

STATE OF ALASKA

William A. Egan, Governor



Annual Progress Report for

*STUDIES ON THE RUSSIAN RIVER
SPORT FISHERY*

by

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RESEARCH PROJECT SEGMENT

State: Alaska

Project No.: F-9-5

Name: Sport Fish Investigations
of Alaska.

Study No.: G-II

Study Title: Sport Fish Studies

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Job Title: Studies on the Russian
River Salmon Sport
Fishery.

Period Covered: July 1, 1972 to June 30, 1973.

ABSTRACT

Creel census on the Russian River revealed an estimated 21,090 red salmon, Oncorhynchus nerka, were harvested by 25,700 man-days of effort. Early and late runs contributed 5,040 and 16,050 salmon, respectively, to the harvest. The seasonal success rate was 0.195 red salmon per hour.

Early and late run escapements were 9,270 and 79,000 red salmon, respectively. Late run escapement is the highest recorded. Sampling at the Russian River weir indicated age class 2.3 comprised 50.0% of the early run. Scale absorption precluded total age determination of late run fish. Both runs were dominated by fish that migrated to sea after two winters in fresh water.

A tagging experiment conducted at the confluence of the Kenai and Russian rivers suggests mortality associated with foul-hooked fish is minimal below the Russian River Falls.

Examination of early and late run salmon after they passed through the fishery revealed 27.2% and 14.4%, respectively, incurred hook-wounds. A tagging experiment indicated unmarked and superficially wounded fish experienced higher survival than moderate or severely wounded fish. Early run mortality associated with foul-hooking, between the weir and spawning grounds, is estimated at 476 red salmon.



Tag recovery of early run fish was 39.4%. Spent, partially spent, and unspawned salmon comprised 89.8%, 6.4%, and 3.8% of the recoveries, respectively. Examination of 5,521 control fish revealed similar information. The average early run salmon spent 13.2 days on the spawning grounds.

Late run tag recovery was 11.2%. Examination of late run untagged carcasses indicated 75.9% were spent. Spawning success was higher in areas of low spawner density.

Egg sampling was conducted in Upper Russian Creek, the only area utilized by the early run. Egg density was 408 eggs/M². Live eggs comprised 94.8% of the sample.

RECOMMENDATIONS

1. Discontinue tagging experiments to assess mortalities associated with an anti-snagging (hook-and-release) regulation. Observations and data collected in 1972 indicate further investigations are not necessary.
2. Conduct a tagging experiment to determine area utilized by late spawning red salmon in Russian River drainage and percent of the run spawning in each area.
3. Sample female red salmon at the Russian River weir to determine fecundity.
4. Determine number of eggs retained by spent female red salmon in the Russian River drainage.
5. Sample redds in red salmon spawning areas to determine the density of egg deposition in relation to numbers of spawning fish.
6. Survey the headwaters of Upper Russian Creek to determine if the area is utilized by early spawning red salmon.
7. Construct a fishway at the Russian River Falls to prevent delay of migrating salmon.

OBJECTIVES

1. To collect and analyze biological data concerning abundance of adult red salmon in the Russian River drainages.
2. To determine racial characteristics and age composition of adult and juvenile red salmon.
3. To determine the sport and commercial harvest of Russian River red salmon.
4. To determine the magnitude of delayed mortality resulting from an anti-snagging (hook-and-release) regulation.
5. To evaluate current regulations on the sport fishery and to provide recommendations for future management and research.

TECHNIQUES USED

The Russian River creel census was a modification of the method described by Neuhold and Lu (1957). Sampling procedures were identical to those outlined by Engel (1965, 1970, 1972), except that harvest, effort, and catch per hour for early and late runs were treated separately. Total harvest and effort estimates were obtained by summing estimates from the respective runs. Annual catch per hour was obtained by dividing total estimated catch by total estimated hours. This provides a true estimate of annual harvest rates as it compensates for disproportionate weekday and weekend angler success. Calculations employing this technique were used to compute harvest, effort, catch per hour, and the percentage of the runs harvested by the sport fishery from 1964 through 1972. Fisheries statistics presented in Tables 1 through 3 reflect these refined calculations which differ from those reported in prior annual progress reports.

Escapements were enumerated at a temporary weir. Weir location and construction has been previously described (Engel, 1970).

A Floy tag applicator utilizing FD-67F internal anchor tags was utilized in tagging experiments at the confluence of the Kenai and Russian rivers. Tags were applied to early run red salmon foul-hooked by sport fishermen. Techniques employed in tagging these salmon have been previously described (Engel, 1970).

Serially-numbered Petersen disc tags, one inch in diameter, were utilized for all tagging experiments at the Russian River weir. Yellow and white tags were applied to early and late run red salmon, respectively. Tags were attached immediately below the dorsal fin with three-inch nickel wire pins (0.0359" diameter).

Hook wound severity was designated superficial (I), moderate (II), or severe (III). Criteria determining wound severity has been previously described (Engel, 1972).

A temporary weir built of wooden panels and anchored by steel posts was constructed in Upper Russian Creek. The weir was approximately 300 yards from the stream mouth and allowed enumeration of all early run red salmon as they moved to the spawning grounds. Tag numbers were recorded as salmon passed the weir. High water resulted in weir failure on August 5 and an unknown number of salmon passed undetected.

Spawning area in Upper Russian Creek was divided into ten 200-yard sections. Daily ground surveys were conducted and numbers of spawning fish in each section recorded. Tag recoveries and carcass examination were effected during these surveys and the section of recovery recorded.

Table 1 Red Salmon Harvest, Effort and Success Rates on the Russian River, 1962-1972.

<u>Year</u>	<u>Early Run</u>	<u>Harvest Late Run</u>	<u>Total</u>	<u>Effort (Man-Days)</u>	<u>Catch/ Hour</u>	<u>Census Period</u>
1962	3,410	1,290	4,700	6,600	0.220	6/15-8/12
1963	3,670	1,390	5,060	7,880	0.190	6/8 -8/15
1964	3,550	2,450	6,000	5,330	0.321	6/20-8/16
1965	10,030	2,160	12,190	9,730	0.265	6/15-8/15
1966	14,950	7,290	22,240	18,280	0.242	6/15-8/15
1967	7,240	5,720	12,960	16,960	0.141	6/10-8/15
1968	6,920	5,820	12,740	17,270	0.134	6/10-8/15
1969	5,870	1,150	7,020	14,930	0.094	6/7 -8/15
1970	5,750	600	6,350	10,700	0.124	6/11-7/27*
1971	2,810	10,730	13,540	15,120	0.192	6/17-8/20**
1972	5,040	16,050	21,090	25,700	0.195	6/17-8/21
1962-1971 Average	6,420	3,960	10,280	12,280		

* Census active from June 11 through July 3, and from July 24 through July 27.

** Census active from June 17 through July 7, and from July 31 through August 20.

Recovered carcasses were opened to determine spawning success. Spawning success was classified as spent (less than 25% eggs retained), partially spent (25% - 75% eggs retained), or unspawned (75% - 100% eggs retained). Male spawning success was determined by gonadal condition and external appearance. These criteria were also used to determine spawning success of late run red salmon.

The number of days tagged early run red salmon remained on the spawning grounds was determined by weir and daily foot survey. Day 1 was the day the fish passed the weir. The final day was the day the carcass was recovered. Numbers of spawning red salmon in a given section were calculated by a modification of the method described by McNeil (1964). Total counts in a section were divided by the average number of days a salmon spent on the spawning grounds. This was divided by the sex ratio to yield the number of females in the section.

Egg density was determined in Upper Russian and Bear creeks with a hydraulic sampler. The sampler is patterned after equipment described by McNeil (1964). Samples were labeled and the eggs counted. Live and dead eggs were separated and percentage of viable eggs calculated. Egg density was expressed as eggs/M².

FINDINGS

A description of the area and prior information collected on the Russian River red salmon, Oncorhynchus nerka, fishery has been presented in Alaska Department of Fish and Game, Federal Aid in Fish Restoration, Annual Progress Reports by Lawler (1963, 1964) and Engel (1965 through 1972). Emphasis from 1962 through 1968 was primarily directed toward the collection and analysis of harvest, effort, and escapement data. Research activities since 1969 have emphasized evaluation of regulatory measures to eliminate snagging, a common angling practice since the inception of the fishery. Emphasis has been placed on determining delayed mortality of red salmon hooked elsewhere than head, mouth, or gills, and released.

A single hook restriction in 1965 and a fly-only regulation in 1966 were transitional attempts by the Alaska Board of Fish and Game to establish an ethically acceptable fishery. The fly-only requirement was supplemented in 1967 with a foul-hook regulation requiring any fish not hooked in head, mouth, or gills, be immediately released. A historic review of Russian River fisheries regulations was presented by Engel (1967).

Creel Census

In accordance with the anti-snagging philosophy, the fly-only and foul-hook requirements remained mandatory in 1972. A sanctuary area was also established at the confluence of the Kenai and Russian rivers. The area extended

from the Kenai River ferry crossing to a marker 500 yards upstream on the Russian River. Engel (1971) concluded early run fish remain in the fishery up to 14 days and are subject to repeated capture. The area was closed to all fishing from June 1 through June 30. Large numbers of early run fish were observed in the area on June 30 and the closure was extended by emergency order through July 14. The sanctuary was implemented to reduce the number of early run fish harvested, while allowing the fishery to continue without total closure. Late run red salmon pass through the fishery in approximately six days and do not require additional protection.

A creel census to evaluate these regulations and measure harvest and effort was continuous from June 17 through August 21. The census sampled all fishing effort on red salmon. Projected angler counts yielded an estimated 25,700 man-days of effort or 108,200 angler hours. Effort on the early and late run was estimated at 12,340 and 13,360 man-days, respectively. Based on interviews with 3,927 anglers who fished 16,645 hours and caught 3,058 fish, the combined harvest was estimated at 21,090 red salmon. Early and late run harvests were 5,040 and 16,050 salmon, respectively. Mean early and late run success rates were 0.096 and 0.287 salmon per hour, respectively. Table 1 summarized harvest, fishing effort, and catch per hour since 1962.

Total angler effort in 1972 was the greatest recorded and total harvest was exceeded only in 1966. Catch per hour was greater during the early years of the fishery (snagging permitted), but was the highest recorded since the introduction of the foul-hook regulation (1967). Increased effort and success rates are related to the following: (1) the fishery was continuous for 66 days with no emergency closures imposed, (2) the total run was the highest recorded.

During the census, an estimated 569 Dolly Varden, Salvelinus malma, 385 silver salmon, O. kisutch, 382 rainbow trout, Salmo gairdneri, 46 pink salmon, O. gorbuscha, and 14 round whitefish, Prosopium cylindraceum, were harvested incidental to red salmon.

Weekday and weekend fishermen counts averaged 73.3 and 138.5 anglers, respectively. Anglers fished an average of 4.0 and 4.4 hours on weekdays and weekends, respectively. Mean early and late run catch per hour was 0.195 for both weekdays and weekends. A summary of fisheries statistics since 1964 are presented in Table 2. Average fishermen counts presented in Table 2 differ from those reported in preceding annual progress reports. Prior to 1971, angler counts were conducted from 0200 to 1000 hours (20-hour day). In 1971, the count schedule was reduced to 12 hours (0600 - 1800). Figures in Table 2 are average counts conducted between 0600 and 1800. These counts are comparable.

Stream counts indicated 47.6% and 48% of the anglers fished the Russian and Kenai rivers confluence during the early and late run, respectively. Angler

Table 2 Differences between Weekday and Weekend Day Fishing Pressures and Rates of Success at the Russian River, 1964 - 1972.

Year	FISHERMEN COUNTS		CATCH PER HOUR		HOURS FISHED	
	<u>Weekdays</u>	<u>Weekend days</u>	<u>Weekdays</u>	<u>Weekend days</u>	<u>Weekdays</u>	<u>Weekend days</u>
1964	29.6	70.9	0.444	0.209	3.3	3.9
1965	31.7	78.1	0.305	0.223	4.5	5.4
1966	53.2	143.1	0.297	0.183	4.8	5.5
1967	68.9	110.5	0.171	0.100	5.3	5.4
1968	71.5	124.9	0.153	0.107	5.3	5.8
1969	64.5	111.7	0.110	0.074	4.9	5.1
1970	83.5	127.8	0.140	0.100	4.8	4.7
1971	87.9	157.2	0.194	0.189	4.8	5.3
1972	73.3	138.5	0.203	0.187	4.0	4.4
1964-1971 Average	61.3	115.5	0.227	0.148	4.7	5.1

concentration changed from 1971, when 79.1% and 27.8% of the anglers fished the confluence during the early and late run, respectively. Change in angler concentration during the early run is related to the sanctuary area, which reduced the area available to anglers by 500 yards. Anglers during the early run sought other locations to avoid congestion. Fishermen during the late run were divided between the confluence and lower Russian River. The large run rendered fishing equally attractive in both areas.

Escapement

Red salmon escapements have been enumerated by counting tower since 1960 and weir, since 1969, at the outlet of Lower Russian Lake. This site permits enumeration of the runs after they have been harvested by the Cook Inlet commercial and Russian River sport fisheries. Prior to 1972, total escapement enumerated at the counting tower/weir averaged 49,305 and ranged from 26,470 to 65,500 red salmon (Table 3).

The Russian River weir was operational on June 15, 1972. The first red salmon was enumerated June 24. An estimated 1,500 red salmon were observed below the weir when it was dismantled August 28.

Early escapement has ranged from 2,650 to 33,300 and averaged 12,623 red salmon (Table 3). Escapement in 1972 was 9,270, or 3,353 below the 12-year mean. The 1972 early escapement was also considerably below the 1966 parent escapement of 16,660.

Escapement of late Russian River stocks has ranged from 18,680 to 54,430 with a 12-year mean of 36,676 salmon (Table 3). The 1972 escapement of 79,000, including 160 jacks, is the highest recorded. The 1972 late run escapement is substantially higher than 1966 or 1967 parent escapements of 34,430 and 49,480 red salmon, respectively.

Foot surveys indicated an estimated 6,000 additional late run salmon spawning below the Russian River Falls. Total late run to the Russian River system, including sport catch, weir escapement, and fish spawning below the falls, was approximately 102,280. Data are not available regarding the early and late runs contribution to the Cook Inlet commercial fishery.

Scale analysis by the Commercial Fisheries Division revealed six-year-old fish comprised 50.0% of the early run (Table 4). Ocean life of late run salmon was not ascertained due to scale absorption. Both runs were dominated by fish which spent two years in fresh water. Male-to-female sex ratio of 994 early and 1,994 late red salmon was 1:1.5 and 1:1.1, respectively.

A total of 666 silver salmon and 172 king salmon, O. tshawytscha, were also enumerated at the weir. Annual silver salmon escapements are not

Table 3 Russian River Red Salmon Escapement Estimates and Harvest Rates for Early and Late Runs, 1960-1972.

Year	ESCAPEMENT			PERCENTAGE OF RUN CAUGHT BY SPORT FISHERY**	
	Early Run	Late Run	Total	Early Run	Late Run
1960	9,120	34,850	43,970	--	--
1961	7,790	18,680	26,470	--	--
1962	33,300	22,370	55,670	9.3	5.5
1963	14,380	51,120	65,600	20.3	2.6
1964	12,700	46,930	59,630	21.8	5.0
1965	21,510	21,820	43,330	31.8	9.0
1966	16,660	34,430	51,090	47.3	17.5
1967	13,710	49,480	63,190	34.6	10.3
1968	9,200	48,880	58,080	42.9	10.6
1969	5,000*	28,920	34,000	54.0	3.8
1970	5,450	28,200	33,650	51.3	2.1
1971	2,650	54,430	57,080	51.5	16.4
1972	9,270	79,000	88,270	35.2	16.8
1960-1971 Average	12,623	36,676	49,305	36.5***	8.3***

* Escapement determined by foot survey of Upper Russian Creek.

** Based on escapements passed the weir; commercial harvest and fish spawning downstream from the weir were not considered.

*** Ten-year mean.

Table 4 Age Analysis of Early Red Salmon Escapements Past Lower Russian Lake Weir, 1972.

Age Class	Sample Size	Parent Year	Percent of Sample
1.2	5	1968	3.0
1.3	63	1967	38.0
2.2	14	1967	8.4
2.3	83	1966	50.0
2.4	1	1965	.6

comparable as the run is not complete when weir operations are terminated. King salmon escapements are comparable as the run passes the weir prior to August 20. Escapements for 1969, 1970, and 1971, were 119, 240, and 21 king salmon, respectively.

Confluence Tagging Investigation

An estimated 51.2% of the red salmon landed in 1972 were released because they were illegally hooked. This is considerably greater than the 1967-71 mean of 39.3%. This increase is probably related to the magnitude of the late run. These fish were so numerous that at times it was difficult to fish without inadvertently foul-hooking a salmon.

A tag and recovery investigation initiated in 1969 was continued in 1972 to determine mortality associated with foul-hooked and released early run red salmon. Tagging was conducted at the confluence of the Kenai and Russian rivers, the only area where sufficient numbers of salmon were available.

Tagging at the confluence, however, interjected an unavoidable unknown as red salmon that are not of Russian River origin pass through this portion of the fishery. The vastness of the Upper Kenai River drainage and the glacial nature of much of the water precluded a meaningful tag recovery program to assess stock mixture at the tagging site.

Tags were applied to 47 early run salmon that were foul-hooked, landed, and released by participants in the sport fishery. Twenty-eight salmon were tagged during the weekend of June 24 - 25, and an additional 19 on July 1 - 3. Tagging was discontinued on July 4, as there were insufficient salmon at the tagging site.

Twenty-eight (59.6%) tagged fish were recovered: 23 at the Russian River weir and five during the creel census. As estimated, 24 salmon were recaptured in the sport fishery (Table 5).

Although Table 5 indicated negative mortality occurred below the Russian River Falls, other factors must be considered: (1) sample size was small in relation to total numbers of foul-hooked fish, (2) creel census may not have been random in sampling tagged fish, (3) all fish tagged may not have been Russian River stocks, (4) Engel (1971; 1972) during similar studies reported four tagged foul-hooked fish were found dead. This investigation showed minimal mortality occurred below the Russian River Falls.

Studies conducted in 1970 and 1971 revealed 28.3% and 15.1%, respectively, of the tagged foul-hooked fish passed the Russian River weir. This increased to 48.9% in 1972. This increase is attributed to the sanctuary area which reduced the numbers of early fish harvested.

Table 5 Number and Percent of Recovered Foul-Hooked Early Red Salmon Tagged at the Kenai and Russian River Confluence, 1972.

	<u>Fish Tagged</u>	<u>Tagged Fish Recovered at Weir</u>	<u>Projected Sport Harvest of Tagged Fish</u>	<u>Total</u>
Number	47	23	24	47
Percent	100.0	48.9	51.1	100.0

Table 6 Summary of Hook Injuries Sustained by Early Run Russian River Red Salmon, 1971-1972.

<u>Year</u>	<u>No. Fish Tagged</u>	<u>No. Fish w/Injuries</u>	<u>% Fish w/Injuries</u>	<u>% Injury in Each Category</u>			
				<u>0</u>	<u>I</u>	<u>II</u>	<u>III</u>
1971	746	472	63.3	36.7	40.3	16.5	6.5
1972	994	270	27.2	72.9	17.8	5.4	3.9

Table 7 Summary of Hook Injuries Incurred by Late Run Russian River Red Salmon, 1971-1972.

<u>Year</u>	<u>No. Fish Tagged</u>	<u>No. Fish w/Injuries</u>	<u>%Fish w/Injuries</u>	<u>% Injury in Each Category</u>			
				<u>0</u>	<u>I</u>	<u>II</u>	<u>III</u>
1971	997	116	11.6	88.4	8.8	2.0	0.8
1972	2003	288	14.4	85.6	8.7	4.2	1.5

Average time required for a tagged salmon to migrate from the confluence area to the weir, a distance of approximately 2.5 miles, ranged from 8 - 15 days and averaged 10.8 days. This is somewhat less than the 14 days reported by Engel (1971). Low water facilitated fish passage in 1972 and may account for the timing differential.

Weir Tagging Investigations

Determination of delayed mortality between weir and spawning grounds as well as spawning success as it relates to foul-hooked fish and effected by a tagging study at the Russian River weir. A total of 994 early run salmon (10.7% of the escapement) were tagged. Tagged fish were examined for hook-wounds and, if present, the severity noted. Fish were classified, according to the seriousness of the wound, as unmarked (0), superficial (I), moderate (II), and severe (III). A summary of hook injuries for early Russian River red salmon are presented in Table 6.

Table 6 indicated a substantial decrease in the number, percent, and severity of wounds incurred by early fish in 1972. Two factors account for this reduction (1) low water facilitated fish passage and salmon moved rapidly through the fishery, (2) the closed area at the Kenai and Russian River confluence reduced the incidence of recapture.

A total of 2,003 late run red salmon were tagged at the weir or 2.5% of the escapement (Table 7). This table reveals a greater percentage of late fish sustained hook wounds in 1972 than in 1971. The percentage incurring moderate or severe wounds also increased. These increases are related to the following: (1) The area above the Homer Electric power line was closed to salmon fishing on August 11, 1971. This afforded increased protection to late salmon. There were no closures in 1972. (2) The record run in 1972 is related to the increased percentage of wounded fish.

Escapement, number of fish tagged, and the percent of the escapement by weekly period is presented in Table 8. This table indicates tagging was disproportionate and sampling did not reflect weekly escapements. Disproportionate tagging did not affect investigations relating to early run fish. Angling pressure was constant throughout the run and all early run salmon spawn in Upper Russian Creek. Late run angling pressure was also constant. These fish spawn in various areas of Upper Russian Lake drainage and disproportionate tagging may have influenced the number of tags recovered in a given area.

Early Run Tag Recovery

Tag recovery of early run salmon was effected by daily surveys of the spawning grounds in Upper Russian Creek. Thirty-one surveys were conducted encompassing the period July 22 through August 21. Tag recovery was 39.4%. Tag recovery was hampered by intense bear predation and high water. A summary of hook injuries and recovery rates for early salmon are presented in Table 9.

Table 8 Escapement, Number of Red Salmon Tagged, Percent Tagged and the Percent of the Escapement by Weekly Period, Russian River, 1972.

<u>Weekly Period</u>	<u>Escapement*</u>	<u>Early Run</u>		<u>% of Total Escapement</u>
		<u>Number Tagged</u>	<u>% Weekly Escapement Tagged</u>	
6/18-6/24	7	7	100.0	0.07
6/25-7/ 1	517	58	11.2	5.58
7/ 2-7/ 8	5,116	465	9.1	55.19
7/ 9-7/15	3,438	464	13.5	37.09
7/16-7/22	105	---	----	1.13
7/23-7/29	87	---	----	0.94
Total	<u>9,270</u>	<u>994</u>		<u>100.00</u>
		<u>Late Run</u>		
7/30-8/ 5	42,265	1,124	2.7	54.92
8/ 6-8/12	29,488	743	2.5	38.31
8/13-8/19	4,806	---	----	6.24
8/20-8/26	<u>404</u>	<u>127</u>	31.4	<u>0.53</u>
Total	<u>76,963</u>	<u>1,994</u>		<u>100.00</u>

* Late run escapement, percent of the total escapement and percent tagged based on escapement as of 8/26. Jacks are not included in the calculation.

Table 9 Summary of Hook Injuries and Recovery Rates for Early Run Russian River Red Salmon, 1972.

<u>Class Injury</u>	<u>Weir Observations Number of Fish</u>	<u>Percentage</u>
Unmarked	724	72.9
Superficial	177	17.8
Moderate	54	5.4
Severe	39	3.9
<u>Spawning Ground Recoveries</u>		
Unmarked	301	76.8
Superficial	66	16.8
Moderate	18	4.6
Severe	7	1.8

Table 9 indicates unmarked and superficially wounded salmon experienced greater survival than moderately or severely wounded fish. These findings are similar to those reported by Engel (1972).

The percent survival, number of fish in each category and numbers of fish surviving are presented in Table 10. A survival rate of 100% is assumed for all unmarked fish.

Table 10 indicated mortality associated with wounded foul-hooked fish does occur between the Russian River weir and spawning grounds at Upper Russian Creek, a distance of approximately 14 river miles. Loss is estimated at 476 red salmon or 5.1% of the early escapement. This loss is the maximum mortality associated with foul-hooked fish. The following are presented in support of this conclusion: (1) Carcass and live counts at Upper Russian Creek peaked at 8,410 red salmon, only 384 less than the calculated spawning population. Failure of the observed fish to equal the calculated population is attributed to high water and bear predation (2) Tagging after salmon experienced the stress of foul-hooking undoubtedly maximized mortality associated with hook wounds. (3) Natural mortality associated with brown, Ursus arctos, and black, U. americanus, bear predation must be taken into account. Although it is generally believed significant bear predation occurs only on the spawning grounds (Foerster, 1968), predation is known to occur in the stream between Upper and Lower Russian Lake. The extent of this predation is unknown. (4) Injuries sustained in negotiating the Russian River Falls may contribute to delayed mortality between the weir and spawning grounds. No mortality was observed in the Falls in 1972. Nineteen early run salmon (1.9% of those examined) displayed abrasive injuries presumably caused by this natural obstacle. (5) Injuries received when escaping commercial fishing gear should be considered. Twelve (1.2% of the sample) salmon displayed marks caused by gill nets. Nelson and Abegglen (1955) in a controlled experiment at Karluk Lagoon, Kodiak, Alaska, concluded, "...that from 10 to 20 percent of gill-net-marked fish escaping commercial nets die because of injuries inflicted by the webbing." They also concluded the majority of mortality occurred shortly after fish were freed from the nets. It is therefore doubtful that mortality occurring between the Russian River weir and spawning grounds is directly related to gill net injuries. The possibility that fish injured in commercial nets were more susceptible to disease, parasitism, predation, and injury from natural barriers, should not be discounted. (6) A combination of any or all of the above may be contributing to mortality between weir and spawning grounds, irrespective of hook wounds.

Spawning success of tagged early run fish recovered from Upper Russian Creek is presented in Table 11. Complete spawning was noted in 78.4% and 89.8% of the males and females, respectively. Unspawned fish comprised 3.8% of the total recovered. If partially spent fish are considered spent, the combined spawning success is 96.2%. Only 2.7% of the females were unspawned.

The unbalanced male-to-female sex ratio (1:1.5) and the relatively low percentage of spent males would not affect egg fertilization. Mathisen (1955), in a

Table 10 Percent Survival, Number of Fish in Each Class and Number of Surviving Fish in Each Class, Russian River, 1972.

<u>Class Injury</u>	<u>Percent Survival</u>	<u>No. of Fish in Each Class</u>	<u>No. Survivors in Each Class</u>
Unmarked	100.0	6,758	6,758
Superficial	89.7	1,650	1,480
Moderate	80.0	501	401
Severe	43.0	361	155
Total		9,270	8,794

Table 11 Percent Spawning Success of Tagged Early Run Red Salmon Recovered at Upper Russian Creek, 1972.

	<u>Spawning Success</u>			<u>Total</u>
	<u>Spent</u>	<u>Partially Spent</u>	<u>Unspawned</u>	
Male	78.4	15.4	6.2	100.0
Female	95.4	1.9	2.7	100.0
Combined	89.8	6.4	3.8	100.0

controlled experiment, concluded that fertilization is relatively complete even when the male-to-female sex ratio is 1:15.0.

Table 12 indicates unmarked or superficially wounded fish experienced greater spawning success than moderately wounded fish. The small number of severely wounded fish recovered does not justify comparison with other wound classifications. It is of interest to note, however, that six of the seven fish in this category were spent.

Untagged carcasses were examined in conjunction with stream counts and tag recovery. All fish were opened to determine spawning success (Table 13). Complete spawning was 88.0% and 92.1% for males and females, respectively. Unspawned fish comprised only 1.3% of the salmon examined. If partially spent fish are considered spent, the combined spawning success is 98.7%. This information is similar to data obtained from tagged and recovered fish. Discrepancies between tagged fish and the control group may be related to the small size of the former.

Stream counts revealed the majority of spawning in Upper Russian Creek occurred in sections IV through VI and the majority of carcasses were recovered in these sections. No correlation was found between the section of tag recovery and spawning condition of the fish.

Twenty-nine females and 23 males were recovered dead immediately above the weir. All fish were unspawned. Thirteen unspawned females and three unspawned males were recovered dead below the weir. The factors contributing to these mortalities is not known but may be related to injuries incurred passing or while attempting to pass the weir. These fish were deleted from computations relating to spawning success.

Forty-six loose tags were recovered which had been applied to 25 males and 21 females. Male-to-female sex ratio for lost tags is therefore 1:0.8. These data indicate males lost their tags at a greater rate than females. Disproportionate tag loss is probably related to advanced sexual development of male salmon. Males display elongated jaws and hooked snout, large teeth, prominent hump on the back, and the body is compressed. Body compression may loosen the tags, making it more susceptible to loss.

Early run salmon spawned in Upper Russian Creek between July 27 and August 25. Tag recoveries were greatest during the five-day period, August 16 - 20 (Table 14). This table also indicates partially spent or unspawned salmon perished somewhat before the majority of spent fish. Stream counts revealed 61.0% of the early run fish perished prior to August 21. It is concluded that spawning peaked during the five-day period, August 11 - 15.

Tags from 129 salmon which were recorded at the weir were recovered on the spawning grounds. Tagged early run salmon spent an average of 13.2 days on the spawning grounds (Table 15).

Table 12 Percent Spawning Success by Sex and Degree of Injury for Early Tagged Red Salmon Recovered in Upper Russian Creek, 1972.

<u>Hookwound</u>	<u>Sex</u>	<u>Spent</u>	<u>Partially Spent</u>	<u>Unspawned</u>	<u>Total</u>
0	Males	78.4 (80)	15.7 (16)	5.9 (6)	100.0 (102)
0	Females	97.5 (195)	1.5 (3)	1.0 (2)	100.0 (200)
0	Combined	91.1 (275)	6.3 (19)	2.6 (8)	100.0 (302)
1	Males	84.0 (21)	8.0 (2)	8.0 (2)	100.0 (25)
1	Females	92.5 (37)	5.0 (2)	2.5 (1)	100.0 (40)
1	Combined	89.2 (58)	6.2 (4)	4.6 (3)	100.0 (65)
2	Males	-- (0)	100.0 (2)	--- (0)	100.0 (2)
2	Females	81.3 (13)	-- (0)	18.7 (3)	100.0 (16)
2	Combined	72.2 (13)	11.1 (2)	16.7 (3)	100.0 (18)
3	Males	100.0 (1)	--- (0)	--- (0)	100.0 (1)
3	Females	83.3 (5)	--- (0)	16.7 (1)	100.0 (6)
3	Combined	85.7 (6)	--- (0)	14.3 (1)	100.0 (7)

Table 13 Spawning Success by Percent and Number (in parenthesis) of Untagged Early Red Salmon in Upper Russian Creek, 1972.

	<u>Spawning Success</u>		<u>Unspawned</u>	<u>Total</u>
	<u>Spent</u>	<u>Partially Spent</u>		
Male	88.0 (2,312)	10.6 (279)	1.4 (37)	100.0 (2,628)
Female	96.0 (2,776)	2.9 (84)	1.1 (33)	100.0 (2,893)
Combined	92.1 (5,088)	6.6 (363)	1.3 (70)	100.0 (5,521)

Table 14 Number and Percent (in parenthesis) Recovery of Tagged Early Run Red Salmon by Salmon by Five Day Period, Upper Russian Creek, 1972.

Category	Five Day Period						Total
	7/27-7/31	8/1-8/5	8/6-8/10	8/11-8/15	8/16-8/20	8/21-8/25	
Spent	0 (-)	2 (0.6)	17 (4.8)	97 (27.5)	166 (47.2)	70 (19.9)	352 (100.0)
Partial/ Unspawned	4 (10.0)	1 (2.5)	8 (20.0)	10 (25.0)	12 (30.0)	5 (12.5)	40 (100.0)

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Table 15 Average Number of Days Early Run Red Salmon Remained on the Spawning Grounds, Upper Russian Creek, 1972.

	Spawning Success						Combined
	Spent Female	Spent Male	Partially Spent Female	Partially Spent Male	Unspawned Female	Unspawned Male	
Days	14.1	12.6	11.2	12.7	5.2	---	13.2

These data are in agreement with those of Kuznetsov (1928) in Kamchatka, U.S.S.R., where red salmon spent approximately 15 days on the redd. Barrett's (1972) investigations of seven red salmon spawning streams in Tustumena Lake drainage (Alaska) indicated stream life in five streams ranged from 11.8 to 14.4 days. Stream life in two remaining streams was calculated at 20.6 and 26.5 days, respectively. A study of the Kvichak red salmon (Hartman, 1959) indicated females remained on the redd 7.75 days. In a similar experiment on the Alaska Peninsula (Eicher, 1959) concluded tagging did not alter the behavior of red salmon.

Late Run Tag Recovery

Late run tag recovery was effected by six foot-surveys of the spawning areas and two float trips between Upper and Lower Russian lakes. The recovery rate was 11.2% (233 tags). A summary of hook injuries and spawning ground recoveries are presented in Table 16.

Table 16 indicates spawning success of unmarked tagged and recovered late run fish was 86.7%. This is comparable to the spawning success of 89.8% for early run tagged fish in the same category. All recovered superficial and moderately wounded fish had successfully spawned.

An estimated 2,000 - 4,000 late run salmon spawned in Upper Russian Creek. The arrival of these fish corresponded to the cessation of early run spawning on approximately August 25. A float trip on August 23 indicated an estimated 5,000 late run fish spawning in Upper Russian River. Spawning was observed from the outlet of Upper Russian Lake to a series of rapids approximately 2.5 miles downstream. Observations below the canyon were similar to those of Engel (1972) in that no spawning fish were observed.

Surveys during late August revealed late spawners concentrated along the north and east beaches of Upper Russian Lake. Removal of a beaver dam from a small tributary (Bear Creek) on September 28 facilitated fish passed into this stream. Thousands of red salmon immediately entered the system and commenced spawning. Successive waves of spawners were also observed at the mouth. Quantitative escapement counts were not conducted.

Few salmon were observed spawning in the lake and few carcasses were recovered from this area. These observations suggest the majority of fish observed along north and east beaches did not spawn in the lake, but utilized the Bear Creek system.

A timing differential exists between late run salmon which spawn between Upper and Lower Russian lakes and those which utilize Bear Creek. A float trip between the two lakes on September 29 revealed no live salmon. Spawning was observed as late as October 27 in Bear Creek.

Table 16 Summary of Hook Injuries and Spawning Ground Recoveries of Late Run Russian River Red Salmon, Upper Russian Lake, 1972.

<u>WEIR OBSERVATIONS</u>			
<u>Class Injury</u>	<u>No. of Fish</u>	<u>Percent</u>	
Unmarked	1,715	85.6	
Superficial	175	8.7	
Moderate	83	4.2	
Severe	30	1.5	

<u>SPAWNING GROUND RECOVERIES</u>			
	<u>No. Recovered</u>	<u>% Recovered</u>	<u>% Spawning Success of Recovered Fish</u>
Unmarked	211	12.3	86.7
Superficial	15	8.6	100.0
Moderate	4	4.8	100.0
Severe	3	10.0	66.7

Table 17 Percent Spawning Success of Untagged Late Run Red Salmon in the Upper Russian Lake Drainage, 1972.

<u>Sex</u>	<u>Number</u>	<u>% Spawned</u>	<u>% Partially Spawned</u>	<u>% Unspawned</u>
Male	268	76.5	20.9	2.6
Female	589	75.7	19.9	4.4
Combined	857	75.9	20.2	3.9

Untagged carcasses were examined in areas utilized by late run salmon to determine spawning success (Table 17). Spent salmon comprised 75.9% of late run fish examined. This is considerably less than the 92.1% spawning success of early untagged fish. If partially spent fish are considered spent, this percentage increases to 96.1%. This is comparable to 98.7% determined for spent and partially spent early run fish. The increased percent of partially spent late run fish is related to spawner density.

Table 18 presents spawning success of late run salmon examined in various spawning areas. Bear Creek had the greatest spawner density and the lowest percent of completely spent fish. Observations in this system suggest there was competition for available spawning area. Upper Russian Creek was utilized by 2,000 -4,000 late salmon. Competition for redd sites was not observed. This stream had the highest percent of spent fish.

The percent females which perished without spawning was the greatest in Bear Creek (5.7%) and lowest in Upper Russian Creek (2.5%). These data concur with Foerster's (1965) conclusion, "...When runs are heavy and where competition for spawning ground is very keen the number of undeposited eggs in female fish and the number of females dying unspawned increases."

Egg Sampling

Egg sampling was conducted in Upper Russian and Bear creeks. Ten samples were collected in each of five, 200-yard sections in Upper Russian Creek. Numbers of early salmon which utilized these five sections were determined by the technique described by McNeil (1963). Daily stream counts were conducted during the spawning period. Total counts were divided by average days a salmon remained on the spawning grounds.

$$\frac{75,091 \text{ salmon-days}}{13.2} = 5,689 \text{ red salmon}$$

Numbers of female salmon utilizing these sections was determined by the male-female sex ratio. An estimated 3,346 females deposited eggs at a rate of 408 eggs/M² in five sections of Upper Russian Creek. Eighty-one percent of the eggs were viable at the time of sampling.

Ten samples were collected from each of three ponds (Beaver, Duck, and Alder) in Bear Creek. Average egg deposition was 2,622.9 eggs/M². Alder Pond had the greatest density at 3,239 eggs/M². Spawning was not complete at the time of sampling, and densities are considered minimal. The number of late run salmon spawning in this area is unknown. Egg survival was 94.8%.

Table 18 Percent Spawning Success of Late Run Red Salmon Examined in Different Areas of Upper Russian Lake Drainage, 1972.

<u>Area</u>	<u>No.</u>	<u>% Spent</u>	<u>% Partially Spent</u>	<u>% Unspawned</u>
Upper Russian Ck.	133	85.7	12.0	2.3
Upper Russian Lk.	407	85.3	11.3	3.4
Upper Russian R.	27	77.8	22.2	----
Bear Ck.	290	58.3	36.2	5.5
Combined	857	75.9	20.2	3.9

LITERATURE CITED

- Barrett, Bruce M. 1972. 1972 Tustumena Sockeye Salmon Research Report. (Unpublished, 35 pp) on file at Alaska Department of Fish and Game, Soldotna, Alaska.
- Eicher, G. J., Jr. 1951. Effect of Tagging on the Subsequent Behavior and Condition of Red Salmon. U. S. Fish & Wildlife Service, Spec. Sci. Rept. No. 64, 4 pp. In: R. E. Foerster. *The Sockeye Salmon, Oncorhynchus nerka*. Fish. Res. Bd. of Canada, Ottawa.
- Engel, Larry J. 1965. Inventory and Cataloging of the Sport Fish and Sport Fish Waters of the Kenai Peninsula, Cook Inlet - Prince William Sound Areas. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1964-1965. Project F-5-R-6, 6: 111-127.
-
- _____. 1966. Inventory and Cataloging of the Sport Fish and Sport Fish Waters on the Kenai Peninsula, Cook Inlet - Prince William Sound Areas. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1965 - 1966. Project F-5-R-7. 7: 59-78.
-
- _____. 1967. Inventory and Cataloging of the Sport Fish and Its Waters on the Kenai Peninsula, Cook Inlet - Prince William Sound Areas. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1966-67. Project F-5-R-8. 8: 73-81.
-
- _____. 1968. Inventory and Cataloging of the Sport Fish and Waters on the Kenai Peninsula, Cook Inlet - Prince William Sound Areas. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1967-1968. F-5-R-9: 95-116.
-
- _____. 1969. Inventory and Cataloging of Kenai Peninsula, Cook Inlet, and Prince William Sound Drainages and Fish Stocks. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1968-1969. Project F-9-1, 10: 111-130.
-
- _____. 1970. Studies on the Russian River Red Salmon Sport Fishery. Alaska Department of Fish and Game. Federal Aid in Fish Restoration. Annual Report of Progress, 1969-1970. Project F-9-2, 11: 129-134.

- _____. 1971. Studies on the Russian River Red Salmon Sport Fishery. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1970-1971. Project F-9-3, 12: 78-89.
- _____. 1972. Studies on the Russian River Red Salmon Sport Fishery. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1971-1972. Project F-9-4. Vol. 13. 19 pp.
- Foerster, R. E. 1968. The Sockeye Salmon, Oncorhynchus nerka. Fish. Res. Bd. of Canada. Bulletin 162. 422 pp.
- Hartman, W. L. 1959. Red Salmon Spawning Behavior. Sci. Alask; Proc. North Alaska Sci. Conf. College, Alaska, 1958, p. 48. In: R. E. Foerster, *The Sockeye Salmon, Oncorhynchus nerka*. Fish. Res. Bd. of Canada, Ottawa.
- Kuzentsov, I. I. 1928. Some Observations on the Propagation of the Amur and Kamchatka Salmon. *Izvestia TINRO*, 2(3):1-195. (FRI Translation). In: R. E. Foerster. *The Sockeye Salmon, Oncorhynchus nerka*. Fish. Res. Bd. of Canada, Ottawa.
- Lawler, Robert R. 1963. Inventory and Cataloging of the Sport Fish and Sport Fish Waters on the Kenai Peninsula and Prince William Sound. Alaska Department of Fish and Game. Federal Aid in Fish Restoration. Annual Report of Progress, 1962-1963. Project F-5-R-4. 4:145-160.
- _____. 1964. Inventory and Cataloging of the Sport Fish and Sport Fish Waters on the Kenai Peninsula, Cook Inlet - Prince William Sound Areas. Alaska Department of Fish and Game. Federal Aid in Fish Restoration. Annual Report of Progress, 1963-1964. Project F-5-R-5, 5:113-122.
- Mathisen, Ole A. 1955. Studies on the Spawning Biology of the Red Salmon, Oncorhynchus nerka (Walbaum), in Bristol Bay, Alaska, with the Special Reference to the Effect of Altered Sex Ratios, p. 41. In: R. E. Foerster. *The Sockeye Salmon, Oncorhynchus nerka*. Fish. Res. Bd. of Canada, Ottawa.
- McNeil, William J. 1964. A Method of Measuring Mortality of Pink Salmon Eggs and Larvae. U. S. Fish & Wildlife Service. Fish. Bull. 63(3): 575-588.
- Nelson, Philip R. and C. E. Abegglen. 1955. Survival and Spawning of Gill Net Marked Red Salmon. U. S. Fish & Wildlife Service. Res. Rept. #40. 19 pp.

Neuhold, J. M. and K. H. Lu. 1957. Creel Census Method. Utah Department
of Fish and Game. Publication No. 8, 33 pp.

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