been in the majority. Chapman's (1948) method was used to calculate 95% confidence intervals for each estimate. The respective lower and upper limits for the males are 2,127 and 5,620 and for the females, 2,198 and 3,847. Because the sex of 12 tag-scarred fish was estimated and included in these calculations, the spread of these limits must be considered minimal.

TABLE 2

King Salmon Carcasses Examined for Size and Sex, South Fork Trinity River and Hayfork Creek, 1964

	Spring-run		Fall-run	
	Number	Percent	Number	Percent
Females				
Over 23 7/8 inches, F. L.	494	61.1	85	46.4
Under 23 7/8 inches, F. L.	41	5.1	3	1.6
TOTAL FEMALES	535	66.1	88	48.1
Males				
Over 23 7/8 inches, F. L.	224	27.7	76	41.5
Under 23 7/8 inches, F. L.	50	6.2	19	10.4
TOTAL MALES	274	33.9	95	51.9
Skeletons	57		14	
GRAND TOTAL	866	100.0	197	100.0

TABLE 3

Carcasses Recovered and Fish Tagged

River Sections 3-6

	Males	Females	Total
Fish tagged	309	426	735
Total carcasses recovered	221	430	651
Tagged carcasses	7	46	53
Tag-scarred carcasses, sex known	7	9	16
Tag-scarred carcasses, sex calculated	5	7	12
Total marked carcasses recovered	19	62	81

We captured many more females than males (535 and 274); it was (and is) our belief that females were more abundant.

Since the number of carcasses collected in the spring-run sections outside the tagging areas could not be used in the calculations, the redd counts made during the first two survey trips were used to provide a basis for estimating the total spring-run population. The ratio of population estimate to redds in sections 3-6 was considered to be equal to the ratio of total spring-run population to total spring-run redds.

$$\frac{6,344}{1,346} = \frac{\text{Total population}}{2,462} \text{ ; Total population (spring-run only) = 11,604}$$

Similar problems occurred in estimating the fall-run population. Since no tagging was done, the population estimate was to be based on carcass recovery or on redd counts. Carcass recovery efficiency was poor. The problem of predation on the fall-run carcasses was not as acute, but this advantage was offset by poor recovery conditions. Stream flows and turbidity were higher during the spawning of the fall-run. In particular, water conditions made the 17 miles of the river below Grouse Creek impossible to survey, except for the first run, October 20-21, when the fall-run had just begun spawning.

Because of the difficulty of using carcass counts, the fall-run population was estimated on the basis of redd-counts, using the same method as used to estimate the total spring-run population. The population to redd count ratio was considered to be equal to that of spring-run sections 3-6.

$$\frac{6,344}{1,346} = \frac{\text{Fall-run population}}{708} \text{ ; Fall-run population = 3,337}$$

The primary purpose of this experiment was to determine if an estimate of the spring-run population of king salmon in the South Fork Trinity River could be obtained by the "Petersen" or "mark and recovery" method. We did not meet with complete success, most noticeably because the tagged fish did not become distributed uniformly throughout the population. The fish moved only a relatively short distance from resting pools to spawning riffles.

If future experiments of this type are to be performed on the South Fork, an effort should be made to attain better distribution of the tagged fish. Two possible ways this could be accomplished are: (1) tag in more locations; (2) tag earlier in the season.

The greatest problem with (1) would be logistics. Access along the South Fork is limited. It is not practical to try to tag more than about 1/4 mile from a vehicle. Most pools that contained large numbers of salmon were more than a mile apart. Moving the necessary equipment any distance from a vehicle becomes a major task.

The possibility of a serious biological problem is present in suggestion (2); the best time to tag the fish for optimum dispersal would be when they are migrating. If the fish were tagged in late April, May and early June, what effect would the handling have on the fish? Within two to three weeks after the late August tagging, the tagged fish were noticeably more fungused than untagged fish. The results from tagging fish three to five months before they spawned could well be disastrous.

If the fish would not suffer undue tagging mortality, there would still be unknown natural and fishing mortalities taking place. Angling mortality, in some areas, is relatively high, since the fish concentrate in clear, easily accessible pools.

The seines we used were made of heavy twine and had large, rough knots. These knots may have contributed to the increased fungusing which was noticed on the tagged fish. Perhaps seines made of heavy knotless nylon mesh would be less damaging to the fish.

The efficiency of the carcass recovery could be increased by shortening the time between runs. Old carcasses were scarce due to predation by animals. If the runs had been made twice weekly, instead of weekly, the number of carcasses and tags recovered would probably have been nearly doubled. This would have increased the accuracy of the population estimate.

The material used for the tags was not satisfactory. More than 1/3 of the tag recoveries were tag scars. This is a high rate of loss over such a short period of time. The "Resinite" tubing which was used may have been too old. It was purchased circa 1957. This particular tubing is soft and flexible, but apparently it could not withstand the stresses placed upon it by spawning salmon.

CONCLUSIONS

A Petersen-type experiment was only partially successful for estimating the spring-run king salmon population on the South Fork Trinity River. Refinements of tagging time and/or location and intensification of the carcass recovery effort would produce more accurate results.

The spawning population of the spring-run kings was estimated to be 11,600 (11,604) fish.

The spring-run spawned in the South Fork Trinity River from about two miles above Hyampom, upstream for about 46 miles and in Hayfork Creek from two to seven miles above its mouth.

The fall-run of kings spawned in the South Fork from its mouth upstream to just above Hyampom, and in the lower three miles of Hayfork Creek. The fall-run was estimated to be 3,300 (3,337) fish.

Since the spring and fall-runs of king salmon are sufficiently separated in their migrating and spawning times and spawning areas, each run can be evaluated independently.

ACKNOWLEDGMENT

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