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STATE OF ALASKA

Jay S. Hammond, Governor

Annual Performance Report for

RUSSIAN RIVER SOCKEYE SALMON STUDY

by

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Section O

Study AFS 44
Anadromous Fish Studies

Job No. AFS 44-4
Russian River Sockeye Salmon Study

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RESEARCH PROJECT SEGMENT

State: ALASKA NAME: Sport Fish Investigations of Alaska

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Job No.: AFS 44-4 Job Title: Russian River Sockeye Salmon Study

Period Covered: July 1, 1977 to June 30, 1978

ABSTRACT

A creel census was conducted during the Russian River sockeye salmon, Oncorhynchus nerka (Walbaum), sport fishery to determine harvest and effort. The census revealed 69,510 man-days were expended to harvest 47,840 sockeye salmon. The early run contributed 20,400 salmon and the late run 27,440 salmon to this harvest. Both early and late run harvest are the highest recorded at Russian River. Angler effort was also the highest recorded and exceeds average historical effort levels by 311.6%. Early and late run harvest rates were 0.147 and 0.186 sockeye salmon per angler hour, respectively. anglers harvested 46.7% of the sockeye salmon that entered Russian River in 1977.

Escapements of early and late run sockeye salmon were determined by a weir at the outlet of Lower Russian Lake. The early run escapement of 16,070 is one of the highest escapements recorded for this segment of the population and exceeds the historical mean early run escapement by 43.2%. Late run escapement of 21,410 is one of the lowest escapements recorded. It is estimated that late run Russian River sockeye salmon contributed 8.4% of the total Kenai River sockeye salmon escapement in 1977. This is the lowest contribution recorded for late run Russian River stocks and is well below the 1968-1976 average of 34.3%.

In 1977 Russian River discharge rates were approximately twice the historical rate. Both early and late runs experienced extreme difficulty negotiating Russian River Falls at these velocities. The Department of Fish and Game therefore initiated a "fish rescue" and transported sockeye salmon over the barrier via helicopter. Over 50% of the early run and 30% of the late run escapements were transported in this manner. Methodology involving the transport and the ramifications of this barrier regarding management, migrational timing and spawning potential are presented and discussed.

Analysis of scales collected at Lower Russian Lake weir revealed the early run was dominated (62.6%) by sockeye salmon that resided one year in fresh water. This is a radical departure from the historic early run age structure,

as prior data indicate an average of 81.6% of this run spends two years rearing in Upper Russian Lake. Early run salmon were primarily three-ocean (85.7%) which corresponds to historical periods of ocean residency. Late run escapement was again dominated by fish that resided two years in fresh water and two years in the marine environment before returning in their fifth year of life. Mean lengths of early and late run fish were 605.3 and 570.5 mm, respectively. Male to female sex ratio for the early run was 1:0.4. Late run male to female sex ratio was 1:0.9.

Fecundity investigations conducted at Lower Russian Lake weir revealed early and late run female salmon averaged 4,313 and 3,302 eggs per female, respectively. Early run fish utilized in this study averaged 602.7 mm in length and 2.852 kg in weights. Late run salmon were somewhat smaller, averaging 567.1 mm and 2.438 kg in length and weight, respectively.

It was estimated that approximately 18.2 million early run sockeye salmon eggs were potentially available for deposition in Upper Russian Creek in 1977. Hydraulic egg sampling conducted in this stream revealed actual egg deposition to be approximately 935,310 or an average density of 67.7 eggs/M^2. This density is one of the lowest recorded since 1972 despite the exceptionally high early run escapement. Observations are presented which indicate Upper Russian Creek was subject to severe flood conditions for the second consecutive year. These observations coupled with low egg density suggest many eggs were washed from the gravel prior to sampling.

Climatological data were again collected at Lower Russian Lake weir site. Rainfall recorded during a 72-day period totaled 93.1 mm (3.7"). Stream discharge was exceptionally high during both runs remaining above 450 cfs until mid-August when it began a steady decline.

BACKGROUND

Russian River is a clear stream adjacent to the Sterling Highway, six miles west of the Kenai Peninsula community of Cooper Landing and 150 miles south of Alaska's largest city, Anchorage. At this point the Russian River enters the larger glacial Kenai River. It is here that a privately operated ferry transports anglers to the south bank. Figure 1 depicts the Russian River in relation to the Kenai River drainage and other pertinent landmarks.

Sockeye salmon sport fishing is restricted to Lower Russian River from a marker 600 yards below Russian River Falls to a marker 1,800 yards below the Kenai and Russian River confluence, a distance of approximately three river miles. This area is commonly known as the "fly fishing only area," and from June through August terminal gear is restricted to streamer (coho) flies with gap between point and shank no greater than 3/8". The area between a marker below the ferry crossing and a marker 700 yards upstream on the Russian River is closed to all fishing from June 1 through July 14 to provide additional protection to early run stocks which concentrate in this area for a period of time before continuing their upstream migration (Figure 2). Sockeye salmon fishing below the "fly fishing only area" is permitted with standard sport fishing tackle.

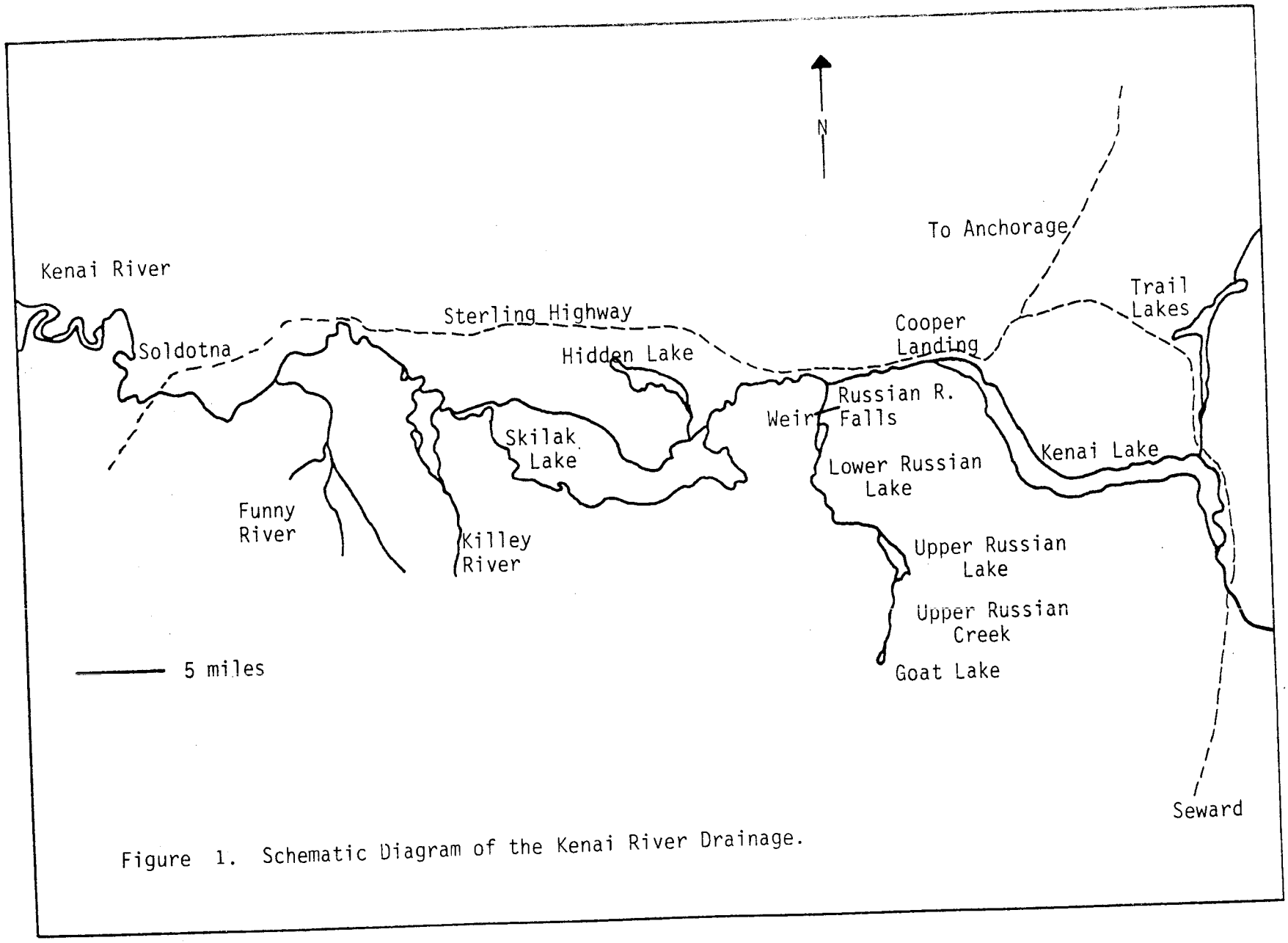

Figure 1. Schematic Diagram of the Kenai River Drainage.

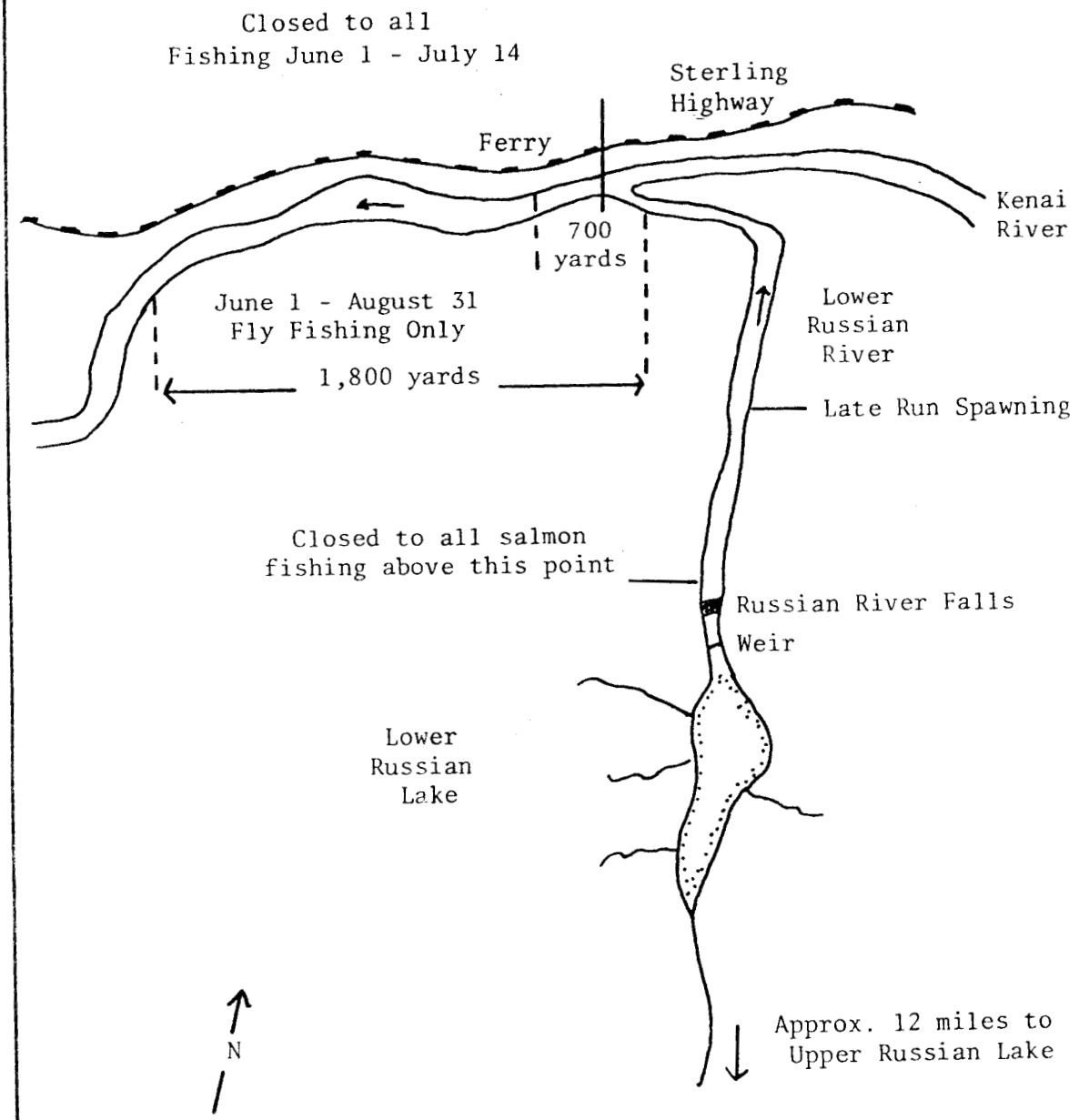

Figure 2 . Schematic Diagram of Lower Russian River and Kenai and Russian River Confluence (Not To Scale).

Harvest and effort is, however, minimal due to the glacial nature of the Kenai River.

Lower Russian River from its confluence to a point approximately two miles upstream is of moderate gradient. Upstream from this point the river flows through a canyon of considerable gradient commonly known as Russian River Falls. During the past 15 years sockeye salmon migration has known to have been delayed in the canyon on several occasions due to a velocity barrier created by abnormally high water. The only documented mortality prior to 1977 associated with the Falls occurred in 1971 when an estimated minimum of 10,000 to 12, 000 sockeye salmon perished (Engel, 1972).

Russian River sockeye salmon runs are bimodal, i.e., there are two distinct runs. Migrational timing, entry into the fishery and average run size has been previously discussed (Nelson, 1976 and 1977). Russian River also supports chinook, O. tshawytscha (Walbaum); coho, O. kisutch (Walbaum); and pink salmon, O. gorbushca (Walbaum). Resident game species include rainbow trout, Salma gairdneri Richardson, and Dolly Varden, Salvelinus malma (Walbaum).

Lower Russian Lake, located approximately 0.8 kilometers (0.5 miles) above Russian River Falls, supports an active Dolly Varden and rainbow trout sport fishery. The lake's maximum depth is 7.6 meters (25 feet) and it is 87 hectares (215 acres) in area. No known salmon spawning areas are located here, but the lake is utilized by rearing chinook and coho salmon.

Upper Russian River enters Lower Russian lake from the south. This stream contains excellent spawning gravel and connects Upper and Lower Russian Lake. Nelson (1976) has presented a detailed description of Upper Russian Lake. Figure 3 is a schematic diagram of this area depicting the known spawning areas of both early and late runs.

Management and research of this complex system has been conducted by the Sport Fish Division of the Alaska Department of Fish and Game since 1962. Prior information pertaining to this fishery has been presented by Lawler (1963, 1964), Engel (1965 through 1972) and Nelson (1973 through 1977).

To monitor angler effort and derive accurate harvest estimates, a creel census has been conducted since the inception of this project. During the 16 years the census has been active, Fish and Game personnel have contacted 63,300 anglers who reported harvesting in excess of 44,900 sockeye salmon. Fishermen have annually averaged 0.7 fish per angler day. Total harvest since 1963 is estimated at 224,510 salmon.

Prior to 1967, salmon harvested per angler day averaged 1.1. Between 1967 and 1977 this average decreased to 0.7. This decline should not be interpreted as a reduction in sockeye salmon abundance or angler expertise, but rather to regulatory measures designed to eliminate snagging. Nelson (1976) has presented the history of this practice as it pertains to Russian River as well as the management and research programs associated with it.

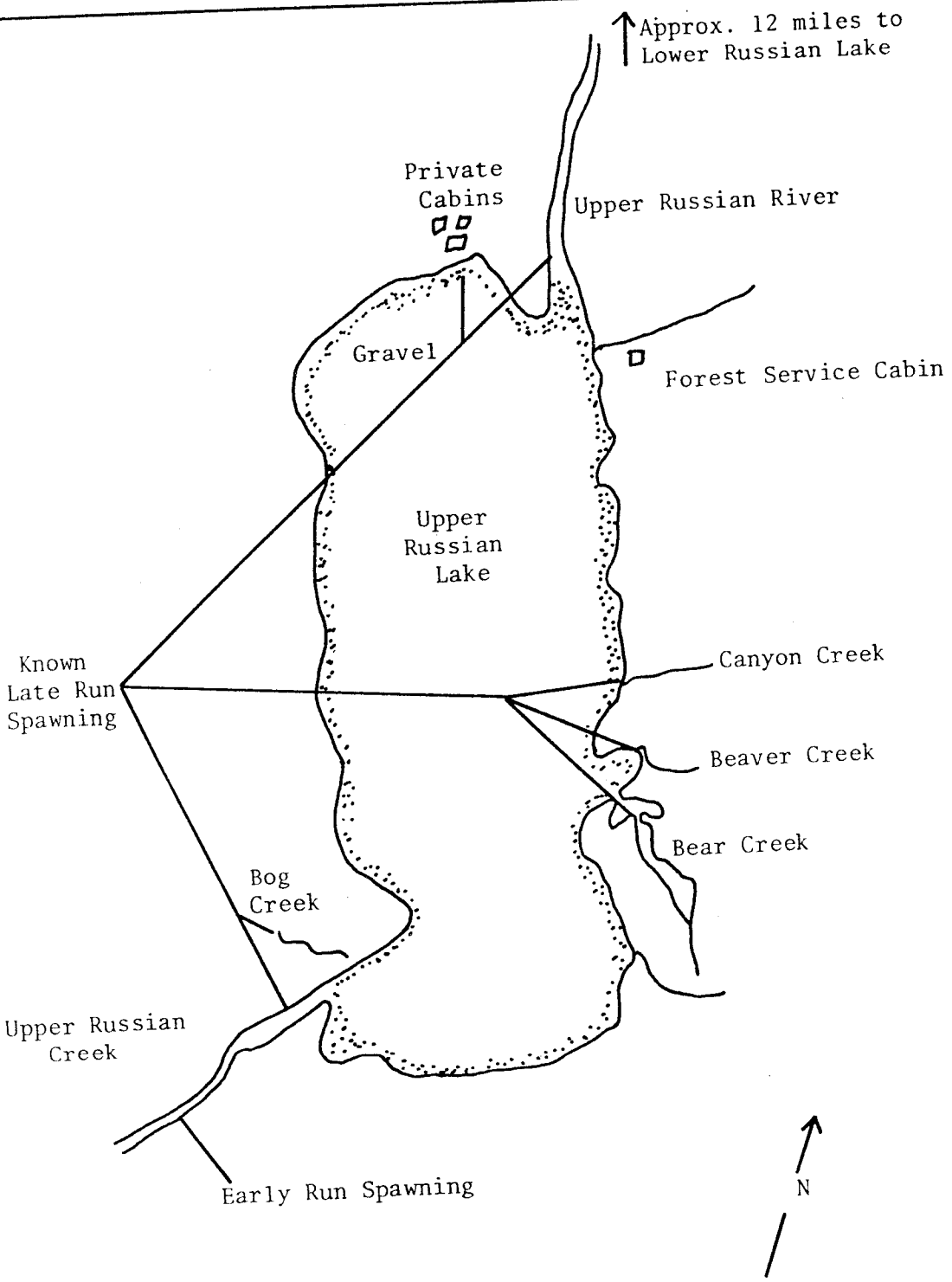

Figure 3. Schematic Diagram of Upper Russian Lake (Not To Scale).

Regulatory measures affecting this fishery from 1960 through 1966 have been presented by Engel (1967). Regulatory changes from 1966 through 1975 have been reviewed by Nelson (1976). Regulation of the fishery in 1976 and 1977 was identical to 1975.

Despite an increasingly restrictive fishery, recreational demands placed upon the Russian River sockeye salmon resource has at times been greater than the stocks can sustain. This is evidenced in that the Sport Fish Division has closed all or part of the fishery on 14 different occasions since 1969. Three emergency closures were required for mangement purposes in 1977 (Table 1).

The Russian River management program is currently directed toward "in season" evaluation of stock status and analysis of fisheries statistics to determine the effects and effectiveness of current regulatory practices. Research activities presently emphasize collection and evaluation of life history data. Objectives include determination of optimum escapement goals for both runs and ultimately predictions of sockeye salmon returns to Russian River. The latter objective can not be realized until a smolt weir is constructed at the outlet of Lower Russian Lake and stock separation techniques are perfected in Cook Inlet to determine Russian River's contribution to the commercial harvest.

Life history investigations of early run sockeye salmon stocks are presently confined to Upper Russian Creek, the only spawning area utilized by these fish. Escapement counts are made to determine spawner distribution in the stream. Potential egg deposition is estimated employing fecundity and mortality data. Actual egg deposition is determined by sampling various areas of the stream with an hydraulic sampler. Egg survival to the "eyed" stage is determined from these data.

Late run investigations are directed toward determining numbers of salmon that utilize respective spawning areas of Upper Russian Lake. This is effected by ground counts and, from 1973 through 1975, by weir counts on the largest tributary utilized by late run stocks (Bear Creek). Escapements to this stream in 1976 and 1977 were minimal and a weir was not required. When feasible, egg densities and egg survival in Bear Creek are also determined employing techniques identical to those used to sample Upper Russian Creek.

RECOMMENDATIONS

1. Construct a fishway ladder at Russian River Falls. Velocity barriers which delayed migration in 1971 and 1977 and which resulted in unnecessary sockeye salmon mortality clearly show an immediate need for this structure.

2. Close the Russian River "fly fishing only area" to the taking of sockeye salmon after August 20. Data indicate increasing angling effort is occurring after this date and sockeye salmon spawning below Russian River Falls require increased protection.

Table 1 . Emergency Closures Issued by the Sport Fish Division of the Alaska Department of Fish and Game Affecting the Russian River Sport Fishery, 1969-1977*.

Year	Closure Date	Total or Partial Closure	Days Closed**	Run Affected
1969	7/27-8/8	Total	13	Late
1970	7/ 4-7/23	Total	20	Early
	7/28---	Total	24	Late
1971	7/ 8-7/30	Total	24	Early
	8/14---	Partial***	7	Late
1972	Closure at confluence of Kenai and Russian River extended 14 days.			
1973	Closure at confluence of Kenai and Russian River extended 14 days.			
	7/ 5-7/14	Total	10	Early
1974	7/ 1-7/5	Total	5	Early
	7/31---	Total	21	Late
1975	7/ 1-7/14	Total	14	Early
	8/13---	Total	8	Late
1976	6/28-7/4	Total	7	Early
1977	6/10-6/18	Total	8	Early
	6/18-7/15	Partial***	27	Early
	8/18-8/20	Total	2	Late

* No emergency closure affecting this fishery were issued prior to 1969.

** When the fishery was closed for the remainder of the season, it was assumed the season ended August 20.

*** Fishery closed upstream from the Homer Electric power line, a distance of approximately 1.5 miles, to protect fish experiencing difficulty negotiating Russian River Falls due to atypically high water.

3. The feasibility of "artificially" enhancing early run Russian River stocks should be explored. Data and observation indicate that high water in Upper Russian Creek during the egg incubation period in 1976 and 1977 may have washed large numbers of eggs from the gravel which will adversely affect the number of returning adults.

4. Modify the existing weir at Lower Russian Lake to permit sockeye salmon smolt enumeration.

OBJECTIVES

1. To determine sport harvest of adult early and late run Russian River sockeye salmon.

2. To collect and analyze biological data concerning abundance and migrational timing of adult sockeye salmon in Russian River drainage.

3. To determine age composition of adult early and late run Russian River sockeye salmon stocks.

4. To determine egg deposition of early and late run spawning sockeye salmon in the two major tributaries to Upper Russian Lake, i.e., Upper Russian and Bear Creeks.

5. To determine fecundity of early and late run Russian River sockeye salmon and to determine the relationship between body weight, length and average number of eggs per female salmon.

6. To collect basic climatological data (precipitation, water and air temperature, stream velocity) at lower Russian Lake weir and to determine if a correlation exists between these parameters and migrational timing.

7. To evaluate current regulations governing this sport fishery and to provide recommendations for future management and research.

TECHNIQUES USED

The 1977 Russian River creel census was a modification of the technique described by Newhold and Lu (1957). Sampling procedures were identical to those outlined by Engel (1965, 1970, 1972) and Nelson (1973, 1975).

Escapements were enumerated by weir at the outlet of Lower Russian Lake. The present weir was constructed in June, 1975 and replaced a temporary weir (described by Engel, 1970) which had been in use since 1969. Nelson (1976) has presented a detailed description of the present structures.

A velocity barrier in 1977 at Russian River Falls necessitated that a segment of each run be transported over the barrier via helicopter. Helicopters

utilized were a Bell 204 and 205. Both models were equally satisfactory. Sockeye salmon were transported in a cannery tote of standard manufacture. The tote was secured by two chokers (cables) 6 meters (20 feet) in length. The chokers were in turn secured by a clevis to form a bridle. During early operation a 15.2 meter (50 foot) cable was suspended beneath the helicopter. The terminal end was composed of a hook and swivel which was attached to the clevis. Attachment and disengagement were manual. During the latter phases of the operation a 21 meter (70 foot) cable was suspended from the helicopter and the release on the hook was electrical. Additionally, the helicopter was equipped with "bubble" windows. The additional cable, electric release, and "bubble" windows were superior to the manual release and shorter cable as it provided more maneuverability for the helicopter in relation to surrounding trees. The pilot also had an unobstructed view of ground operations. Fish were captured below Russian River Falls by dipnet as water velocity was too rapid to permit seine operation. Up to nine sockeye salmon were captured per net with the average approximating two or three. The cannery tote was filled by pump and aeration device designed originally for hydraulic egg sampling and described by McNeil (1964). Without the aeration device salmon experienced low oxygen levels and attempted to jump from the tote. It was determined that 50 sockeye salmon approximated the optimum number which could be transported per tote. The trip from the base of Russian River Falls to Lower Russian Lake a distance of 0.8 kilometer (0.5 mile) took about three minutes. The tote was manually dumped into the lake. Three totes were utilized on a rotating basis, i.e., one at the falls, one at Lower Russian Lake, and one in the air.

In addition to individuals associated with helicopter operation provided by the charter service, 12 Fish and Game personnel were required. Nine individuals were below the falls. Four individuals captured the salmon. The nets were passed to two individuals who emptied the fish into the tote. One individual operated the pump and another enumerated the fish. The ninth individual maintained communications with the helicopter and acted as general supervisor. Two individuals were required to dump the tote at Lower Russian Lake. All ground personnel wore construction hardhats.

Average egg content of early and late run female sockeye salmon was determined by sampling at the weir site. Sampling technique and methodology employed have been described by Nelson (1975).

Samples to determine age structure and sex ratio of early and late runs were collected at Lower Russian Lake wier. Fifteen fish were sampled daily. Lengths from mid-eye to fork of tail were recorded for each specimen. Scales were impressed on cellulose acetate and read on a Bruning 200 microfiche projector. Age designation is expressed by the European formula as discussed by Koo (1962).

Age structure for the respective runs was calcultate by determining the age structure from each day's sample and applying these results to that day's total escapement. The number of fish in each age class for each day the run was in progress were then summed to arrive at the true age class composition of the entire run. Male to female sex ratio was determine in like manner.

Early run egg density in Upper Russian Creek was determined by hydraulic sampler patterned after equipment described by McNeil (1964). Techniques utilized and sampling scheme employed in hydraulic egg sampling have been described by Nelson (1977). Potential eggs available for deposition in Upper Russian Creek were also determined. The method of estimation has been described by Nelson (1975).

Water and air temperatures at Lower Russian Lake were determined by Taylor maximum-minimum thermometer. Stream discharge was determined by Head Rod method previously described (Nelson, 1977). Precipitation was recorded daily and determined by gauge of standard manufacture.

All numerical data presented have been rounded to the nearest significant figure.

FINDINGS

Results

A creel census to evaluate management regulatory measures and to determine harvest and effort was in effect from June 18 through August 17. All recreational effort directed toward Russian River sockeye salmon, Oncorhynchus nerka, stocks was sampled. Data indicated anglers expended 69,510 man-days of effort or 279,366 angler hours in 1977. Effort directed toward early and late run stocks was estimated at 38,200 and 31,310 man-days, respectively.

Based on interviews with 4,304 anglers who reported harvesting 2,966 sockeye salmon, total recreational catch was estimated at 47,840 salmon. Early and late runs contributed 20,400 and 27,440 fish, respectively, to this harvest. Mean hourly early and late run catch rates were higher on weekdays (0.172) than on weekend days (0.164) due to greater angler congestion during weekend periods. Seasonal average catch per hour was 0.168. Harvest effort and catch per hour estimates since 1963 are summarized in Table 2.

Total man-days of effort were the highest recorded for this fishery. Effort increased 164.2% compared to 1976 estimates and exceeded the previous high of 30,590 man-days (1973) by 127.2%. Increased angler participation is attributed to the exceptionally high return of early run fish and the velocity barrier in effect throughout most of the early and late run. These two factors combined during the early run, as a result, large numbers of fish were concentrated in areas open to fishing.

Total return (sport harvest plus escapement above and below Russian River Falls) of late run sockeye salmon was the third highest return since 1968. As with the early run, the velocity barrier at Russian River Falls concentrated these fish in areas open to fishing where they were readily available to anglers. Large numbers of accessible sockeye salmon therefore attracted anglers in record numbers to Russian River during the 1977 season.

Table 2. Sockeye Salmon Estimated Harvest, Effort and Success Rates on Russian River, 1963-1977.

Year	Harvest			Total Effort (Man-Days)	Catch/ Hour	Census Period
	Early Run	Late Run	Total			
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 1/
1971	2,810	10,730	13,540	15,120	0.192	6/17-8/20 2/
1972	5,040	16,050	21,090	25,700	0.195	6/17-8/21
1973	6,740	8,930	15,670	30,590	0.102	6/ 8-8/19 3/
1974	6,440	8,500	14,940	21,120	0.131	6/ 8-7/30 4/
1975	1,400	8,390	9,790	16,510	0.140	6/14-8/13 5/
1976	3,380	13,700	17,080	26,310	0.163	6/12-8/23 6/
1977	20,400	27,440	47,840	69,510	0.168	6/18-8/17 7/
1963-1976 Average	5,985	6,634	12,619	16,888	0.174	

1/ Census active from June 11 to July 3 and from July 24 to July 27.
2/ Census active from June 17 to July 7 and from July 31 to August 20.
3/ Census active from June 9 to July 4 and from July 15 to August 19.
4/ Census active from June 8 to June 30 and from July 6 to July 31.
5/ Catch/hour computed on data collected when fishery was open and fish were present. Data collected from July 15 to 24 when fishery was open and fish were not present is not included in the calculations.
6/ Census active from June 12 to June 27 and from July 5 to August 23.
7/ Census did not commence until June 18 as fishery was closed by emergency order prior to that date. Fishery again closed by emergency order on August 18.

Record angler participation resulted in the largest harvest since 1963. Early run harvest exceeded the previous high (14,950 in 1966) by 36.5% and was more than three times the historical average harvest rate of 5,985. Late run harvest of 27,440 was more than four times greater than the average historical level of 6,634 and exceeded the previous high harvest year (16,050 in 1972) by 71.0%. Total 1977 harvest of 47,840 sockeye salmon was 115% greater than any previous total harvest recorded for this fishery.

Total weekday and weekend day stream counts averaged 201.7 and 438.6 anglers, respectively, in 1977. These counts exceeded the historical average weekday and weekend day counts by 169.7% and 238.2%, respectively. Average angler counts do not accurately reflect total angler effort, but do indicate an exceptionally high average number of anglers on the stream during different segments of the 1977 fishery.

Early run weekday counts ranged from 106 to 455 anglers, averaging 222.8. Late run weekday counts were somewhat less averaging 180.4 anglers per count. Weekend counts during the early run ranged from 65 to 691 averaging 463.4.

Late run weekend counts ranged from a low of 203 to a high 576, averaging 407.5. It is therefore evident that the greatest concentration of anglers occurred during the early run weekend fishing periods. This is in contrast to 1976 angler distribution when the greatest concentration of fishermen occurred during late run wekend periods. The probable explanation for this is that the United States Forest Service restricted use of Russian River Campground during the late run which effectively reduced the number of anglers on the stream. No restrictions were imposed during the early run migration.

Each angler fished an average of 3.9 hours on weekdays and 4.3 hours on weekends. This represents a decrease in average hours fished in relation to historical data. Fisheries statistics derived from creel census data collected since 1964 are presented in Table 3.

Stream counts revealed 10.1% and 27.7% of the anglers enumerated during total stream counts fished the confluence area of the Kenai and Russian Rivers during the early and late run, respectively. These percents represent the lowest angler effort recorded in this area since the inception of the creel census program in 1963.

The tendency for the majority of the anglers to concentrate their efforts on the clear waters of the Russian River as opposed to the confluence area is related to an emergency closure which delayed the historical opening of the fishery by approximately 10 days and to the velocity barrier at Russian River Falls. Early run salmon generally enter Russian River between June 7 and June 20 with a mean arrival date of June 12. These stocks are intercepted by anglers at the confluence area. In 1977, due to anticipated low returns of early run fish, the fishery was closed prior to June 18. By this date large numbers of fish had passed through this area and entered Russian River. A large percentage of these salmon were unable to negotiate Russian River Falls and concentrated in Russian River. Anglers therefore followed the stocks upstream. Late run fish were intercepted at the confluence which accounts for a higher percentage of late, as opposed to early run, effort in this area. These stocks, however, moved rapidly through

Table 3 . Differences Between Weekday and Weekend Day Fishing Pressure and Rates of Success at Russian River, 1964-1977.

Year	Angler Counts		Catch/Hour		Average Hours Fished	
	Week-days	Weekend Days	Week-days	Weekend Days	Week-days	Weekend Days
1964	29.6	70.6	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
1973	147.1	195.0	0.113	0.088	4.8	5.5
1974	123.8	144.4	0.164	0.085	4.7	5.7
1975	65.0	149.6	0.145	0.136	4.5	5.1
1976	72.5	134.4	0.165	0.161	3.5	4.5
1977	201.7	438.6	0.172	0.164	3.9	4.3
1964-1976 Average	74.8	129.7	0.200	0.142	4.6	5.1

the area only to encounter the velocity barrier at the falls. They also concentrated in Russian River and were subject to intense fishing pressure.

During the census 32 Dolly Varden, Salvelinus malma (Walbaum), 11 rainbow trout, Salmo gairdneri Richardson, 11 coho salmon, O. Kisutch (Walbaum), and one Arctic grayling, Thymallus arcticus (Pallas), were creel checked. These data were expanded revealing a total incidental harvest of 548 Dolly Varden, 191 rainbow trout, 189 coho salmon and three Arctic grayling. No pink salmon, O. gorbuscha (Walbaum), were observed during the census. The harvest of coho salmon is considered minimal as the census was terminated during the early segment of this species migration which usually peaks the last week of August.

Escapement:

Arrival date of the 1977 early run Russian River sockeye salmon at the confluence of the Kenai and Russian Rivers is not definitely known as the fishery was initially closed and no creel census was conducted. Observation by residents of the area suggest fish were present as early as June 7 or 8. Russian River weir was operational on June 17 and fish were passed on that date. Fishermen reported early run sockeye salmon were passing the weir site prior to this date. Numbers of salmon that passed the site prior to weir installation are not known, but their numbers are probably insignificant in relation to the total escapement.

Early run salmon were delayed by a velocity barrier at Russian River Falls and 8,477 of these fish were transported over the barrier via helicopter. The remaining 7,593 negotiated the falls and were enumberated at the weir. Total early run escapement was therefore 16,070. Early run passage was complete by August 4.

Early run sockeye salmon escapements average 11,224 fish (1963-1976) and have ranged from 2,650 to 21,510. The 1977 escapement of 16,070 is the highest escapement recorded since 1966 and is 43.2% greater than the historical average. Russian River early and late run escapements and harvest rates are summarized in Table 4.

Anglers harvested 55.9% of the early run stocks to reach Russian River. This is an appreciable increase compared to the historical average harvest rate of 35.4% and exceeds the previous high harvest rate of 54.0% established in 1969.

Late run Russian River escapements through Russian River weir have ranged from 21,820 to 79,000 averaging 39,768. In 1977, 7,436 were transported over the falls by helicopter and an additional 13,974 successfully negotiated the falls and passed through the weir. Total late run escapement in 1977 was therefore 21,410. This is the lowest escapement recorded above Russian River Falls. A ground survey between Russian River Falls and the confluence of Kenai and Russian rivers revealed an additional 17,085 late run sockeye salmon spawning in this area (Table 5). Total late run Russian River escapement is therefore estimated at 38,495 or 10.6% below the historical average (Table 6).

Table 4 . Russian River Sockeye Salmon Escapement Estimates and Harvest Rates for Early and Late Runs, 1963-1977.

Year	Escapement			Percentage of Run Caught by the Sport Fishery*		
	Early Run	Late Run	Total	Early Run	Late Run	Combined
1963	14,380	51,120	65,500	20.3	2.0	7.2
1964	12,700	46,930	59,630	21.8	5.0	9.6
1965	21,510	21,820	43,330	31.8	9.0	21.6
1966	16,660	34,430	51,090	47.3	17.5	30.3
1967	13,710	49,480	63,190	34.6	10.3	17.0
1968	9,200	48,880	58,080	42.9	10.6	18.0
1969	5,000**	28,920	33,920	54.0	3.8	17.1
1970	5,450	28,200	33,650	51.3	2.1	15.9
1971	2,650	54,430	57,080	51.5	16.4	19.2
1972	9,270	79,000	88,270	35.2	16.8	19.3
1973	13,120	24,970	38,090	33.9	26.3	29.1
1974	13,150	24,650	37,800	32.9	25.6	28.3
1975	5,640	31,970	37,610	19.9	20.8	20.7
1976	14,700	31,950	46,650	18.7	30.0	26.8
1977	16,070	21,410	37,480	55.9	56.2	56.1
1963-1976 Average	11,224	39,768	50,992	35.4	14.0	20.0

* Based on escapement passed weir. Commercial harvest and fish spawning downstream from Russian River weir are not considered.

** Escapement determined by foot survey of Upper Russian Creek.

Table 5 . Late Run Sockeye Salmon Escapements Enumerated Between Russian River Falls and Confluence of Kenai and Russian Rivers, 1968-1977.

Year	Escapement Below Falls	Total Late Run Return*	Percent of Total Return Spawning Below Falls
1968	4,200	58,900	7.1
1969	1,100	31,170	3.5
1970	222	29,022	0.8
1971	10,000	75,160	13.3
1972	6,000	101,050	5.9
1973	6,685	40,585	16.5
1974	2,210	35,360	6.3
1975	690	41,050	1.7
1976	3,470	49,120	7.1
1977	17,085	65,935	25.9
1968-1976 Average	3,842	51,268	6.9

* Includes sport harvest, fish spawning below Russian River Falls and escapement enumerated at Lower Russian Lake weir.

Table 6 . Late Run Russian River Sockeye Salmon Escapements Enumerated above Russian River Falls by Weir Counting Tower and Below Russian River Falls by Ground Survey, 1968-1977.

Year	Escapement Above Falls	Escapement Below Falls	Total Late Run Escapement
1968	48,800	4,200	53,000
1969	28,920	1,100	30,020
1970	28,200	222	28,422
1971	54,430	10,000	64,430
1972	79,000	6,000	85,000
1973	24,970	6,685	31,655
1974	24,650	2,210	26,860
1975	31,970	690	32,660
1976	31,950	3,470	35,420
1977	21,410	17,085	38,495
1968-1976 Average	39,210	3,842	43,052

Escapement below Russian River Falls in 1977 was the highest recorded, exceeding the average escapement in this area by 344.7% or 13,243 fish. It is of interest to note that the years 1971 and 1977 both experienced record escapements in this area and that these escapements corresponded to a velocity barrier at Russian River Falls. Several possible explanations for these high escapements may be proposed.

(1) Nelson (1977) suggested that the 1971 escapement counts below the falls may have been erroneously high as fish destined to spawn above Russian River Falls and unable to ascend the barrier were included in the count because of their advanced sexual development. Although this may have occurred, similar 1977 counts were conducted by highly qualified individuals after water levels had subsided allowing normal migration over the falls.
(2) Numbers of spawning fish below the falls are cyclic and record numbers in 1971 and 1977 are a natural phenomenon which would have occurred irrespective of high water. Assuming the age structure of these fish corresponds to the age structure of late run salmon spawning above the falls (primarily 2.2 or five-year fish) the 1977 return would be the progeny of a 6,000 salmon escapement in 1972. Return per spawner would be 2.8. This, however, does not fully explain why a 10,000 late run escapement in 1971 returned only 3,470 sockeye salmon in 1976 for a return rate of 0.3 fish per spawner.
(3) Late run Russian River sockeye salmon may not be as "site-specific" as previously supposed. Unable to ascend Russian River Falls due to a velocity barrier, the fish spawned successfully below the barrier. This appears unlikely. Foerster (1968) reviewed the "now-famous" Hells Gate slide on the Fraser River in 1913. Sockeye salmon were unable to continue their upstream migration due to a massive rock slide. High mortality was recorded and the production of the Fraser River was depressed. Identical observations were made during a blockage of the Babine River in 1951. Similarly, why did a minimum of 10,000 to 12,000 unspawned fish perish below Russian River Falls in 1971 (Engel, 1972) if they were capable of successfully spawning below the barrier?

Reason(s) for record late run spawning escapements below Russian River Falls during years a velocity barrier was in effect are therefore not definitely known. The most probable explanation presently appears to be that these escapements were naturally occurring phenomena which have no relation to water levels. The failure of the 1971 escapement to reproduce itself in 1976 may be attributed to fluctuating reproductive potential and survival rates. Additional data will, however, be required to definitely resolve this question.

Table 7 indicates that prior to 1971 over 50% of angler effort was directed toward early run stocks. In 1971 an extended closure during the early run directed effort toward late run fish. From 1972 through 1974 effort was divided between these two segments of the population. Effort on early run stocks in 1975 and 1976 was the lowest recorded, averaging 32.7%. Nelson (1977) suggested this trend was expected to continue because of the restrictive one fish limit and emergency closures to increase escapement levels of early run stocks. Table 7 indicates 55.0% of all angler effort was directed toward early run fish in 1977. This departure from the 1975-76 trend is again attributed to the velocity barrier at Russian River Falls and the exceptionally large 1977 early run return. It is anticipated that in future years angler effort will again focus on the more numerous late run fish.

Table 7 . Angler Effort Directed Toward Early and Late Run Russian River Sockeye Salmon Stocks, 1963-1977.

Year	Effort (Man-Days)*		Effort (Percent)	
	Early Run	Late Run	Early Run	Late Run
1963	5,710	2,170	72.5	27.5
1964	3,980	1,350	74.7	25.3
1965	7,750	1,970	79.7	20.3
1966	11,970	6,310	65.5	34.5
1967	11,460	5,500	67.6	32.4
1968	11,780	5,500	68.2	31.8
1969	12,290	2,640	82.3	17.7
1970	9,700	1,000	90.7	9.3
1971	6,250	8,870	41.3	58.7
1972	12,340	13,360	48.0	52.0
1973	15,220	15,470	49.6	50.4
1974	11,090	10,030	52.5	47.5
1975	5,210	11,300	31.5	68.5
1976	8,930	17,380	33.9	66.1
1977	38,200	31,310	55.0	45.0
1963-1976 Average	9,549	7,346	61.3	38.7

* Man-day is defined as one angler fishing for one day irrespective of the amount of time fished.

A total of 37 chinook, O. tshawytscha (Walbaum), and 1,884 coho salmon were enumerated at Russian River weir in 1977 (Table 8). An additional 145 chinook salmon were also observed spawning between Russian River weir and the confluence of Kenai and Russian rivers. Total chinook escapements to this system was therefore 182 or 45 salmon less than the historical average escapement (Table 9). The coho escapement is the second largest escapement recorded at Russian River and the fourth consecutive year of above average escapements.

Management of the 1977 Fishery:

Early run Russian River sockeye salmon returns have historically been dominated by six-year fish. These fish generally spend two years rearing in Upper Russian Lake and three years in the marine environment before returning to their natal stream as age class 2.3 in their sixth year of life (see Table 10). The majority of the 1977 early run sockeye return was therefore expected to be the progeny of the 1971 escapement.

Early run escapement in 1971 of 2,650 fish was the lowest recorded for Russian River and well below the minimum escapement of 8,500 established for this segment of the population. Additionally, the 1971 escapement had been delayed for an extended period of time by a velocity barrier at Russian River Falls. Engel (1972) has presented a detailed account of the 1971 velocity barrier and its affects on early and late run spawning escapements. Production per spawning fish in the early run escapement has ranged from a low of 0.3 to a high of 3.3 with a mean of 1.4 (Nelson, 1977). Even if the maximum return rate was assumed to eventuate from the 1971 escapement, the 1977 early run return to Russian River would approximate 8,700 or slightly higher than the minimum escapement goal. The 1977 Russian River early run sport fishery was therefore closed to sockeye salmon fishing on June 1. No fishing on these stocks was to be permitted and the fishery was not to reopen until the arrival of the late run, about July 15.

Observation below the falls as early as June 15 indicated a valocity barrier was in effect and that the run was several times larger than expected. Fish were concentrated in all quiet waters between the base of the falls and the Homer Electric power line, a distance of approximately 2.4 kilometers (1.5 miles).

A velocity barrier at Russian River Falls which precluded the majority of the run from continuing their migration and an early run return which rapidly developed into one of the largest recorded created unprecedented problems for fisheries managers. It was evident a surplus of fish was available for utilization by the angling public. Fish were so concentrated in the upstream section of the Russian River, however, that their vulnerability raised serious ethical and aesthetic questions regarding whether or not fishing should be permitted in this area. Similarly, unless water levels rapidly declined, the desired escapement level would not be achieved despite the record return, and salmon massed below the falls would perish as they did in 1971. These fish would be lost to both the escapement and recreational angler.

Table 8 . Coho and Chinook Salmon Escapements Enumerated at Russian River Weir, 1969-1977.

Year	Coho Salmon	Chinook Salmon	Weir Opened	Weir Closed
1969	70	119	June 21	August 19
1970	957	240	June 14	August 24
1971	839	21	June 23	September 8
1972	666	172	June 15	August 28
1973	200	243	June 14	August 30
1974	1,508	124	June 14	August 28
1975	4,000*	102	June 25	September 1
1976	1,791**	145	June 16	September 2
1977	1,884	37	June 17	September 5
1969-1976 Average	1,254	146		

* As of September 1, 1975, 1,875 coho had passed the weir. It was estimated a minimum of 2,000 coho were below the weir when it was removed. Escapement is therefore estimated at 4,000.

** As of September 1, 1,391 coho had passed the weir. It was estimated that 400 coho were below the weir when it was removed. Minimum escapement is therefore estimated at 1,791.

Table 9 . Russian River Chinook Salmon Escapements, 1953-1977.

Year	Weir/Counting Tower Escapement	Lower River Escapement	Total Escapement
1953		85**	
1954		87**	
1955		42**	
1956		40**	
1957		44**	
1958		98**	
1966		182	
1967		26	
1968	56*	63	119
1969	119	31	150
1970	240	125	365
1971	21	149	170
1972	172	108	280
1973	243	104	347
1974	124	59	183
1975	102	32	134
1976	145	155	300
1977	37	145	182
Average through 1976	136	84	227

* Estimated from tower count.
** FWS survey.

Table 10. Age Class Composition by Percent of Early and Late Run Adult Sockeye Salmon Escapements Sampled at Russian River Weir, 1970-1976.

Year	1.2	1.3	1.4	2.2	2.3	2.4	3.2	3.3
				Early Run Age Class				
1970	0.4			8.9	87.1	3.6		
1971	1.1	3.2		6.4	89.3			
1972	3.0	38.0		8.4	50.0	0.6		
1973			No Data Available					
1974	0.5	32.0		3.4	63.6	0.5		
1975	0.4	1.8	0.4	19.7	75.1	0.4	0.9	1.3
1976	16.8	1.5		11.4	61.1		0.8	8.4
1977	1.9	60.7	___	14.0	23.4	___	___	___
1970-1976 Average*	3.7	12.7	0.1	9.7	71.0	0.9	0.3	1.6
				Late Run				
1970	2.5	2.9		87.3	7.3			
1971	1.9	5.3		61.5	30.3			1.0
1972			No Data Available					
1973			No Data Available					
1974	5.5	9.0		58.6	26.9			
1975	5.4	2.9		65.9	23.9		1.9	
1976	10.9	4.3		59.6	23.6		1.0	0.6
1977	6.6	7.7		72.6	13.1		___	___
1970-1976 Average**	5.2	4.9		66.6	22.4		0.6	0.3

* 1973 deleted from computations. Six year average.
** 1972 and 1973 deleted from computations. Five year average.

In view of the above considerations Russian River was opened to sockeye salmon sport fishing on June 18. Fishing was permitted in the "fly fishing only area" from a point 1,646 meters (1,800 yards) below the confluence of Kenai and Russian rivers upstream to the Homer Electric power line. The 640 meter (700 yard) sanctuary area remained closed as did the area above the power line to protect fish heavily concentrated in these areas. Concomitant with the opening of the fishery, plans were formulated to capture and transport fish over the barrier if water levels did not subside.

Water levels remained high and the "fish rescue" was initiated on July 8. The fishery above the Homer Electric power line was opened on July 15. By this date escapement of early run fish had exceeded the minimum escapement goal. Fish remaining below the falls in late July appeared in a weakened condition and were beginning to assume nuptual coloration. Although a portion of the early run is known to have perished below the obstruction, quantitative data are not available regarding the loss. Observation by this author suggests this loss was minimal in relation to the total run and probably did not exceed 3,000 fish.

Late run sockeye salmon are primarily five year fish that rear at Upper Russian Lake for two years, spend two years at sea, and return to Russian River in their fifth year of life (see Table 10). The return in 1977 was therefore expected to be the progeny of the 1972 record spawning escapement of 79,000 late run salmon. Enumeration of sockeye salmon by sonar counter operated by the Commercial Fisheries Division in the Lower Kenai River indicated the largest return to the Kenai River drainage since 1968. The record high parent year escapement to Russian River in 1972 coupled with record sockeye salmon to the Kenai River drainage in 1977 strongly suggested an exceptionally large late run Russian River return. No management measures, i.e. emergency closures to increase escapement levels, were therefore anticipated.

Late run fish entered the Russian River sport fishery on July 17. These fish were also subject to the velocity barrier at Russian River Falls. They therefore intermingled with remaining early run fish rendering accurate assessment of their numbers impossible. Fish again began to mass below the falls and large concentrations were in evidence for more than 3.2 kilometers (2 miles) downstream. Assessment of run strength was further complicated in that a portion of the late run also spawns below Russian River Falls. By mid-August it became impossible to differentiate between the few remaining early run fish, late run fish destined to spawn above the falls, and those late run sockeye salmon which historically spawn below the falls.

Historically, 50% of the late run escapement has passed Lower Russian Lake weir by August 6. In 1977 only 5,536 fish had been enumerated by this date. A fish rescue similar to that conducted during the early run was therefore initiated on August 13. It was terminated on August 18 when it became evident that: (1) the majority of late run fish remaining below the barrier would spawn in that area and (2) water levels were receding and remaining fish destined for Upper Russian Lake spawning grounds could successfully negotiate the falls. The recreational fishery was closed by emergency order

on August 18 for the remainder of the season to protect large numbers of spawning fish below the falls. A minimal number of late run fish perished as a result of the velocity barrier. Quantitative data are not available regarding magnitude of the loss. Observation suggests it was somewhat less than that sustained by the early run.

The return of record numbers of early run fish, the "fish rescue" and the above management practices combined to produce the highest early run escapement since 1966 and the greatest harvest recorded. Mortality associated with the velocity barrier was minimal. Management of the early run was therefore most successful as it maximized harvest, escapement and fishing opportunity.

Indicators such as parent year escapement and record numbers of sockeye salmon entering the Kenai River suggested an exceptionally large late run return to Russian River. These indicators are, however, fallible (Engel, 1972) and fisheries managers rely on weir counts, catch statistics and observation of numbers of fish within the fishery to formulate management decisions. The velocity barrier at Russian River Falls concomitant with large numbers of fish concentrated below the falls which represented several segments of the total population negated catch statistics as a management tool. Escapement counts obtained at the weir could not be employed as a management tool because of the migrational delay. Visual observation in the fishery was inaccurate due to intermingling of the spawning populations. The true magnitude of the late run could therefore not be determined. Management practices during the late run maximized fishing opportunity which resulted in the highest harvest of late run Russian River sockeye salmon to date. Escapement, however, was the lowest recorded. Management of the late Russian River run was therefore only partially successful as the escapement goal of 30,000 was not attained.

Engel (1972) recommended construction of a fish passage facility at Russian River Falls. This recommendation was made in view of the 1971 velocity barrier which adversely affected management and reproductive potential of the stocks. Similar recommendations were made in all subsequent years. If the fish passage facility would have been constructed, the 1977 migrational delay would not have occurred. Escapements would have been enumerated in a normal manner at Russian River weir. When weir counts indicated a lower than anticipated late run escapement, the recreational fishery would have been closed by emergency order. Although such action would not necessarily have assured achievement of the minimum escapement goal, escapements would have undoubtedly exceeded 21,410 fish.

Russian River Falls and Migrational Delay:

Engel (1972) indicated that high water passing through a canyon of considerable gradient (Russian River Falls) had delayed migration of Russian River sockeye salmon on several occasions between 1960 and 1970. The delay appeared to have affected only the early run and no documented mortalities are known to have occurred although they were suspected. In 1971 a late spring breakup coupled with exceptionally heavy late spring and summer rains created a total velocity barrier at the falls. An unknown number of early

run and an estimated 10,000-12,000 late run fish perished below the obstacle. Data suggested that females suffered greater mortality than males. Examination of 1,368 late run carcasses below the falls revealed 62.7% were females (Engel, 1972).

Migrational patterns were similar to historical timing in 1972, 1973 and 1974. Nelson (1976) indicated early run fish may have been delayed in the falls area for three or four days in 1975. No mortality is known to have resulted from this delay. No delays occurred in 1976 (Nelson, 1977).

Higher elevations of the Kenai Peninsula experienced exceptionally heavy snowfall during the winter of 1977-78. Spring runoff resulting from this heavy snowfall again created a velocity barrier at Russian River Falls during 1977 early and late run migrations.

Figure 4 compares the average Russian River discharge during an eight year period as opposed to 1977 Russian River discharge rates. The period under consideration (June 16 through August 29) corresponds to the period of time sockeye salmon ascend Russian River Falls. It is evident from this figure that stream discharge in 1977 was between two and three times the average discharge. It should also be noted that these discharge rates are exclusive of Rondezvous Creek discharge which enters Russian River immediately above the falls. If this stream's contribution to the total discharge passing through the falls is considered, both average and 1977 discharge would be increased approximately 11.2% or an average of 70 cfs.

Figure 5 indicates a correlation exists between migration through the falls and the exceptionally high 1977 discharge rates. As discharge rates increased, numbers of fish capable of negotiating the falls decreased. The converse was also true. Observation by this author and data graphically depicted in Figure 5 suggest that salmon experience difficulty passing through the canyon when Russian River discharge exceeds 400 cfs.

Table 11 presents arrival dates and dates by which 50% of the escapement has ascended Russian River Falls and passed the counting tower weir. During years of weir operation the average date when 50% of the early run had passed the weir was July 5. In 1971 half the escapement did not pass this point until July 15. In 1977, 50% of early run passage occurred on July 11. High water (discharge rates) therefore delayed early run migration ten days in 1971 and seven days in 1977. Fifty percent of the late run escapements generally pass the weir by August 6. In 1971 high water delayed their passage by approximately 16 days. In 1977 the delay was somewhat less or about five days. Had a fish rescue not been initiated during both runs, the 1977 delay would have been greater than indicated by data presented in Table 11.

Figure 6 graphically depicts migrational timing differences of passage rates during years of average stream flow as opposed to passage rates during high water years of 1971 and 1977. Although Russian River discharge rates are not available for 1971, Figure 6 suggests they may have been greater than 1977 discharge.

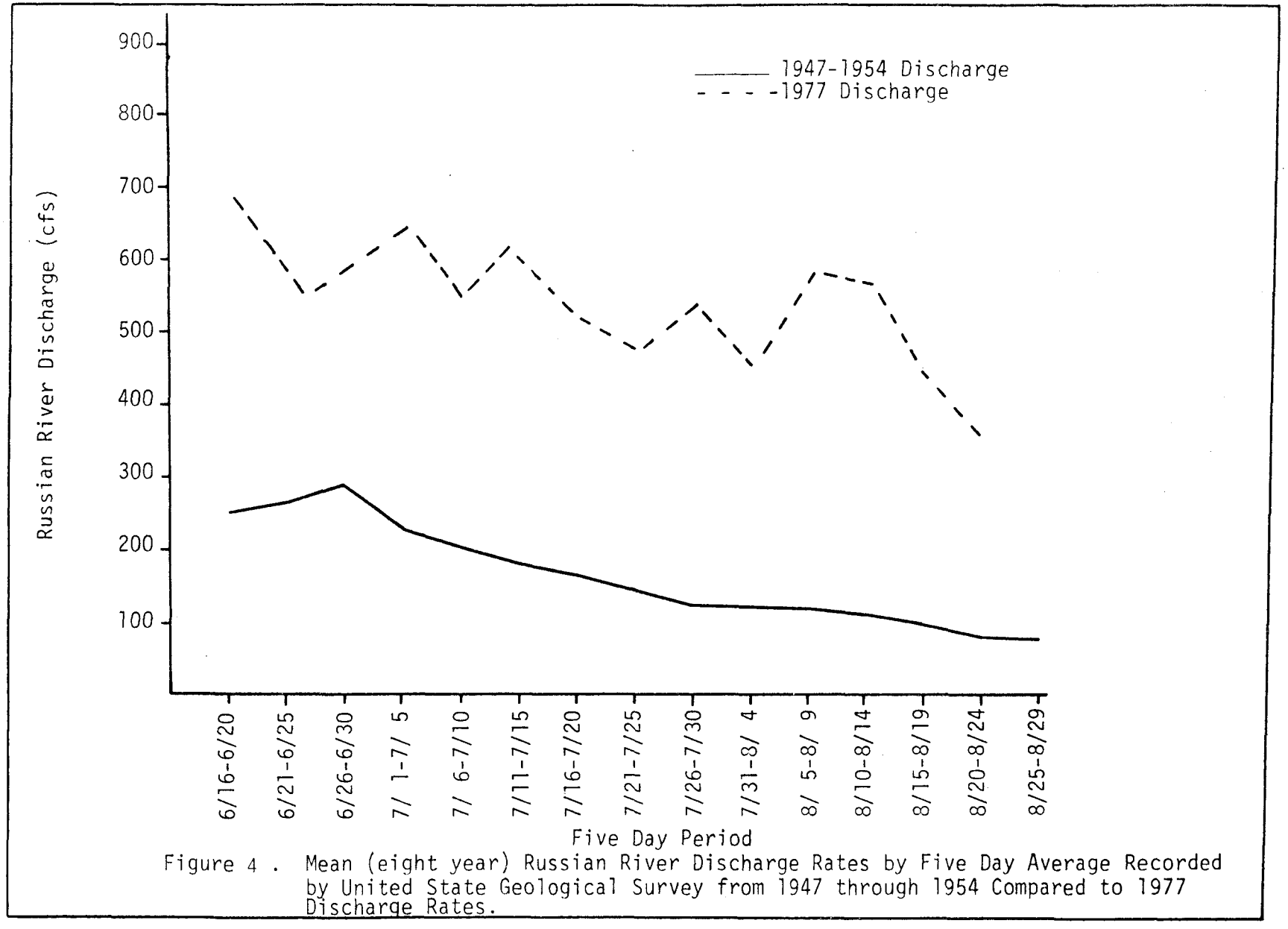

Figure 4 . Mean (eight year) Russian River Discharge Rates by Five Day Average Recorded by United State Geological Survey from 1947 through 1954 Compared to 1977 Discharge Rates.

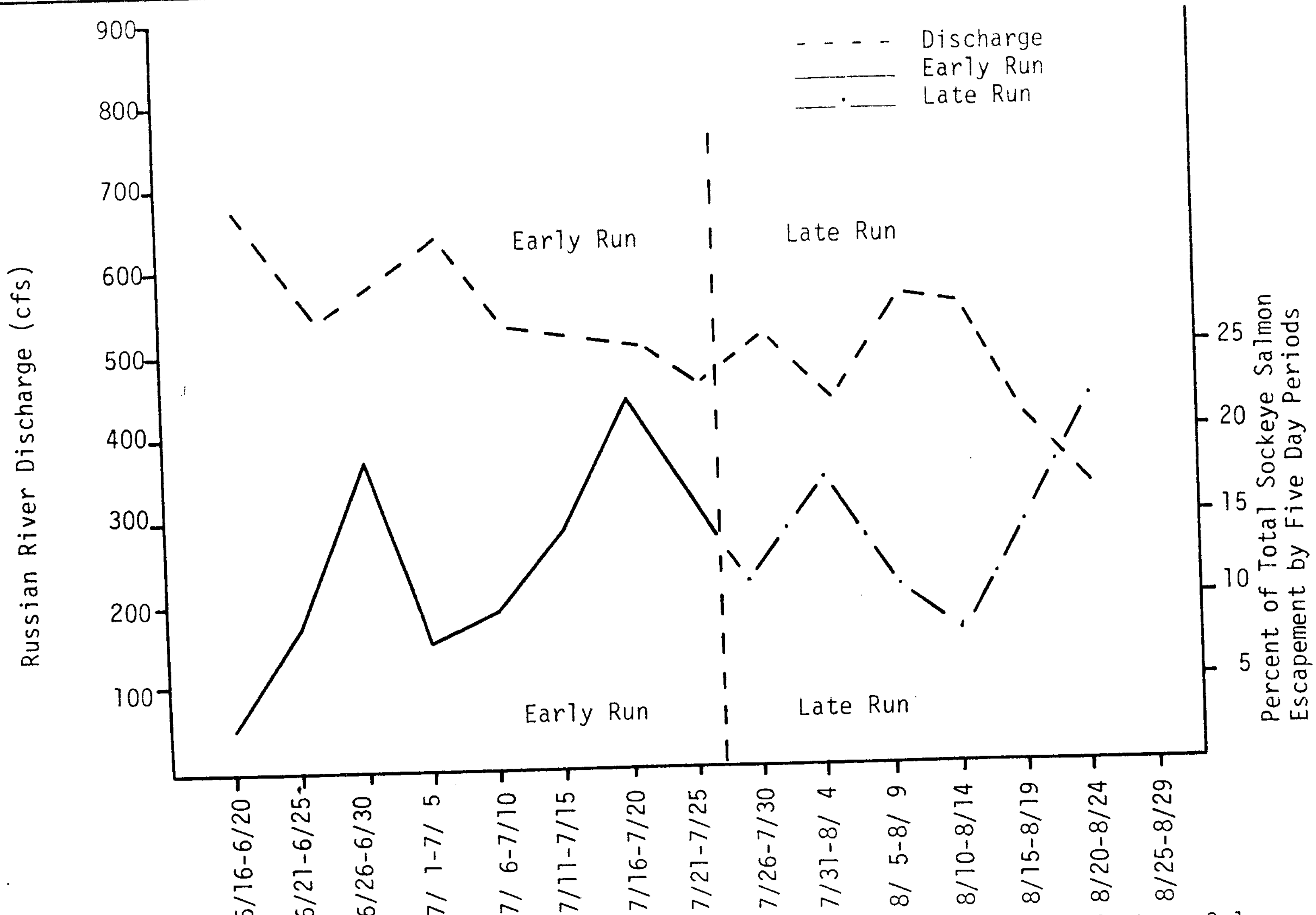

Figure 5 . Russian River Discharge Compared to Early and Late Run Sockeye Salmon Migrational Timing Through Russian River Weir, 1977.

Table 11. Arrival Dates, Date Fifty Percent of the Escapement Passed Weir/Counting Tower and Termination Dates of Early and Late Russian River Sockeye Salmon Runs, 1963-1977*.

	Early Run			Late Run		
Year	Arrival At Weir/ Counting Tower	Date 50% Passed	Date Run Ended	Arrival At Weir/ Counting Tower	Date 50% Passed	Date Run Ended
1963	6/18	7/ 1	7/12	7/16	7/31	8/23
1964	6/20	7/ 7	7/15	7/16	7/30	8/15
1965	6/22	7/ 4	7/15	7/16	8/ 5	8/15
1966	6/20	6/29	7/15	7/16	7/30	8/17
1967	6/20	6/28	7/15	7/16	8/ 2	8/18
1968	6/25	6/29	7/13	7/19	7/31	8/14
1969		No Data		7/16	8/ 2	8/18
1970	6/17	7/ 5	7/15	7/16	8/ 7	8/23
1971	7/ 6	7/15	7/27	7/28	8/23	9/ 6
1972	6/24	7/ 5	7/29	7/30	8/ 5	8/28
1973	6/21	7/ 6	7/15	7/16	8/ 1	8/30
1974	6/14	7/ 1	7/21	7/22	8/ 7	8/27
1975	6/25	7/ 6	7/27	7/21	8/ 6	9/ 1
1976	6/17	6/30	7/16	7/17	8/ 2	9/ 1
1977	6/17	7/11	8/ 4	7/24	8/12	9/ 5
1963-1976 Average	6/20	7/ 3	7/17	7/18	8/ 5	8/22
1969-1976 Average**	6/20	7/ 5	7/21	7/20	8/ 6	8/27

* 1971 and 1977 data were deleted when computing averages as high water at Russian River Falls resulted in atypical migrational timing.

** Years of weir operation.

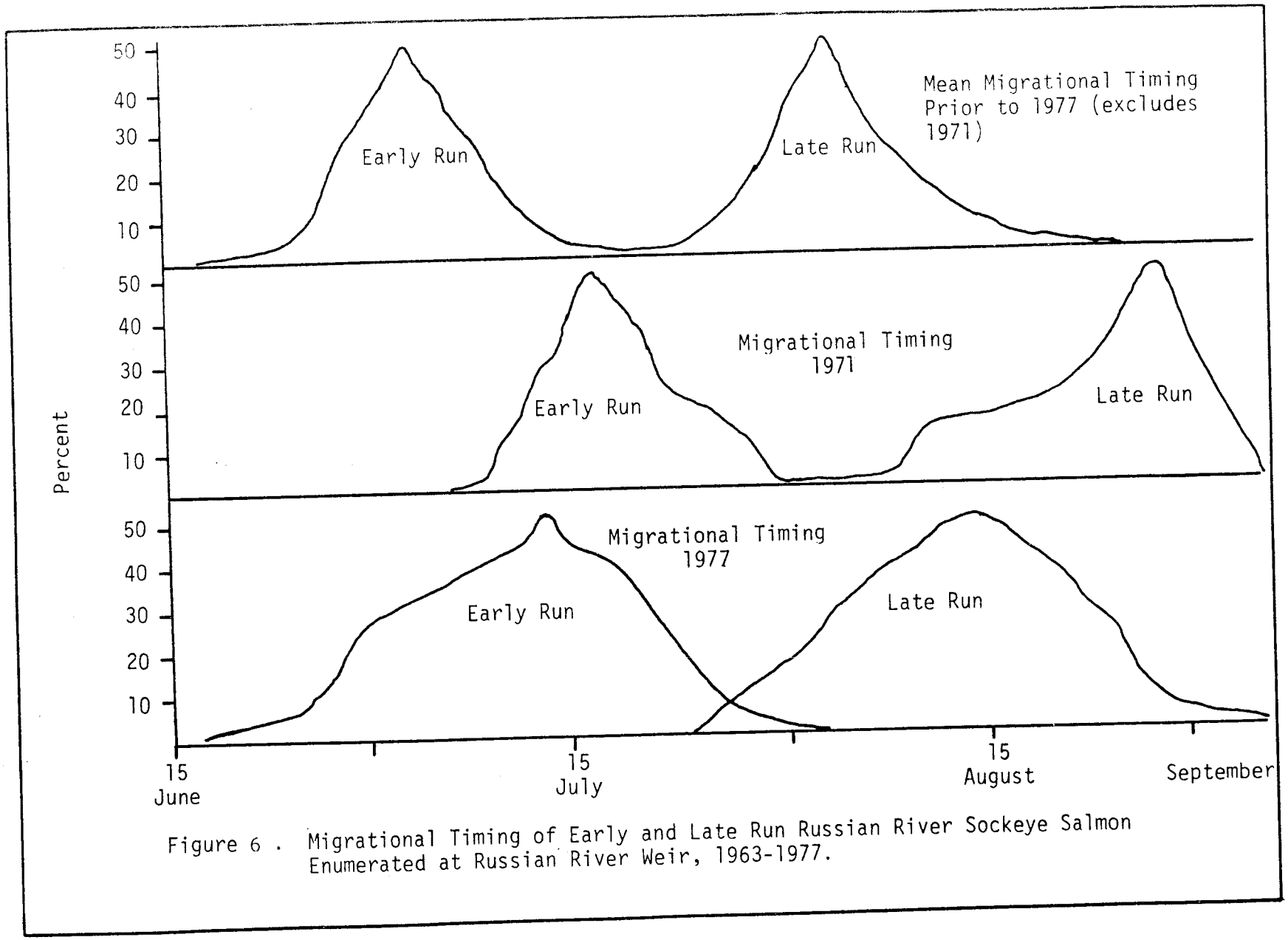

Figure 6 . Migrational Timing of Early and Late Run Russian River Sockeye Salmon Enumerated at Russian River Weir, 1963-1977.

In 1971 early run sockeye salmon did not arrive at the confluence of the Kenai and Russian rivers until June 17. The first early run fish was not enumerated at the weir until July 6, or 13 days after arrival at the confluence. Normally 50% of the run would be expected to pass the weir by July 5. In 1977 sockeye salmon were observed at the confluence on June 8 with an unknown number passing the weir site prior to weir installation on June 17. It is therefore evident that discharge rates during the early segment of the 1971 early run migration were of sufficient magnitude to totally preclude fish passage. The falls was a partial barrier in 1977 as some fish from both early and late runs were capable of ascending the falls at all water levels.

Fish Rescue:

It becomes evident as early as June 15 that the majority of early run fish were experiencing difficult negotiating Russian River Falls due to high water. Numbers of salmon below the falls justified a "fish rescue" of some type to achieve escapement goals and prevent mass mortality such as occurred in 1971.

On June 19 an attempt was made to reduce the volume of water flowing through the falls area by laying Visqueen across the weir face. This created a dam with Lower Russian Lake acting as the reservoir. The Visqueen was placed at 1600 hours. In an approximately 30 minute period the water level below the weir dropped from 745 mm to 300 mm--a decrease of 445 mm or 17.5 inches. Observations in the falls area indicated a similar reduction in water height. Although the weir structure per se appeared capable of restricting the flow, the possibility of severe substrate erosion dictated removal of the Visqueen at 1830 hours. Few fish ascended the falls during the 2.5 hours of decreased flow and the attempt to control stream flow by use of the weir was abandoned.

On July 1 fisheries managers considered the feasibility of constructing a tram from the base of the falls to quiet water above the barrier. On-site inspection revealed that any device of this type would require fish to be moved 450 feet. Large numbers of fish to be moved and construction problems associated with the distance involved indicated such a method could not achieve satisfactory results.

In view of the large numbers of fish below the falls and their advancing sexual condition, transportation via helicopter appeared the only alternative. The first phase of the "fish rescue" commenced July 8 and terminated July 10, with 4,003 sockeye salmon transported during the three day period.

The second phase of the operation began July 15. As with the first, and all subsequent lifts, difficulty was encountered acquiring a suitable helicopter as many of these aircraft were engaged in fire suppression activities. The second lift terminated July 18 with the transport of an additional 4,474 early run sockeye. Total early run sockeye transported during seven days was 8,477 or 52.7% of the 1977 early run escapement (Table 12).

Table 12. Transport of Early Run Russian River Sockeye Salmon via Helicopter from the Base of Russian River Falls to Lower Russian Lake, 1977.

Date	Number of Lifts	Average Number of Salmon/Lift	Total Salmon Transported
July 8	13	81.7	1,062
July 9	14	80.6	1,128
July 10	28	64.7	1,813
July 15	20	43.3	867
July 16	26	46.0	1,197
July 17	21	58.4	1,227
July 18	22	53.8	1,183
Total	144		8,477
Average	20.6	58.7	1,211

May and June are historically the months of greatest stream flow at Russian River with discharge rates decreasing in July and August (Nelson, 1975). In 1977 the water remained exceptionally high during these months and the Department of Fish and Game again had no choice but to transport the late run over the obstruction.

The second run lift began on August 13 and terminated six days later on August 18. One hundred forty-one lifts were made during this period for an average of 52.7 sockeys salmon per lift. Total sockeye salmon transported was 7,436 or an average of 1,239.3 fish per day (Table 13). Second run fish transported via helicopter totaled 34.7% of the late run escapement above the falls.

Mortality of both early and late run fish which is known to be associated with the "fish rescue" was negligible. On the first day of the operation (July 8) an estimated 10% of the fish transported perished due to oxygen deficiency and crowding in the tote. This was corrected by reducing numbers of fish carried per lift and aerating the water. Condition of the fish transported ranged from "fresh and bright" to sockeye salmon that were "running eggs" and on the verge of spawning. Many salmon transported displayed abrasive injuries that were assumed to have occurred during attempts to negotiate the falls.

Use of a helicopter to transport fish over Russian River Falls is costly. Cost of leasing a helicopter during the early run "fish rescue" was approximately $23,000. Groceries, fuel and fixed wing aircraft charter added an additional $2,500. Minimum expenses incurred were therefore about $25,500 or $3.00 per fish transported.

Transporting fish during the late run was more costly than during the early run. A suitable helicopter was not available in the Cook Inlet area during the late run's migration which necessitated that one be ferried from Sitka at additional expense to the Department of Fish and Game. Seasonal employees who would normally have been terminated in early August were retained for the program. Total cost to include additional wages, helicopter lease, groceries, fuel, equipment, etc., is minimally estimated at $39,750 or $5.35 per fish. Total cost for both early and late run "fish rescues" was therefore about $62,250 or an average of $4.10 per fish. It should be noted the above costs are minimal and do not reflect wages of permanent employees, administrative expenses, etc.

Age Composition:

Scale analysis from samples collected at Lower Russian Lake weir revealed sockeye salmon in their fifth year of life comprised 74.7% of the early Russian River run. Salmon in their sixth year of life contributed 23.4% and the remaining 1.9% were four-year fish.

Early run age composition in 1977 was therefore atypical and contrary to data analyzed during the previous 7-year period. Historically, early run fish are salmon in their sixth year of life composed of age class 2.3. This age class has contributed an average of 71.0% to the early run. In

Table 13. Transport of Late Run Russian River Sockeye Salmon via Helicopter from the Base of Russian River Falls to Lower Russian Lake, 1977.

Date	Number of Lifts	Average Number of Salmon/Lift	Total Salmon Transported
August 13	35	39.2	1,371
August 14	30	47.8	1,433
August 15	28	58.2	1,630
August 16	17	64.8	1,102
August 17	18	61.9	1,115
August 18	13	60.4	785
Total	141		7,436
Average	23.5	52.7	1,239.3

1977 the contribution of this age class was only 23.4%. Age class 1.3's average contribution to the early run is 12.7%. In 1977 this age class dominated the escapement comprising 60.7% of the fish sampled.

Early run salmon averaged 605.3 mm in length, 9.5 mm larger than in 1976 and 17.0 mm larger than in 1975. Average lengths of two and three-ocean fish were 559.6 and 610.5 mm, respectively. It is assumed that the larger average size of early run fish in 1977 is related to the velocity barrier at Russian River Falls. Fish that negotiated the falls area at the high 1977 discharge rates appeared to be the larger fish. Male to female sex ratio of the early run was 1:0.4. As males are generally larger than females, the sex ratio also influenced average size of early run fish in the escapement.

Late run stocks were dominated by fish that migrated to the marine environment after two years in fresh water (85.7%). The majority of this run (92.3%) spent two years in salt water prior to returning to their natal stream. Majority of the salmon examined were the progeny of the 1972 escapement. Male to female sex ratio was 1:0.9. These salmon averaged 570.5 mm or 34.8 mm less than the average early run fish. This difference is at least partially attributed to age structure in that the average early run fish remains at sea three years as opposed to two years for the majority of late run fish. Two- and three-ocean adults averaged 553.7 and 614.9 mm in length.

Table 14 presents the estimated number of salmon in the escapement by age class, parent year of the respective age classes, and the average length of fish in these age classes.

Figure 7 presents the length frequency of 367 early run salmon. Inspection fails to clearly differentiate two- and three-ocean salmon by length. Figure 8 depicts length frequency of two- and three-ocean early run sockeye salmon as determined by scale analysis. This graph clearly illustrates the length ranges for these two-ocean age classes and that extensive overlap occurs. Length frequency analysis alone could therefore not be employed in 1977 to separate early run sockeye salmon ocean-age classes.

Length frequency of 257 late run sockeye salmon is presented in Figure 9. This graph clearly shows appreciable variation in lengths of late run adult (jacks excluded) fish which range in length from less than 520 to more than 649 mm.

A tentative division between ocean age individuals is indicated between 580 and 589 mm. If the division were made here it would indicate two-ocean comprised 64.9% and three-ocean salmon 35.1% of the 1977 late run escapement. Scale analysis indicated the true ocean-age composition was 79.2% two-ocean and 20.8% three-ocean. Utilizing length-frequency alone to determine ocean-ages of late run sockeye salmon in 1977 would result in an error of 14.3%. Figure 10 depicts length-frequency of two- and three-ocean late run fish as determined by scale analysis. This graph clearly shows the degree of overlap between two- and three-ocean late run sockeye salmon.

Table 14. Age Class Composition, Sample Size, Parent Year and Average Length of Adult Sockeye Salmon in Respective Age Classes for Early and Late Run Russian River Escapements, 1977.

Age Class	Estimated No. In Escapement	Sample Size	Early Run Estimated Percent of Escapement	Parent Year	Average Length (mm)*	SD**
1.2	305	6	1.9	1973	586.8	14.4
1.3	9,755	266	60.7	1972	611.3	17.8
2.2	2,250	31	14.0	1972	554.3	29.1
2.3	3,760	64	23.4	1971	607.0	18.6
Combined	16,070	367	100.0		605.3	24.7
			Late Run			
1.2	1,378	16	6.6	1973	550.3	30.4
1.3	1,607	31	7.7	1972	618.5	15.5
2.2	15,154	172	72.6	1972	554.0	22.7
2.3	2,733	38	13.1	1971	612.0	18.8
Combined	20,872***	257	100.0		570.5	35.0

* Length is from mid-eye to fork of tail.
** Standard Deviation.
*** Excludes 537 jacks.

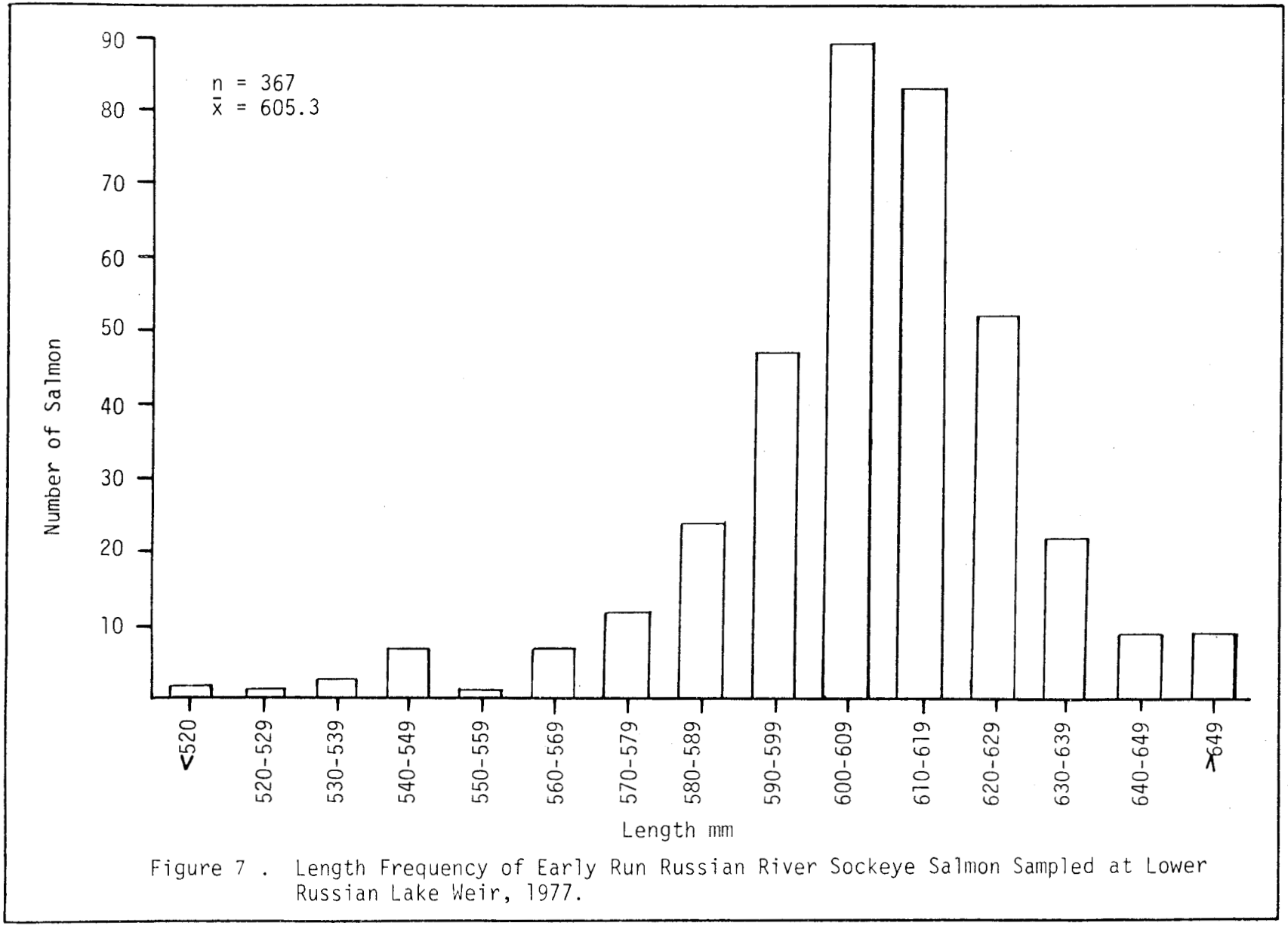

Figure 7 . Length Frequency of Early Run Russian River Sockeye Salmon Sampled at Lower Russian Lake Weir, 1977.

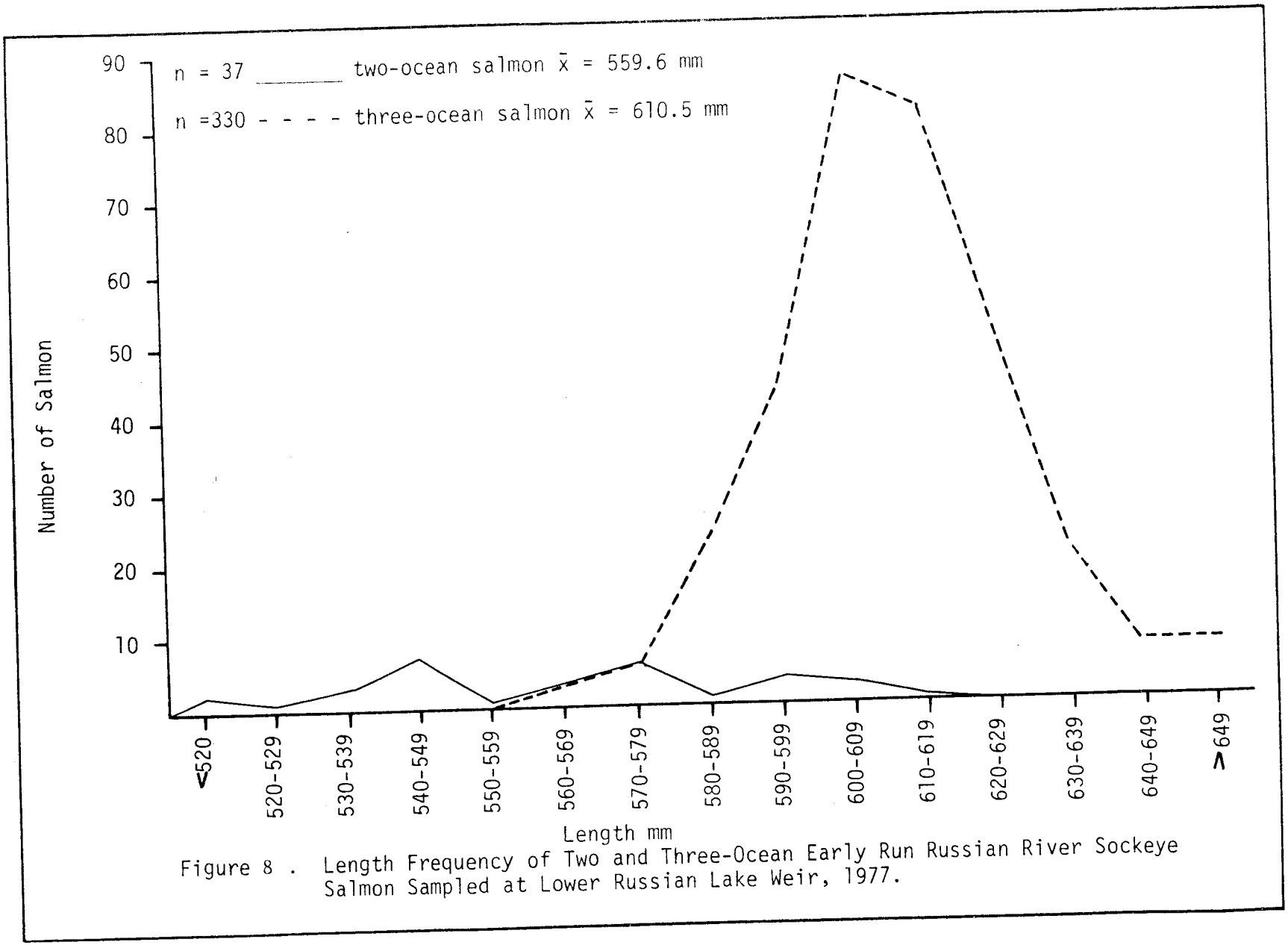

Figure 8 . Length Frequency of Two and Three-Ocean Early Run Russian River Sockeye Salmon Sampled at Lower Russian Lake Weir, 1977.

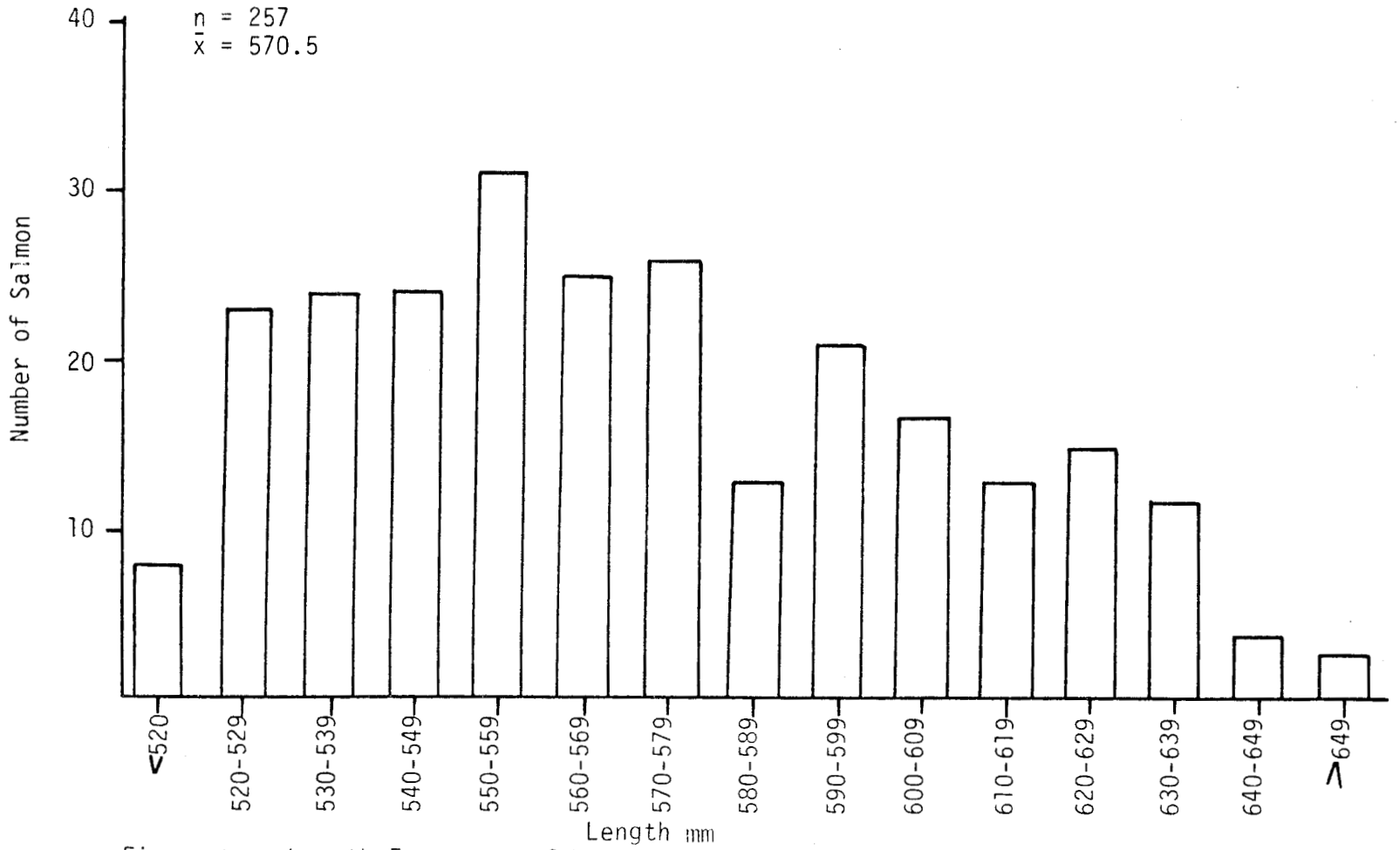

Figure 9 . Length Frequency of Late Run Russian River Sockeye Salmon Sampled at Lower Russian Lake Weir, 1977.

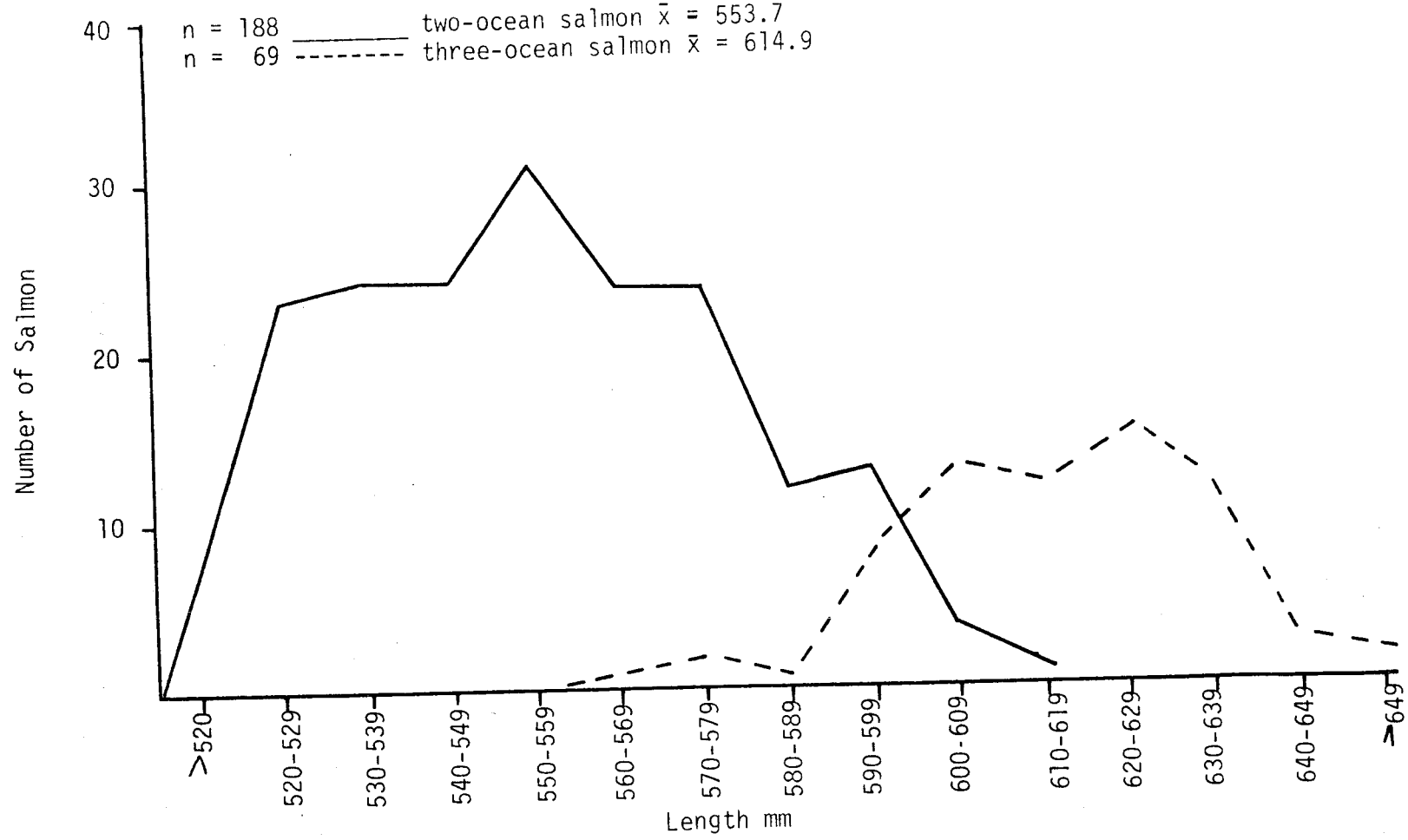

Figure 10. Length Frequency of Two and Three-Ocean Late Run Sockeye Salmon Sampled at Lower Russian Lake Wier, 1977.

Early Run Return Spawner:

Number of salmon produced for each early run fish in the parent year spawning escapement is presented in Table 15. The highest return per spawner of 3.3 was achieved in 1976 and resulted from a relatively small parent year escapement of 5,450 in 1970. The lowest return per spawner (0.3) occurred in 1971 from a parent year escapement of 21,510 in 1965. This exceptionally low return resulted from the highest early run escapement recorded for this segment of the population. It is therefore evident that a large spawning escapement will not necessarily result in high production rates.

Average early run return per spawner is 1.7. Although this production is relatively low, the trend seems to be toward increased production. Production from 1963 through 1966 spawning escapements which averaged 16,312 fish failed to reproduce themselves. Average return rate was only 0.7. Escapements from 1967 through 1970 averaged 8,340. The average return rate was 2.1 or three times the production from the earlier years of relatively high escapements.

As previously noted, the majority of the fish in the early run escapement are historically age class 2.3 or six year fish. It was therefore anticipated that early run fish in 1977 would be the progeny of the 1971 early run escapement which was the lowest recorded for this system. Maximum estimated return would therefore be expected to approximate 8,700 sockeye salmon. Total return, however, was 36,470, the largest return ever recorded.

The explanation for this return may be found by referring to Tables 10 and 15. Table 10 indicates that the 1977 early run escapement was dominated by age class 1.3 or the progeny of the 1972 escapement. Table 15 indicated the return per spawner from this escapement was 2.9. Total contribution to the 1977 return from this year class was therefore 27,239 fish. The small 1971 escapement performed as anticipated, returning an estimated 8,533 sockeye salmon. Total return to Russian River in 1977 therefore was the product of an atypical age structure in which salmon from the 1971 and 1972 escapements both returned in 1977 as age class 1.3 and 2.3.

A small percentage of early run smolt have always migrated as one-check. The presence of a high percent of one-check fish in the 1977 adult return suggests exceptionally favorable rearing conditions in Upper Russian Lake in 1973. Reasons for these conditions are not definitely known but two hypotheses may be advanced. (1) Lake productivity may have increased. The 1972 late run spawning escapement of 79,000 fish was the highest recorded. Record numbers of carcasses may have enriched the lake, increasing basic productivity in 1973. Fry could therefore have experienced accelerated growth causing early migration from the lake as one-check smolt. (2) Rearing fry from the 1972 escapement may have had limited competition from other sockeye salmon age groups. Fry from the 1972 early run escapement were rearing in 1973 and migrated in spring of 1974. In 1973 these fish would have been competing with early run fish from the 1971 escapement and late run fish from the 1971 and 1972 escapements. The 1971 early

Table 15. Estimated Production from Prior Escapements of Early Run Russian River Sockeye Salmon, 1963-1972.

Brood Year	Escapement		Return (Year)	Total Run*	Production	
	Females	Total			Per Female	Per Spawner
1963	7,190**	14,380	1969	10,870	1.5	0.7
1964	6,350**	12,700	1970	11,200	1.8	0.9
1965	10,755**	21,510	1971	5,460	0.5	0.3
1966	8,330**	16,660	1972	14,310	1.7	0.9
1967	6,855**	13,710	1973	19,860	3.0	1.4
1968	4,600**	9,200	1974	19,590	4.3	2.1
1969	2,500**	5,000	1975	7,040	2.8	1.4
1970	2,420***	5,450	1976	18,080	7.5	3.3
1971	1,262****	2,650	1977	8,533	6.8	3.2
1972	5,562*****	9,270	1977	27,239	4.9	2.9
Average	5,582	11,053		14,218	3.5	1.7

* Sport harvest plus escapement. Assumes negligible commercial harvest.
** Assumes a male to females sex ratio of 1:1.
*** Male to female sex ratio of 1:0.8 determined by sampling.
**** Male to female sex ratio of 1:0.9 determined by sampling.
***** Male to female sex ratio of 1:1.5 determined by sampling.

run escapement was exceptionally small and theoretically produced few fry. The 1971 and 1972 late run escapements were exceptionally large. However, returns from these escapements in 1976 and 1977 were quite low which may suggest a spawning failure in Upper Russian Lake. Should the above have occurred, rearing fish from the 1972 early run escapement would have experienced minimal competition for food and space from other sockeye salmon year classes.

Fecundity Investigations:

Fecundity investigations initiated in 1973 were continued at Russian River weir during the early and late runs. Results of the 1977 investigation are presented in Tables 16 and 17.

Direct enumeration was used to check the accuracy of volumetric estimation. Average error utilizing volumetic estimation was 0.226% for early run samples and 2.601% for the late run. All early run samples were directly enumerated and 50% of the late run samples were treated in like manner. Therefore, in the ensuing discussion dealing with fecundity, only data determined by direct enumeration will be presented.

Fecundity of early run salmon ranged from 3,727 to 5,119, averaging 4,312.5. Average weight of females sampled was 2.852 kg and length was 602.7 mm. These fish averaged 1,512 eggs per kilogram of body weight and 7.0 eggs per millimeter of body length. Late run sockeye salmon averaged 3,302 eggs per female with a range of 2,640 to 4,146. Average length and weight of late run salmon sampled was 567.1 mm and 2.438 kg. These fish averaged 1,354 eggs per kilogram of body weight and six eggs per millimeter of body length. Table 18 compares these data with results from prior investigations.

Foerster (1968) indicates the larger the fish the greater the egg content. Table 18 indicates this is generally true but exceptions do occur. Nelson (1977) noted that the average early run female salmon in the 1975 sample was somewhat smaller than the average female utilized in the 1974 investigations, but egg content was 10.7% greater in 1975. Similarly, the average length of early run fish utilized in 1976 was seven millimeters less than the 1974 average, yet average fecundity increased by 9.9 eggs in 1976. This apparent disparity was also noted by Foerster (1968) while investigating the fecundity of Cultus Lake sockeye salmon. He concluded that differences of egg content in relation to size were not statistically significant but were the result of inherent variability of the samples. This is the probable explanation for the variation in Russian River samples.

Foerster (1968, p. 126) provides an excellent summary of sockeye salmon fecundity investigations. Early run Russian River salmon have averaged 4,026.4 eggs per female since 1973. Comparing this average to those discussed by Foerster indicates fecundity of early run Russian River stocks is quite high. The Bolshaya River and Cultus Lake stocks are the only populations discussed whose average fecundity exceeds that of early Russian River fish. Late run Russian River fish are somewhat smaller than early run salmon. Average fecundity for this stock since 1973 has averaged 3,359.8. Although it is difficult to rank various populations when

Table 16. Fecundity of Early Run Russian River Sockeye Salmon as Determined by Actual Count and Volumetric Estimate, Lower Russian Lake Weir, 1977.

Sample Number	Weight (kg)	Length (mm)	Number of Eggs (Actual Count) Right Skein	Left Skein	Combined	Number of Eggs Volumetric Estimate Right Skein	Left Skein	Combined	Percent Error
1	3.302(7.28 lb)	625	2,028	2,673	4,701	2,080	2,663	4,743	-0.893
2	2.495(5.50 lb)	589	2,251	2,344	4,595	2,257	2,312	4,569	+0.566
3	2.835(6.25 lb)	598	1,970	2,148	4,118	1,951	2,129	4,080	+0.923
4	2.948(6.50 lb)	617	2,317	2,802	5,119				
5	2.894(6.38 lb)	610	1,740	1,987	3,727				
6	2.789(6.15 lb)	600	1,755	1,980	3,735	1,718	1,945	3,663	+1.928
7	2.608(5.75 lb)	585	2,006	2,065	4,071	2,160	2,092	4,252	-4.446
8	2.948(6.50 lb)	598	2,161	2,273	4,434	2,174	2,235	4,409	+0.564
Avg.	2.852(6.29 lb)	602.7	2,028.5	2,284.0	4,312.5	2,056.7*	2,229.3*	4,286.0*	-0.226*

* Averages computed utilizing samples 1, 2, 3, 6, 7 and 8 only.

Table 17. Fecundity of Late Run Russian River Sockeye Salmon as Determined by Actual Count and Volumetric Estimate, Lower Russian Lake Weir, 1977.

Sample Number	Weight (kg)	Length (mm)	Number of Eggs (Actual Count) Right Skein	Left Skein	Combined	Number of Eggs (Volumetric Estimate) Right Skein	Left Skein	Combined	Percent Error
1	2.324 (5.12 lb)	555				1,581	1,674	3,255	-4.221
2	2.948 (6.50 lb)	600	1,941	2,205	4,146	1,940	2,381	4,321	
3	2.438 (5.37 lb)	570				1,911	1,600	3,511	
4	2.154 (4.75 lb)	545	1,568	1,687	3,255	1,566	1,752	3,318	-1.935
5	2.381 (5.25 lb)	575				1,449	1,740	3,189	
6	1.814 (4.00 lb)	512	1,363	1,277	2,640	1,427	1,289	2,716	-2.879
7	3.060 (6.75 lb)	620				1,806	2,000	3,806	
8	2.297 (5.06 lb)	570				1,665	1,764	3,429	
9	2.296 (5.06 lb)	545	1,306	1,512	2,818	1,413	1,547	2,960	-5.039
10	2.523 (5.56 lb)	551				2,234	2,000	4,234	
11	2.720 (6.00 lb)	579	1,820	1,803	3,623	1,778	1,861	3,639	-0.442
12	2.155 (4.75 lb)	535				1,408	1,622	3,030	
13	2.494 (5.50 lb)	560	1,600	1,620	3,220	1,642	1,594	3,236	-0.497
14	3.450 (7.60 lb)	622				1,894	2,270	4,164	
15	2.551 (5.62 lb)	563	1,850	2,078	3,928	1,897	2,086	3,983	-1.400
16	2.324 (5.12 lb)	550	1,381	1,692	3,073	1,480	1,767	3,247	-5.66
17	2.211 (4.87 lb)	575	1,560	1,629	3,189	1,580	1,660	3,240	-1.599
18	2.041 (4.50 lb)	555				1,291	1,156	2,447	
19	2.182 (4.81 lb)	560	1,670	1,458	3,128	1,710	1,491	3,201	-2.334
20	2.400 (5.29 lb)	600				1,980	2,494	4,474	
Average	2.438 (5.37 lb)	567.1	1,605.9*	1,696.1*	3,302*	1,682.6	1,787.4	3,470	-2.601*

* Averages computed utilizing samples 2,4,6,9,11,13,15,16,17 and 19 only.

Table 18. A Comparison of Fecundity Data Collected at Lower Russian Lake Weir During Early and Late Run Russian River Sockeye Salmon Migrations, 1973-1977.

Year	Average Fecundity	Average Length (mm)	Average Weight (kg)	Eggs/ Kilogram	Eggs/ Millimeter
		EARLY RUN			
1973	4,630	627.0	2.968	1,560	7.0
1974	3,569	603.0	2.603	1,371	6.0
1975	3,952	600.0	2.540	1,556	7.0
1976	3,668	596.0	2.608	1,407	6.0
1977	4,313	602.7	2.852	1,512	7.0
		LATE RUN			
1973	3,190	569.0	2.187	1,459	6.0
1974	3,261	558.0	2.301	1,417	6.0
1975	3,555	555.0	2.257	1,575	6.0
1976	3,491	587.3	2.533	1,378	6.0
1977	3,302	567.1	2.438	1,354	6.0

dealing with fecundity, a comparison of late run Russian River sockeye salmon fecundity with those examined by Foerster (1968) suggests these stocks are "intermediate" in relation to other populations.

Egg Deposition:

Assuming that average fecundity of early run samples is representative of early run stocks, the potential number of eggs available for deposition in Upper Russian Creek may be calculated. It is recognized that losses between weir and spawning grounds, females that perish without spawning, and average number of eggs retained per female must be considered. These criteria have been presented in detail by Nelson (1976).

Applying the parameters as outlined by Nelson (1976) potential early run egg deposition is calculated as follows:

Early run escapement	16,070
Early run female escapement	4,592
Mortality between weir and spawning grounds	5.1%
Female salmon to reach spawning grounds	4,358
Female salmon that perished without spawning	(1.1%) 50
Remaining female salmon	4,308
Average fecundity per female	4,313
Total possible eggs deposited	18,580,404
Percent eggs deposited per female	98.0%
Estimated potential egg deposition	18,208,796

Potential egg deposition in 1977 of approximately 18.2 million is within the range of estimates for prior years. Estimated potential deposition for 1973, 1974, 1975, and 1976 were 29.6, 17.7, 12.7, and 23.5 million eggs, respectively. The estimated potential deposition in 1977 is therefore the third highest recorded. Early run escapement was the highest recorded since 1966. Considerable variability in reproductive potential exists independent of actual numbers of spawners (Hartman and Conkle, 1960).

Annual differences in sex ratios can cause substantial differences in eggs available for deposition. In 1973 (year of highest potential deposition) females dominated the escapement with a male to female sex ratio of 0.9:1. In 1977 an unbalanced sex ratio favored males (1:0.4). Thus, the 1977 record early run escapement produced relatively fewer eggs than smaller escapements with a more balanced sex ratio.

Egg sampling to determine actual egg deposition and survival of early run eggs in Upper Russian Creek was conducted October 4-6. Sampling was conducted in all 11 sections of the creek and was proportionate to section

area, i.e., the larger the area the more samples dug. Points to be dug were randomly selected. A total of 108 points were scheduled to be dug. However, due to the sampling point falling on a rock or in a pool, only 78 points were actually dug.

Initial sampling indicated few eggs were present and deposition was subsequently estimated at 67.7 eggs/M^2. This is one of the lowest densities recorded and approximates 1976 density of 61.3 eggs/M^2. Egg survival was 55.0% at time of sampling which is the lowest survival rate recorded. Techniques employed to calculate egg density have been previously described (Nelson, 1975). Density and survival estimates from 1972 to 1977 are presented in Table 19.

Egg density estimates obtained by hydraulic sampler may also be used to estimate total egg deposition in Upper Russian Creek. Multiplying the estimated spawning area available to early run fish by the estimated eggs/M^2 yielded a total deposition of only 935,310 eggs. Thus the estimated deposition in Upper Russian Creek as determined by hydraulic sampler is many times lower than the theoretical number of eggs potentially available (18.2 million). This disparity between potential and actual deposition has been previously noted (Nelson, 1976, 1977).

It does not necessarily follow that because major disparities exist between potential and acutual deposition estimates that one or the other method is incorrect (Nelson, 1976). Indirect estimation yields the maximum potential eggs available for deposition and does not necessarily reflect numbers of eggs in the stream. Direct estimation (providing sampling design is correct) should indicate the number of eggs in Upper Russian Creek at the time of sampling.

Nelson (1977) indicated that water levels were exceptionally high in Upper Russian Creek when 1976 sampling was conducted. There was evidence that the stream had left its banks and several large trees which had been across the stream since 1972 had been dislodged. This suggested Upper Russian Creek was subject to flood conditions in 1976 which may have washed large numbers of early run sockeye salmon eggs from the redds. It appears that a similar situation may have occurred in 1977. Observation on August 5 indicated the stream was exceptionally high and had assumed glacial coloration. Observation conducted while sampling indicated the stream substrate had shifted in several areas. High water in both 1976 and 1977 could therefore account for relatively low egg densities in relation to high escapements.

Bear creek is a small (approximately 5,400 M^2) spring fed tributary on the east side of Upper Russian Lake. The system has been described in detail by Nelson (1976). Nelson (1977) indicated that the 1978 escapement to this system was expected to be greater than average. This assumption was based on the exceptionally large 1972 parent year escapement to the stream (Nelson, 1973). For reasons presently unknown the anticipated large 1977 return did not occur. Ground counts indicate less than 750 fish returned to Bear Creek. Hydraulic egg sampling was therefore not conducted.

Table 19. Early Run Russian River Sockeye Salmon Egg Densities Determined by Hydraulic Sampler in Upper Russian Creek, 1972-1977.

Year	No. Points Dug	Total Eggs Dug	Average Eggs Per Point	Survival (%)	Density (Eggs/M^2)
1972	50	3,790	75.8	81.1	407.8
1973	50	2,967	59.3	93.0	319.6
1974	98	8,229	83.9	64.2	455.6
1975	98	605	6.2	84.3	33.3
1976*	71	901	12.7	91.6	61.3
1977*	78	981	12.6	55.0	67.7

* 1976 and 1977 data are comparable. These two years, however, may not be comparable to prior years due to revised methods of estimating egg density.

Climatological Observations:

Air and water temperatures recorded at Lower Russian Lake were grouped by 6-day periods to facilitate analysis (Table 20). No correlation was found between air or water temperature and sockeye salmon migration. Total precipitation recorded during the 72-day period was 93.1 mm (3.7"). This is appreciably less than the 235 mm (9.3") recorded during a similar period in 1976. However, rainfall recorded in this area has very little affect on the volume of water in Russian River. Precipitation and runoff at Upper Russian Lake are of much greater significance (Nelson, 1976).

Stream velocity was greatest during the early portion of the first run and exhibited a gradual decline thereafter. Data indicate 1977 Russian River discharge was approximately two or three times greater than historical discharge rates (Figure 4). The affects of these discharge rates on migration of early and late run stocks have been discussed earlier in this report.

Average low and high air temperatures in 1976 were 7.5°C and 18°C. Average low and high air temperatures for a similar period in 1977 were 7.8°C and 19.8°C. Warmer temperatures in 1977 were, in all probability, a contributing factor to the exceptionally high runoff from the Upper Russian Lake drainage. Maximum and minimum water temperatures for 1975 through 1977 are comparable.

DISCUSSION

Creel census statistics collected during the Russian River sockeye salmon sport fishery revealed a harvest of 47,840 salmon. Early and late runs contributed 20,400 and 27,440 salmon, respectively to this harvest. Angler effort directed toward early and late run populations was estimated at 38,200 and 31,310 man-days, respectively. Total effort (69,510 man-days) was the highest recorded at Russian River exceeding 1976 effort estimates by 164.2%. Harvest was also the highest recorded exceeding the previous high harvest estimate set in 1972 by 126.8%.

Anglers harvested 55.9% of the early and 56.2% of the late run which reached Russian River. These are the highest harvest rates recorded for either run. Factors contributing to these high harvest rates are: (1) The early run return was the largest recorded at Russian River and large numbers of these fish were available to the recreational angler. The late run return was also above average. (2) A velocity barrier was in effect at Russian River Falls during both runs. Salmon that could not negotiate the barrier were confined to quiet waters downstream where they were readily accessible to a record number of anglers.

Sockeye salmon escapements were enumerated at Lower Russian Lake weir. A segment of each run was also transported over Russian River Falls via helicopter due to the velocity barrier. Total early run escapement was 16,070. This is the largest early run escapement since 1966. Total return (escapement plus harvest) of early run fish to Russian River was therefore 36,470. This is the highest total return recorded for this segment of the population. Late run escapement above and below Russian River Falls was 21,410 and 17,085 salmon, respectively. Escapement above the

Table 20. Climatological and Hydrological Observations by Six-Day Period Recorded at Lower Russian Lake Weir, June 18 - August 29, 1976.

Period	Air Temperature*		Water Temperature*		Rainfall	Discharge*
	Max. °C	Min. °C	Max. °C	Min. °C	(mm)**	(cfs)***
6/19-6/24	17.8	5.6	10.7	10.2	8.4	641.2
6/25-6/30	19.9	9.7	12.1	11.7	19.9	535.2
7/ 1-7/ 6	20.2	6.4	12.8	12.2	2.7	635.5
7/ 7-7/12	23.1	6.9	14.3	12.9	0.8	561.8
7/13-7/18	18.9	5.7	13.2	12.8	1.7	569.8
7/19-7/24	20.1	9.3	14.6	13.3	0.5	477.0
7/25-7/30	21.7	8.8	13.7	12.9	1.6	527.6
7/31-8/ 5	19.2	8.3	13.3	12.8	18.4	486.7
8/ 6-8/11	17.3	9.3	12.7	12.2	24.4	583.2
8/12-8/17	17.7	8.9	12.9	12.3	14.7	543.0
8/18-8/23	23.1	7.2	14.1	13.2	0.0	374.0
8/24-8/29	19.1	7.4	13.1	12.8	0.0	325.0

* Air temperature, water temperature and discharge for the respective periods are the average of the daily recordings.

** Rainfall for each period is the cumulative total of the daily readings.

*** Russian River discharge only. Discharge for Rondezvous Creek is not included.

falls was the lowest recorded since 1963. Escapement below the falls was the largest known spawning escapement in this area. Total late run escapement of 38,495 was therefore 10.6% below historic average escapement levels. Total late run return of 65,935 is the third highest return recorded for the late run.

Mangement of the Russian River recreational sockeye salmon fishery in 1977 was complicated by a velocity barrier at Russian River Falls, a record high early run return, and a smaller than anticipated late run return. The 1971 early run parent year escapement of 2,650 was the lowest early run escapement recorded. The 1977 early run fishery was initially closed because of this anticipated low return. By June 15 it was evident that predictions were erroneous and that early run fish were returing in record numbers. On June 18 the fishery was opened below the Homer Electric power line. The area above the power line remained closed to protect fish experiencing difficulty negotiating Russian River Falls. The entire "fly fishing only area" was opened on July 15 after the minimum early run escapement goal had been achieved.

Late run fish entered Russian River on July 17 and became mixed with remaining early run sockeye salmon. Difficulties were encountered evaluating run strength as late run fish also encountered the velocity barrier. As the run progressed, it became impossible to differentiate between late run fish spawning below the falls and those destined to spawn above the falls but unable to negotiate the obstacle. The late run fishery was closed on August 18 for the remainder of the season after water levels receded and it becaume evident that late run escapement goals above the falls would probably not be achieved.

The velocity barrier at Russian River Falls delayed early migrational timing a minimum of seven day and late run five days. Had a "fish rescue" not been initiated this delay would have been greater. Data suggest that discharge rates in 1977 were at least twice the historic average. Both runs sustained mortalities as a result of the barrier. Although quantitative data are not available, observation suggests a maximum early run mortality of 3,000 fish. Late run mortality is thought to be somewhat less. The early run male to female sex ratio was 1:0.4. Engel (1972) indicated females are more susceptible to the affects of the falls at high water than males. The unbalanced early run sex ratio strongly suggests that the fish that perished below the obstacle were females.

It was evident as early as June 15 that early run fish were experiencing difficulty negotiating the falls. The only feasible method of transporting fish over the barrier was via helicopter. Early run fish were transported from July 8 to 10 and again from July 15 to 18. A total of 8,477 early sockeye were transported in this manner or 52.7% of the escapement. Late run salmon were transported in this manner from August 13 to 18. Total late run salmon transported was 7,436 or an average of 1,239.3 fish per day. Second run fish transported via helicopter totaled 34.7% of the late run escapement above the falls.

In addition to the obvious safety hazard to personnel when utilizing a helicopter, use of this type of aircraft is costly. Expense associated with the first run "fish rescue" totaled an estimated $25,500 or about $3.00 per fish. Expenses during the second run were somewhat greater as a helicopter had to be ferried from Sitka. Estimated cost was $39,750 or $5.35 per fish. Total minimum cost for both early and late run "fish rescues" approximated $65,250 or an average of $4.10 per sockeye salmon transported.

Scale analysis from early run fish collected at Russian River weir revealed 60.7% of the run was composed of five-year fish of age class 1.3. The age structure of the 1977 early run was therefore atypical as historically the early run is dominated by six-year fish of age class 2.3. Early run salmon averaged 605.3 mm in length. The male to female sex ratio was 1:0.4. The unbalanced sex ratio suggests that a greater number of females than males perished below Russian River Falls as a result of the velocity barrier.

Late run stocks were dominated by fish that migrated to the marine environment after two years in fresh water (85.7%). The majority of this run (92.3%) spent two years in salt water prior to returning to their natal stream. Age composition of the late run is comparable to the historic age structure of this stock. These salmon averaged 570.5 mm or 34.8 mm less than the average early run fish. Male to female sex ratio was 1:0.9.

Early run return per spawner has ranged from 0.3 to 3.3, averaging 1.7. As the early run is historically composed of age class 2.3, the 1977 total return would be the progeny of the 1971 escapement of 2,650. Sclae analysis revealed only 23.4% of the run was composed of this age class. Total contribution of this age class was therefore estimated at 8,533 fish for a return of 3.2 fish per spawning adult. Age class 1.3 contibuted 60.7% or 27,239 salmon. Return per spawner for this age class was 2.9. The exceptionally large early run return to Russian River in 1977 was therefore the product of an atypical age structure and a high return per spawner in which salmon from the 1971 and 1972 escapements returned in 1977 as age class 1.3 and 2.3, respectively.

Reason(s) for the atypical age composition of the early run fish which resided one rather than the traditional two years in fresh water are unknown. The presence of a high percentage of these fish in the adult return suggest favorable rearing conditions occurred at Upper Russian Lake in 1973. These conditions may have resulted from increased lake productivity and/or the absence of competition from other rearing sockeye salmon age classes.

Annual fecundity (1973-1977) of early run salmon has averaged 4,026.4 eggs per female. Fecundity of late run stocks during the same period has averaged 3,359.8. Although it is difficult to rank the fecundity of various sockeye salmon populations, data suggest that the early run is somehwhat "above average" while late run fecundity is "intermediate" when ranked with other geographic areas.

Numbers of early run sockeye salmon eggs available for deposition in Upper Russian Creek were estimated at 18.2 million. The estimated potential deposition in 1977 is therefore only the third highest recorded despite the near record numbers of fish in the escapement. In 1977 an unbalanced male to female sex ratio (1:0.4) favored males. Thus, the 1977 escapement produced relatively fewer eggs than smaller escapements with a more balanced sex ratio.

Egg sampling at Upper Russian Creek to determine density and survival was conducted following the cessation of early run spawning. Egg deposition was estimated at 67.7 eggs/M^2. This is one of the lowest densities recorded (despite the exceptionally high escapement) since sampling was initiated in 1972. Egg survival at time of sampling was 55.0% and total deposition is estimated at only 935,310.

The disparity between potential and actual deposition may be related to adverse environmental factors similar to those observed in 1976 (Nelson 1977). Observation during August spawning period revealed Upper Russian Creek was exceptionally high and had assumed glacial coloration. Observation during the sampling period indicated stream substrate had shifted in several areas. It therefore appears Upper Russian Creek was subject to flood conditions for the second consecutive year. Although the impact of this phenomenon can not be fully assessed until the adult return in 1982 and 1983, available data suggest the returns from both the 1976 and 1977 parent years will be somewhat less than would normally be expected from escapements approximating 16,000 fish.

Climatoligical data were recorded at Lower Russian Lake. Total rainfall during the 72 day period was 93.1 mm (3.7"). This is appreciably less than the 235 mm (9.3") recorded during a similar period in 1976. Stream discharge was approximately twice historical discharge rates, and both runs experienced difficulty negotiating Russian River Falls at these velocities. Maximum and minimum air tempertures were higher in 1977 than in 1976. Warmer temperatures in 1977 were probably a contributing factor to the exceptionally high runoff from the Upper Russian Lake drainage.

LITERATURE CITED

Engel, L.J. 1965. Inventory and Cataloging of the sport fish and sport fish waters of the Kenai Peninsula, Cook Inlet-Prince William Sound areas. Alaska Dept. of Fish and Game. Fed. 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 Dept. Fish and Game. Fed. 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 sport fish waters of the Kenai Peninsula, Cook Inlet-Prince William Sound areas. Alaska Dept. of Fish and Game. Fed. Aid in Fish Restoration, Annual Report of Progress, 1966-1967. Project F-5-R-8. 8:73-81.

_____. 1968. Inventory and cataloging of the sport fish and waters of the Kenai Peninsula, Cook Inlet-Prince William Sound areas. Alaska Dept. of Fish and Game. Fed. Aid in Fish Restoration, Annual Report of Progress, 1967-1968. Project F-5-R-9. 9:95-116.

_____. 1969. Inventory and cataloging of Kenai Peninsula Cook Inlet and Prince William Sound drainages and fish stocks. Alaska Dept. 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 Dept. of Fish and Game. Fed. 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 Dept. of Fish and Game. Fed. 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 Dept. of Fish and Game. Fed. Aid in Fish Restoration, Annual Report of Progress, 1971-1972. Project F-9-4. 13:19 pp.

Foerster, R.E. 1968. The sockeye salmon, Oncorhynchus nerka. Fish. Res. Bd. of Canada, Bull. 162. 422 pp.

Hartman, Wilber L. and Charles Y. Conkle. 1960. Fecundity of sockeye salmon at Brooks and Karluk Lakes, Alaska. U.S. Fish & Wildlife Serv. Fish Bull., 180(61):53-60.

Koo, Ted S.Y., ed. 1962. Studies of Alaska sockeye salmon. Univ. of Washington Press. pp. 37-48.

Lawler, R.R. 1963. Inventory and cataloging of the sport fish and sport fish waters on the Kenai Peninsula and Prince William Sound. Alaska Dept. of Fish and Game. Fed. Aid in Fish Restoration, Annual Report of Progess, 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 Dept. of Fish and Game. Fed. Aid in Fish Restoration, Annual Report of Progess, 1963-1964. Project F-5-R-5. 5:113-122.

McNeil, W.J. 1964. A method of measuring mortality of pink salmon eggs and larvae. U.S. Fish and Wildlife Service, Fish Bull., 63(3):575-588.

Nelson, D.C. 1973. Studies on Russian River red salmon sport fishery, Alaska Dept. of Fish and Game. Fed. Aid in Fish Restoration, Annual Report of Progess, 1972-1973. Project F-9-R-5. 13 pp.

_____. 1974. Studies on the Russian River red salmon sport fishery. Alaska Dept. of Fish and Game. Fed. Aid in Fish Restoration, Annual Report of Progress, 1973-1974. Project F-9-6. 15:21-48.

_____. 1975. Russian River red salmon study. Alaska Dept. of Fish and Game. Anadromous Fish Studies, Annual Report of Progress, AFS 44-1, 1974-1975, F-9-7. 16:1-41.

_____. 1976. Russian River red salmon study. Alaska Dept. of Fish and Game. Anadromous Fish Studies, Annual Report of Progress, AFS 44-2, 1975-1976, F-9-8. 18:1-54.

_____. 1977 Russian River red salmon studies, Alaska Dept. of Fish and Game. Anadromous Fish Studies, Annual Report of Progress, AFS-44-3, 1976-1977, F-9-9. 18:1-54.

Neuhold, J.M. and K.H. Lu. 1957. Creel census method; Utah Dept. of Fish and Game, Publication No. 8. 36 pp.

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