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RUSSIAN RIVER SOCKEYE SALMON STUDY

AFS 44-8 David C. Nelson

ALASKA DEPARTMENT OF FISH AND GAME
Ronald O. Skoog, Commissioner
Division of Sport Fish
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Project AFS 44-8

STATE OF ALASKA

Jay S. Hammond, Governor

Annual Performance Report for

RUSSIAN RIVER SOCKEYE SALMON STUDY

by

David C. Nelson

ALASKA DEPARTMENT OF FISH AND GAME

Ronald O. Skoog, Commissioner

DIVISION OF SPORT FISH

E. Richard Logan, Director

Volume 23 Study No. AFS-44

FINAL REPORT

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Project No.: F-9-14

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Job No.: AFS-44-8 Job Title: Russian River Sockeye Salmon Study

Cooperator: David C. Nelson

Period Covered: July 1, 1974 to June 30, 1982

ABSTRACT

A creel census was conducted during the 1981 Russian River sockeye salmon, Oncorhynchus nerka (Walbaum), sport fishery to determine harvest and angler participation. Analysis of census data revealed 51,030 man-days of angler effort were expended to harvest 34,440 sockeye salmon. Early and late runs contributed 10,720 and 23,720 salmon, respectively, to this harvest. Anglers caught 34.4 percent of the sockeye salmon returning to Russian River in 1981. Seasonal harvest per angler hour was 0.156.

Escapement of early and late run sockeye salmon were determined by a weir located at the outlet of Lower Russian Lake. Early and late run 1981 escapements were 21,140 and 44,530 salmon, respectively. Early run escapement was 48.7 percent above the mean historical escapement and exceeded the minimum spawning goal (9,000) by 12,140 fish. The late run escapement approximated the mean historical escapement (43,572) and exceeded the minimum spawning escapement goal (30,000) by 48.4 percent. An additional 4,160 late run fish spawned below the weir in Lower Russian River. Total late run escapement was therefore 48,690 sockeye salmon. Total 1980 late run return (harvest plus escapement) was 17.7 percent of the Kenai River escapement.

Analysis of scales collected at Lower Russian Lake weir revealed 46.6 percent of the early run were 5-year fish of age class 2.2. Age classes 1.2 and 1.3 contributed 6.3 and 18.9 percent, respectively. Age class 2.3, which is generally the dominant age class, contributed only 28.3 percent. The significance of this departure from the historical age class composition of the run is presented and discussed. Mean length of early run salmon was 588.7 millimeters (23.2 inches). Male to female sex ratio was 1:0.8. Late run fish were primarily (60.2 percent) 5-year fish of age class 2.2. Other age classes represented were: 1.2 (13.8 percent), 1.3 (6.6 percent), 2.3 (18.9 percent) and 3.2 (0.5 percent). These data approximate the historical age class composition of this run. Mean length

of late run fish sampled was 560.5 millimeters (22.1 inches). Male to female sex ratio was 1:1.4.

Smolt out-migration for early and late runs for parent years 1975 and 1976 was 1.86 million. These smolts produced an estimated 210,394 adults exclusive of those adults harvested in the Cook Inlet commercial fishery. Survival rate for 1978 and 1979 out-migrants was 14.0 and 9.4 percent, respectively, with a mean of 11.3 percent.

Fecundity investigations revealed early and late run sockeye salmon averaged 3,412.4 and 3,267.8 eggs per female, respectively. Early and late run fish averaged 6.0 and 5.9 eggs per millimeter of body length and 1,471 and 1,520 eggs per kilogram of body weight, respectively. Mean size of early run fish sampled (both length and weight) was the smallest since fecundity investigations were initiated. Size of late run fish approximated historical data.

Water velocity was a total barrier to sockeye salmon migration during a portion of both early and late runs. Limited operation of the fish pass permitted an estimated 5,500 early run and 13,000 late run salmon to circumvent the Russian River Falls via this route. Use and evaluation of the structure during the 1981 season is presented and discussed.

Egg sampling at Upper Russian Creek revealed early run egg deposition to be 1.34 million or 97.3 eggs per square meter. Egg survival was 59.9 percent at time of sampling.

Climatological data were collected at Lower Russian Lake weir. Air and water temperatures approximated historical data. Water discharge through the falls exceeded historic flow rates. Observation suggested these flow rates were attributable to heavy summer rains in both Upper and Lower Russian Lake drainages. The effect of these flow rates on migrational timing of Russian River sockeye salmon runs is presented and discussed.

KEY WORDS

Sockeye, spawning escapement, production, harvest, weir, fecundity, angler effort, smolt, egg deposition, migrational timing, age classes, fish pass.

BACKGROUND

Russian River is a clear stream adjacent to the Sterling Highway 9.6 km (6 mi) west of the Kenai Peninsula community of Cooper Landing and approximately 161 km (100 mi) south of Alaska's largest city, Anchorage. The stream bisects Federally managed lands. To the south, land is administered by the Kenai National Wildlife Refuge, and on the north by the Chugach National Forest. A privately operated ferry at the Kenai and Russian River confluence transports anglers to the south bank. In an average year, this area (approximately 1.6 km or 1 mi) receives 50% of all angler effort as fishermen attempt to intercept the runs prior to their entry into Russian River. The remaining effort occurs on approximately 3.2 km (2 mi) of Russian River above the confluence area and below Russian River Falls.

Public access to the fishery is provided at the Kenai National Wildlife Refuge campground at the confluence of the Kenai and Russian Rivers and at the Chugach National Forest campground on Russian River. Figure 1 depicts the general location of Russian River in relation to the Kenai River and other pertinent landmarks.

Sockeye salmon sport fishing occurs from a marker 548 m (600 yd) below Russian River Falls to a marker 1,646 m (1,800 yd) below the confluence of Kenai and Russian Rivers, a distance of approximately 4.8 km (3 mi). This area is commonly known as the "fly fishing only area" and, from June 1 through August 20, terminal gear is restricted to coho (streamer) flies with gap between point and shank no greater than 9.5 mm (3/8 in). The area between a marker below the ferry crossing and a marker 640 m (700 yd) upstream on Russian River is closed to all fishing from June 1 through July 14 to provide additional protection to early run sockeye salmon which concentrate in this area prior to continuing their upstream migration (Figure 2). Sockeye salmon sport fishing does occur in the Kenai River below the "fly fishing only" area with conventional tackle. Harvest and effort here is minimal due to the glacial nature of the Kenai River.

Lower Russian River from its confluence with the Kenai River upstream for approximately 3.2 km (2 mi) is of moderate gradient. Above this point, the stream flows through a canyon of considerable gradient known as Russian River Falls. Sockeye salmon migrations have been delayed and/or totally blocked in the canyon on several occasions due to a velocity barrier caused by atypically high water. Documented mortalities of both early and late run sockeye salmon were associated with this barrier in 1971 and 1977 (Nelson, 1978). In 1979, a fish pass was constructed around the falls to enable salmon to negotiate this segment of Russian River at all water levels.

Russian River sockeye salmon runs are bimodal; i.e., there are two distinct runs. Early and late runs have averaged 24,070 and 54,970 fish, respectively, from 1963 through 1980. Migrational timing and entry into the fishery for these stocks have been previously presented (Nelson, 1976 and 1977). Resident and anadromous fish species present in Russian River are presented in Table 1.

Lower Russian Lake, 0.8 km (0.5 mi) above Russian River Falls, supports an active Dolly Varden and rainbow trout sport fishery. Physical characteristics of the lake have been described (Nelson, 1979). Sockeye salmon spawning in this lake is limited to less than 500 late run fish. Observation indicates this lake is utilized by rearing chinook and coho salmon. These species spawn in Upper Russian River between Upper and Lower Russian Lakes. Coho salmon also spawn in Upper Russian Lake tributary streams.

Upper Russian River enters Lower Russian Lake from the south and connects Upper and Lower Russian Lake. Nelson (1976) has presented a detailed description of this stream and the Upper Russian Lake drainage. Figure 3 depicts the Upper Russian Lake drainage and delineates the spawning areas of both early and late runs.

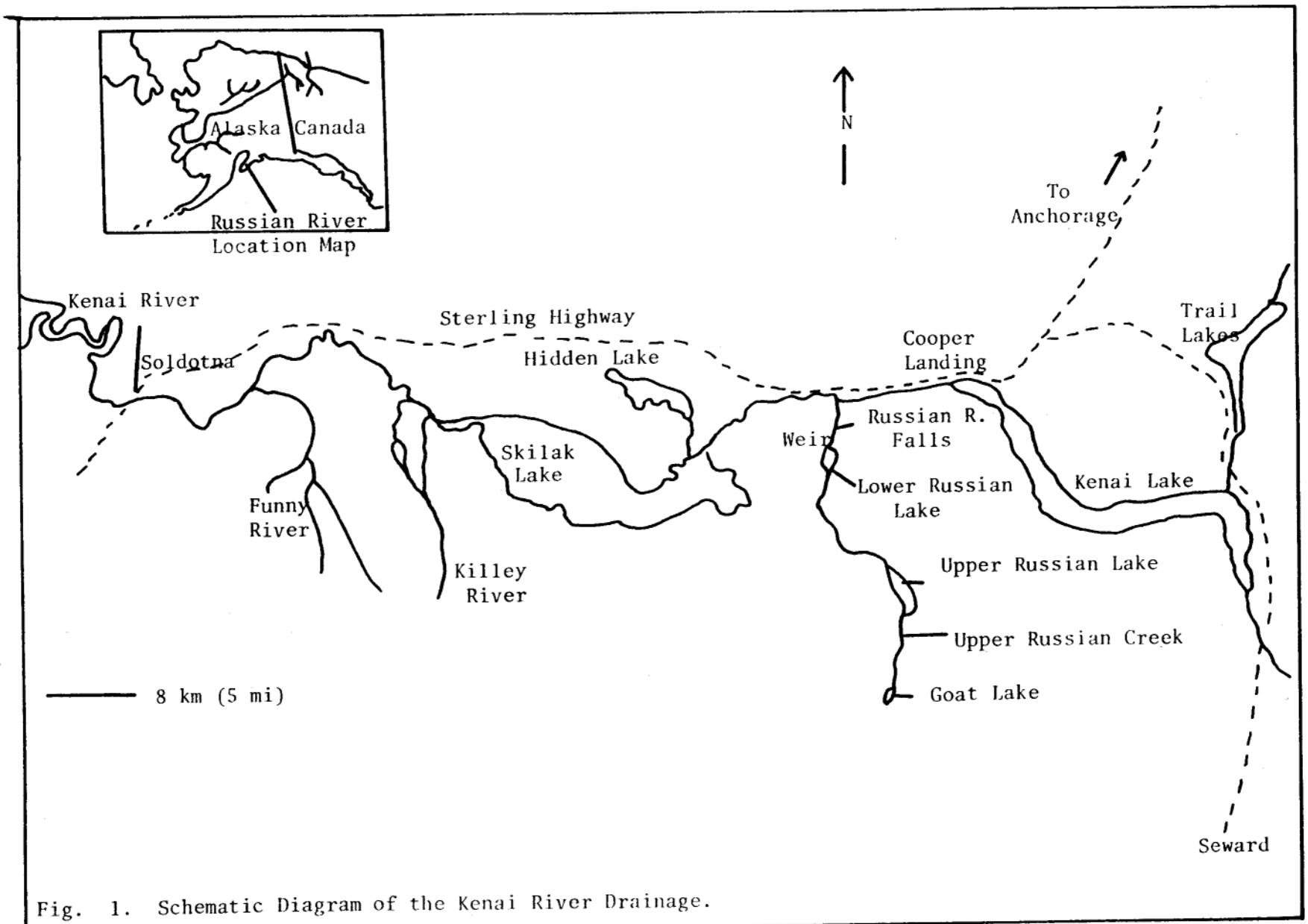

Fig. 1. Schematic Diagram of the Kenai River Drainage.

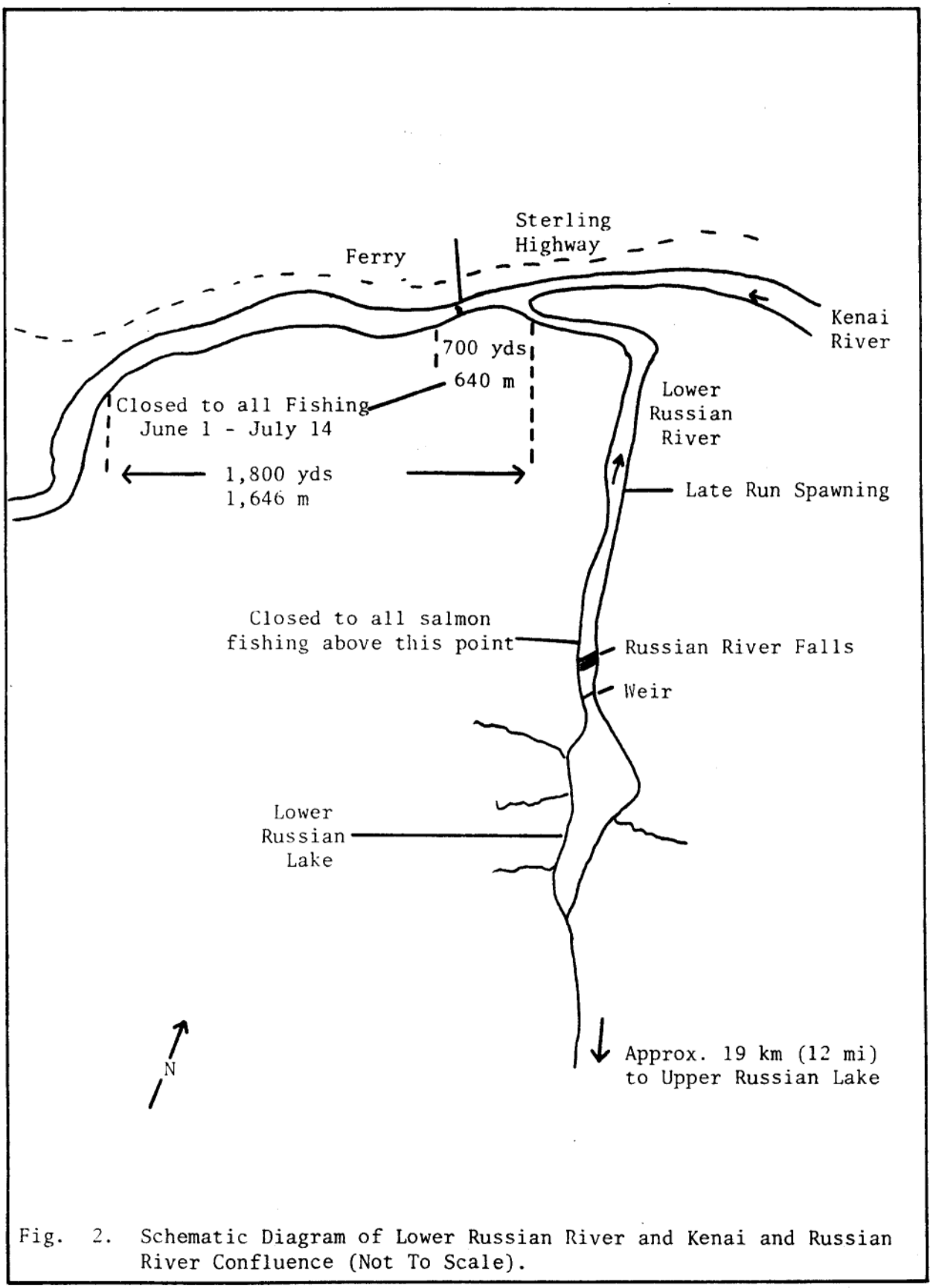

Fig. 2. Schematic Diagram of Lower Russian River and Kenai and Russian River Confluence (Not To Scale).

Table 1. List of Common Names, Scientific Names and Abbreviations.

Common Name	Scientific Name and Author	Abbreviation
Sockeye salmon	Oncorhynchus nerka (Walbaum)	RS
Chinook salmon	Oncorhynchus tshawytscha (Walbaum)	KS
Coho salmon	Oncorhynchus kisutch (Walbaum)	SS
Pink salmon	Oncorhynchus gorbuscha (Walbaum)	PS
Dolly Varden	Salvelinus malma (Walbaum)	DV
Rainbow trout	Salmo gairdneri Richardson	RT
Arctic grayling	Thymallus arcticus (Pallas)	GR
Whitefish	Prosopium cylindraceum Pallas	WF
Slimy sculpin	Cottus cognatus Richardson	SSC

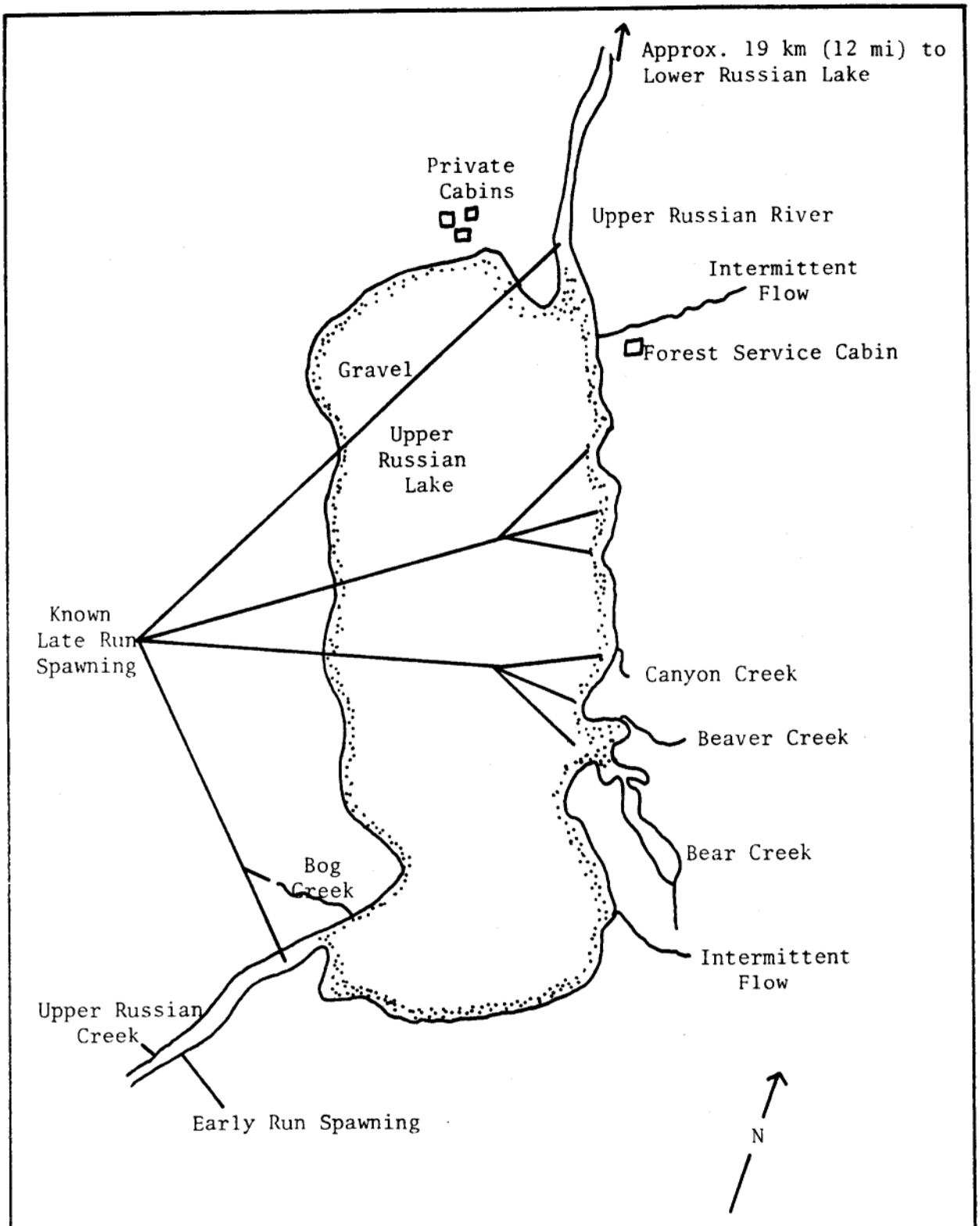

Fig. 3. Schematic Diagram of Upper Russian Lake (Not To Scale).

Management and research associated with the Russian River sockeye salmon sport fishery have been conducted by the Division of Sport Fish, Alaska Department of Fish and Game, since 1962. Prior information pertaining to this fishery has been presented by Lawler (1963, 1964), Engel (1965-1972) and Nelson (1973-1981).

Despite a restrictive sport fishery which limits harvest methods and protects salmon in areas where they are concentrated, recreational demands upon the Russian River sockeye salmon resource has, at times, been greater than the stocks could sustain. This is evidenced in that the Division of Sport Fish has closed all or part of the fishery on 17 different occassions since 1969 to increase spawning escapement levels. Numerous emergency openings and closings of the Russian River sockeye salmon fishery indicate it is the most intensely managed sport fishery in Alaska.

The Russian River program is currently directed toward "in season" evaluation of stock status to determine the effectiveness of current regulatory practices. Research activities emphasize the 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 cannot be realized until stock separation techniques are perfected in Cook Inlet to determine the late run Russian River sockeye salmon's contribution to the commercial fishery.

RECOMMENDATIONS

1. The feasibility of artificially spawning and incubating early run Russian River sockeye salmon eggs should be investigated. If artificial propagation is successful, the resultant fry could be introduced into Upper Russian Lake. These fish would be introduced only if hydraulic egg sampling revealed large numbers of naturally produced eggs were lost due to high water. The desired goal is to stabilize and enhance early run adult returns.

2. Investigate stabilizing the flow of Upper Russian Creek during the early run's spawning and egg incubation period.

3. Management options associated with the operation of the Russian River fish pass should continue to be investigated.

4. Continue the present objectives of the Russian River sockeye salmon study.

OBJECTIVES

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

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

3. To determine age composition of adult early and late run Russian River sockeye salmon escapements enumerated at Lower Russian Lake weir.

4. To determine egg deposition of early run spawning sockeye salmon in Upper Russian Creek.

5. To determine the fecundity of early and late run female sockeye salmon and to determine the relationship between fish length and mean number of eggs per sockeye salmon female.

6. To collect basic climatological data (precipitation, water and air temperature, stream discharge) at Lower Russian Lake and to determine the affect of these parameters on migrational timing of adult early and late run sockeye salmon.

7. To evaluate the effects and effectiveness of a fish pass at Russian River Falls.

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

TECHNIQUES USED

The 1981 Russian River creel census was a modification of the technique described by Neuhold and Lu (1957). Sampling procedures and data analysis were identical to those outlined by Engel (1965, 1970, 1972) and Nelson (1973, 1975).

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

In 1979, a fish pass was constructed around Russian River Falls. Nelson (1980) described the structure. Use of the fish pass by sockeye salmon was determined in 1980 and the technique to ascertain the numbers of fish utilizing the structure is described in Nelson (1981). Similar methods were employed to estimate sockeye salmon usage during the 1981 season.

Fecundities of early and late run sockeye salmon were determined by random sampling at Lower Russian Lake weir. Sampling technique and data analysis have been described (Nelson, 1979).

Early run egg density in Upper Russian Creek was determined by hydraulic sampler patterned after the apparatus described by McNeil (1964). Techniques used and sampling scheme employed have been presented (Nelson, 1977).

Scale samples to determine the age structure of the respective runs were collected at Lower Russian Lake weir. Age designation and methods to determine the adult age structure and male to female sex ratio have been presented (Nelson, 1978).

Water and air temperatures at Lower Russian Lake weir were determined by a Taylor maximum-minimum thermometer. Precipitation was determined by a gauge of standard manufacture. Stream velocity was determined by Head Rod Method as previously described (Nelson, 1977).

FINDINGS

Creel Census

As noted, Russian River sockeye salmon runs are bimodal. During most years, the sport fishery is continuous, as the latter segment of the early run is present when the late run enters the fishery. In 1981, this did not occur. The early run passed through the fishery by July 7 and the late run did not arrive until July 15. Therefore, no creel census was conducted from July 7 to July 14.

During the rest of the season, the creel census revealed anglers expended 51,030 man-days of effort or 212,369 angler-hours. Effort directed toward early and late run stocks was estimated at 24,780 and 26,250 man-days, respectively. Angler effort exceeded the historical mean for this fishery by 88.5%, yet reflects a decrease in angler participation when compared to the previous 4 years. Decreased angler effort is directly related to run strength as the 1977-80 period was characterized by record returns. The 1981 early and late run return was above average but below returns from 1977-80.

Based on interviews with 2,268 anglers who reported harvesting 1,456 sockeye salmon, total catch was estimated at 34,440 fish. Early and late runs contributed 10,720 and 23,720 salmon, respectively, to this harvest. This harvest is above the historical mean harvest of 21,261 sockeye salmon but well below the record 1978 harvest of 62,250 salmon. Harvest is also a reflection of total run strength.

Mean hourly catch rates were higher on weekdays (0.167) than on weekends (0.141) due to greater congestion on weekends which reduced individual angler efficiency. Seasonal catch per hour was 0.156. Table 2 summarizes historical harvest, effort and catch per hour estimates.

Total weekday and weekend day stream counts during the 1981 fishery averaged 195.6 and 238.5 anglers, respectively. Although these stream counts are above the historical mean, they are below similar mean counts for the previous 4 years. The greatest concentration of anglers during the 1981 fishery was recorded on Sunday, July 26, at 1600 hours when 510

Table 2. Estimated Sockeye Salmon Harvest, Effort and Success Rates on Russian River, 1963-1981.

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	6/08-8/15
1964	3,550	2,450	6,000	5,330	0.321	6/08-8/16
1965	10,030	2,160	12,190	9,720	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	17,280	0.134	6/10-8/15
1969	5,870	1,150	7,020	14,930	0.094	6/07-8/15
1970	5,750	600	6,350	10,700	0.124	6/11-8/15*
1971	2,810	10,730	13,540	15,120	0.192	6/17-8/30*
1972	5,040	16,050	21,090	25,700	0.195	6/17-8/21
1973	6,740	8,930	15,670	30,690	0.102	6/08-8/19*
1974	6,440	8,500	14,940	21,120	0.131	6/08-7/30
1975	1,400	8,390	9,790	16,510	0.140	6/14-8/13*
1976	3,380	13,700	17,080	26,310	0.163	6/12-8/23*
1977	20,400	27,440	47,840	69,510	0.168	6/18-8/17
1978	37,720	24,530	62,250	69,860	0.203	6/07-8/09
1979	8,400	26,830	35,230	55,000	0.136	6/09-8/29*
1980	27,220	33,490	60,710	56,330	0.243	6/13-8/20
1981	10,720	23,720	34,440	51,030	0.156	6/09-8/20**
1963-80 Mean	9,863	11,398	21,261	27,068	0.177	

* Census period was not continuous during these years due to emergency closures required to increase escapement levels.

** Census was not conducted from July 7 through 14, 1981 as sport fishing harvest during these dates was negligible.

anglers were enumerated in the "fly fishing only" area. Maximum angler counts exceeded this figure during the previous 4 years. Although still considered crowded by many fishermen, data reveal angler congestion during 1981 was at its lowest level since 1976.

Anglers fished an average of 4.1 hours on both weekdays and weekends. This is the first year since the inception of the census (1963) that mean hours fished per angler on weekends did not exceed the mean hours fished on weekdays. These data also reflect a decrease in mean hours fished per day compared to the historical mean (Table 3). Reason(s) for the decreased time anglers spent on the stream in 1981 is (are) not definitely known. It may be related to run size as suggested by Nelson (1979). Sockeye salmon returned to Russian River in 1972, 1977 and 1978 through 1981 in above average numbers. Average hours fished per angler per day during these years were less than the historical mean.

Stream counts revealed 34.8% and 51.0% of the anglers fished the confluence of the Kenai and Russian Rivers during the early and late run, respectively. The migrational rate of the early run through the confluence area was exceptionally rapid. High water through Russian River Falls slowed this run's migration through Russian River relative to passage rates observed at the confluence. This stock was therefore available for a longer period of time in Russian River than at the confluence area which accounts for disproportionate angler distribution during the early run fishery. The late run's migration through the fishery was also rapid but angler success rates were similar throughout the "fly fishing only" area. Angler distribution during the late run was therefore equally divided between the confluence area and clear waters of the Russian River.

Anglers harvested 33.6% of the early run stock to return to Russian River and 34.7% of the late. The early run exploitation rate is relatively low in relation to total return. The "sanctuary" at the confluence of the Kenai and Russian Rivers was opened on June 26 by emergency order and the fish pass at Russian River Falls was operated in a conservative manner in an attempt to decrease the migrational rate of this stock. Had these two management options not been exercised, the exploitation rate would have been even lower. The migration of early run sockeye salmon was so rapid that increasing the bag and possession limit from one to three fish would not have significantly increased the harvest. Late run salmon entered the fishery on July 15. Catch remained high until August 6 and declined rapidly thereafter. These fish were available in large numbers for only 22 days. In an average year, the late run is present in harvestable numbers until the close of the fishery on August 20. As with the early run, the rapid migration rate of the late run minimized exploitation by recreational anglers. This is the second consecutive year in which rapid migration was at least in part responsible for minimizing exploitation rates. Nelson (1981) reported a similar situation occurred during the 1980 fishery.

Nelson (1976) reviewed angler participation trends at Russian River and suggested fishing effort would continue to shift from the smaller early run to the more numerous late run stock. This trend did not develop as, from 1977 through 1980, 57.9% of all angler effort was directed toward early run fish (Nelson, 1981). The average early run return (harvest + escapement) during these years was 48,082 or more than twice the historical mean return

Table 3. Differences Between Weekday and Weekend Day Fishing Pressure and Rates of Success at Russian River, 1964-1981.

Year	Mean Angler Counts		Catch/Hour		Mean 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
1978	264.1	425.7	0.205	0.191	3.9	4.2
1979	190.6	276.8	0.158	0.117	3.8	3.9
1980	299.1	317.8	0.270	0.210	4.2	4.7
1981	195.6	238.5	0.167	0.141	4.1	4.1
1964-80 Mean	113.4	185.0	0.201	0.148	4.4	4.9

(22,200). Table 4 indicates in 1981, 48.6% of the angling effort was directed toward the early run and 51.4% toward the late. The 1981 early run total return of 31,860 was one of the highest returns recorded but was well below the late run return of 72,410. This suggests that in a given year angler effort will be directed toward the more numerous stock rather than toward the early or late run per se. Run timing, migrational rate and regulations pertaining to the respective runs will also influence angler participation.

During the census 44 Dolly Varden, 32 rainbow trout, 9 pink salmon, 4 coho salmon and 1 whitefish were creel checked. These data were not expanded as in prior years. The fishery for these species occurs prior to, during and after the sockeye salmon fishery. Harvest estimates based on the creel census conducted during the sockeye salmon fishery would therefore be minimal and fail to present true harvest rates for these species.

In 1977, the Division of Sport Fish undertook a Statewide Harvest Survey which sampled anglers who fished Alaskan waters. The Survey was mailed to anglers selected at random. The primary purpose of the Survey was to ascertain harvest and angler participation on fisheries which are not monitored by a formal "on-site" census (Mills, 1978). Although harvest estimates for species other than sockeye salmon are not included as an objective of the Russian River Study, the results of the Survey as they relate to Russian River are presented in Table 5 to maintain the continuity of the Division's research and management efforts on this popular Alaskan stream.

Table 5 indicates a significant increase in the harvest of rainbow trout and Dolly Varden beginning in 1978. Data suggest anglers are seeking these species prior to and after the sockeye salmon fishery, as the relatively low harvest of these fishes in 1977 corresponded to record effort levels during the sockeye salmon fishery. The fishery for rainbow trout on Russian River is considered significant as, in 1980, this stream was surpassed in the harvest of this species on the Kenai Peninsula only by the Kenai River (Mills, 1981).

The coho salmon harvest from Russian River has been relatively stable since 1977. Harvest has ranged from 1,025 to 1,472. This species usually enters Russian River by August 20. The run is basically complete by mid-September but coho salmon have been observed in Russian River Falls in October. Pink salmon return to Kenai Peninsula streams in large numbers only on even years as is demonstrated by the every other year harvest cycle in Table 5. Although Russian River supports a small population of these fish, the majority of pink salmon are caught at the confluence of the Kenai and Russian Rivers. A high percentage of the fish harvested in this area are assumed to be of Kenai River origin.

Arctic grayling are not indigenous to the Kenai Peninsula. All populations currently established here are the progeny of an initial plant in 1952 of 240 sub-adults in Crescent Lake which is a tributary to the Kenai River (Engel, 1973). Although not numerous, a few grayling are harvested annually at the confluence area. Russian River habitat appears suitable for this species, but no grayling have been observed in this stream by this author or reported by anglers.

Table 4. Angler Effort Directed Toward Early and Late Run Russian River Sockeye Salmon Stocks, 1963-1981.

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	41.2	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
1978	51,910	17,950	74.3	25.7
1979	25,670	29,330	46.7	53.3
1980	31,430	24,900	55.8	44.2
1981	24,780	26,250	48.6	51.4
1963-80 Mean	15,605	11,463	60.5	39.5

* Man-day is defined as one angler fishing for one day regardless of the number of hours fished.

Table 5. Estimated Russian River Harvest of Rainbow Trout, Dolly Varden, Coho Salmon, Pink Salmon and Grayling as Determined by Alaska Statewide Harvest Survey, 1977-1980.

Year	Species				
	Rainbow Trout	Dolly Varden	Coho Salmon	Pink Salmon	Grayling
1977	769	914	1,472	37	37
1978	2,423	2,588	1,446	1,300	18
1979	3,109	3,718	1,098	0	9
1980	2,566	2,256	1,025	930	69

Escapement

The weir at the outlet of Lower Russian Lake was operational on June 11. The first sockeye salmon was enumerated June 12, 5 days prior to the historical arrival date of June 17. Fifty percent of the early run had passed the weir by June 25. Early run passage was complete by July 17 (Table 6).

Early run escapement was 21,140 fish. This is one of the largest early run escapements recorded, exceeding the historical mean escapement of 14,218 by 48.7%. Larger early run escapements were recorded only in 1965, 1978 and 1980. This is the sixth consecutive year in which early run escapements have exceeded the minimum escapement goal of 9,000 fish (Table 7).

Late run fish arrived at the weir July 18 which corresponds closely with their historical arrival date of July 17. Fifty percent of this run had passed the structure by July 28. Late run migration was complete when the weir was removed on September 6. Escapement of late run salmon above Russian River Falls was 44,530 which closely approximates the historical mean escapement of 43,572. An additional 4,160 late run fish spawned below Russian River Falls. Total late run escapement in 1981 was therefore 48,690. Total late run return (harvest + escapement) was 72,410. The return of late run fish in 1981 was well below the record 1980 return of 120,690 but exceeded the mean historical return by 7,508 fish or 11.6% (Table 8). This is the fourth consecutive year the late run minimum escapement goal of 30,000 has been exceeded.

Thirty chinook salmon were enumerated at Russian River weir in 1981. This is the lowest escapement of this species above the weir since 1971. An additional 91 fish were enumerated below Russian River Falls which closely approximates the historical spawning escapement in this area. Total chinook salmon escapement to Russian River in 1981 was therefore 121 or 107.4% below the mean historical escapement of 251. Coho salmon escapement was 4,679 which is the highest spawning escapement for this species recorded at Russian River and the third consecutive year the escapement has exceeded the historical mean. Chinook and coho salmon escapements for Russian River are summarized in Table 9.

Relationship of Jacks to Adults

Jack (precocial male) sockeye salmon are generally not associated with the early sockeye salmon run. Historical data indicate jacks have been observed in the early run during only 5 of 11 years, and then not in large numbers (Nelson, 1981). No jacks were present in the 1981 early run escapement. Jacks are more numerous during the late run and comprise 0.2 to 8.8% of the escapement. During the 1981 late run, 2,634 jacks were enumerated contributing 3.9% to the spawning escapement (Table 10). Nelson (1977) suggested a relationship may exist between numbers of jacks in the late run and the magnitude of the late run return the succeeding year. In support of this hypothesis he noted the mean number of jacks in 1969, 1972, 1973 and 1977 was only 345. The mean total return (harvest + escapement) in succeeding years was a relatively low 38,653. Jack returns in 1970-71, 1974-75, 1976 and 1978-79 averaged 1,760. The average return in succeeding years was 75,327. The jack escapement in 1980 was 1,533. The 1981 return

Table 6. Arrival Date, Date Fifty Percent of the Escapement Passed Russian River Weir/Counting Tower and Termination Date of Early and Late Russian River Sockeye Salmon Runs, 1960-1981.*

	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**
1960	June 19	June 26	July 15	July 16	August 1	August 12
1961	June 21	June 28	July 15	July 16	July 31	August 28
1962	June 18	July 4	July 15	July 16	July 30	August 31
1963	June 18	July 1	July 12	July 16	July 31	August 23
1964	June 20	July 7	July 15	July 16	July 30	August 15
1965	June 22	July 4	July 15	July 16	August 5	August 15
1966	June 20	June 29	July 15	July 19	July 30	August 17
1967	June 20	June 28	July 15	July 19	August 2	August 18
1968	June 25	June 29	July 13	July 19	July 31	August 14
1969	- - - - - NO DATA AVAILABLE - - - - -			July 16	August 2	August 18
1970	June 17	July 5	July 15	July 16	August 7	August 23
1972	June 24	July 5	July 29	July 30	August 5	August 28
1973	June 21	July 6	July 15	July 16	August 1	August 30
1974	June 14	July 1	July 21	July 22	August 7	August 27
1975	June 25	July 6	July 27	July 21	August 6	September 1
1976	June 17	June 30	July 16	July 17	August 2	September 1
1978	June 10	July 2	July 24	July 2	July 30	September 1
1979	June 8	June 27	July 15	July 16	July 29	September 2
1980	June 14	June 29	July 20	July 21	July 30	September 6
1981	June 12	June 25	July 17	July 18	July 28	September 6
1960-80 Mean	June 19	July 1	July 17	July 17	August 2	August 24
1969-80 Mean***	June 17	July 2	July 20	July 18	August 3	August 29

* 1971 and 1977 date were deleted due to a velocity barrier at Russian River Falls which resulted in atypical migrational timing.

** Date run ended and/or counting tower or weir count terminated.

*** Years of weir operation.

Table 7. Russian River Sockeye Salmon Escapement and Harvest Rates for Early and Late Runs, 1963-1981.

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	21,710	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
1978	34,150	34,230	68,380	52.5	41.7	47.7
1979	19,700	87,920	107,620	29.9	23.4	24.7
1980	28,670	83,980	112,650	48.7	29.7	35.0
1981	21,140	44,530	65,670	33.6	34.7	34.4
1963-80 Mean	14,218	43,572	57,779	37.9	19.3	24.6

* Escapement passed weir. Commercial harvest and fish spawning downstream from Russian River weir are deleted.

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

Table 8. Late Run Russian River Sockeye Salmon Total Return and Escapement Enumerated Above and Below Russian River Falls, 1968-1981.

Year	Escapement Above Falls	Escapement Below Falls	Total Escapement	Percent of Escapement Below Falls	Sport Harvest	Total Return
1968	48,800	4,200	53,000	7.9	5,820	58,820
1969	28,920	1,100	30,020	3.7	1,150	31,170
1970	28,200	200	28,420	0.8	600	29,020
1971	54,430	10,000	64,430	15.5	10,730	75,160
1972	79,000	6,000	85,000	7.1	16,050	101,050
1973	24,970	6,690	31,660	21.1	8,930	40,590
1974	24,650	2,210	26,860	8.2	8,500	35,360
1975	31,970	690	32,660	2.1	8,390	41,050
1976	31,950	3,470	35,420	9.8	13,700	49,120
1977	21,410	17,090	38,500	44.4	27,440	65,940
1978	34,230	18,330	52,560	34.9	24,530	77,090
1979	87,920	3,920	91,840	4.3	26,830	118,670
1980	83,980	3,220	87,200	4.0	33,490	120,690
1981	44,530	4,160	48,690	8.5	23,720	72,410
1968-80 Mean	44,648	5,934	50,582	12.6	14,320	64,902

Table 9. Coho and Chinook Salmon Escapements in the Russian River Drainage, 1953-1981.

Year	Weir/Counting Tower Escapement		Lower River	Total Escapement	
	Chinook	Coho	Chinook Escapement*	Chinook	Coho
1953			85**		
1954			87**		
1955			42**		
1956			49**		
1957			44**		
1958			98**		
1966			182		
1967			126		
1968	56		36	119	
1969	119	70	31	150	70
1970	240	957	125	365	957
1971	21	839	149	170	839
1972	172	666	108	280	666
1973	243	200	104	347	200
1974	124	1,508	59	183	1,508
1975	102	4,000	32	134	4,000
1976	145	1,791	155	300	1,791
1977	37	1,884	145	182	1,884
1978	253	1,570	165	418	1,570
1979	280	2,400	82	362	2,400
1980	185	3,189	65	250	3,189
1981	30	4,679	91	121	4,679
Mean through 1980	152	1,589	95	251	1,589

* Coho salmon do not spawn in Lower Russian River.

** Fish and Wildlife Service surveys.

Table 10. Late Run Russian River Sockeye Salmon Harvest, Escapement and Returning Jacks, 1969-1981.

Year	Escapement	Harvest	Total Return*	Number of Jacks	Percent of Total Return
1969	28,920	1,150	30,070	352	1.2
1970	28,200	600	28,800	2,542	8.8
1971	54,430	10,730	65,160**	1,429	2.2
1972	79,000	16,050	95,050	160	0.2
1973	24,970	8,930	33,900	332	1.0
1974	24,650	8,500	33,150	1,008	3.0
1975	31,970	8,390	40,360	1,788	4.4
1976	31,950	13,700	45,650	1,204	2.6
1977	21,410	27,440	48,850	537	1.1
1978	34,230	24,530	58,760	2,874	4.9
1979	87,920	26,830	114,750	1,476	1.3
1980	83,980	33,490	117,470	1,533	1.3
1981	44,530	23,720	68,250	2,634	3.9
1969-80					
Mean	44,302	15,028	59,331	1,269	2.7

* Excludes commercial harvest and late run sockeye salmon spawning below Russian River Falls.

** Excludes an estimated 10,000 late run sockeye salmon which perished below Russian River Falls due to a velocity barrier.

of 68,250 was 15.0% above the 1969-80 mean return of 59,331. A relatively small jack return in a given year may be indicative of less than average return the following year. The converse may also be true. Jack escapement in 1981 was 2,634 or the second highest recorded at Russian River. If the above described relationship is valid and not masked by other parameters described below, the 1982 late run return will be above average.

Although available data strongly suggest a relationship between the number of jacks in the late run and the following year's return, a prediction regarding future run strength cannot be made based on this relationship. Jacks are not harvested in the Cook Inlet commercial fishery. Mesh size employed is too large to capture these fish. The percentage of the Russian River late run harvested by the commercial fishery is not definitely known nor is it known whether or not the percentage is constant from year to year. If a high percentage of Russian River sockeye salmon are harvested commercially, this stock's return to Russian River may be relatively low irrespective of the preceding years' jack return. The converse may also occur. Definitive conclusions regarding the relationship of jacks and the succeeding year's return to Russian River must therefore be deferred until the late run Russian River's contribution to the commercial fishery is positively established.

Table 11 compares the migrational timing of jacks to late run adult sockeye salmon. Historical data indicate 50% of the adult escapement may be expected to pass the weir by August 2, while 50% of the jack escapement is not enumerated until August 14, 12 days later than the adults. In 1981, the disparity in timing between jacks and adults was 25 days. In 1980, the timing differential was 20 days and from 1970-1979 it ranged from 3 to 17 days.

This timing differential may be a genetic trait, related to environmental factors or a combination thereof (Nelson, 1976). This author indicated water levels through Russian River Falls generally decrease during the latter part of the late run's migration and may facilitate the movement of the smaller jacks through the falls. Larger adults may be more readily capable of ascending the falls at greater velocities and therefore arrive earlier at the weir. Russian River velocities were atypically high during both the 1980 (Nelson, 1981) and 1981 migration. Despite the presence of the fish pass, smaller jacks may have experienced difficulty ascending and/or circumventing the barrier. This may account for the 20-day timing differential in 1980 and the 25-day disparity in 1981 passage rates between adults and jacks as opposed to the historical 12-day timing differential.

Migrational Rates in the Kenai River

Migrational rates of Russian River stocks within the mainstem Kenai River are limited to isolated tagging studies and a comparison of sonar counts to escapements enumerated at Russian River weir. Nelson (1977) reviewed results of the tagging studies. The sonar counter, located approximately 1.6 km (1 mi) below the Kenai River bridge in Soldotna is operated by the Division of Commercial Fish of the Alaska Department of Fish and Game. The counter is usually operational only during the late run's migration but was used in 1978, 1979 and 1981 to enumerate the early Kenai River sockeye

Table 11. Migrational Timing of the Late Run Russian River Sockeye Salmon Jack Escapement Compared to the Migrational Timing of the Adult Escapement, 1970-1981.*

Year	Jack Escapement	Date 50% Passed Weir	Adult Escapement**	Date 50% Passed Weir	Timing Differential (Days)
1970	2,542	8/10	25,658	8/7	3
1972	160	8/10	78,677	8/4	6
1973	332	8/6	24,642	7/31	6
1974	1,008	8/12	23,639	8/6	6
1975	1,788	8/16	30,179	8/5	11
1976	1,204	8/18	30,746	8/2	16
1978	2,874	8/18	31,356	8/2	16
1979	1,476	8/15	87,920	7/29	17
1980	1,533	8/19	82,450	7/30	20
1981	2,634	8/22	41,896	7/28	25
1970-80					
Mean	1,435	8/14	46,141	8/2	11

* 1971 and 1977 have been deleted due to atypical migrational timing resulting from a velocity barrier at Russian River Falls.

** Escapement passed the weir only. Sockeye salmon spawning below the Falls are not considered.

salmon run. Available data indicate the majority of this early run is of Russian River origin.

Nelson (1979) reported that in 1978 and 1979 it required early run fish 29 and 20 days, respectively, to traverse the 93.5 km (58 mi) between sonar site and weir. The migrational rate ranged from 3.2 km (2 mi) to 4.6 km (2.9 mi) per day. In 1981, 50% of the run passed the sonar counter and Russian River weir on June 7 and June 25, respectively. It therefore required the average early run fish approximately 18 days to travel 93 km (58 mi) or 5.1 km (3.2 mi) per day.

Late run sockeye salmon sonar counts in the Kenai River, Russian River late run escapements and travel time between sonar counter and Russian River weir are presented in Table 12. This table indicates elapsed time between sonar site and weir from 1968-1980 ranged from 10 to 34 days averaging 14.7. Eliminating the 1969 and 1974 extremes of 34 and 23 days decreases this range to between 10 and 13 days. This indicates the late run migrational rate is between 7.2 (4.4 mi) and 8.5 km (5.3 mi) per day. It required late run fish 14 days to travel from sonar site to weir in 1981. Late run sockeye salmon therefore migrate through the Kenai River more rapidly than do early run fish. Reasons for these differing migrational rates are not known.

A comparison of sonar data and total Russian River late run return (harvest + escapement) provides an estimate of Russian River's contribution to the Kenai River sockeye salmon escapement. Table 13 indicates this contribution ranges from 8.7 to 66.9%, averaging 31.0%. In 1981, Russian River accounted for 17.7% of the Kenai River sockeye salmon escapement.

Russian River Falls and Fish Pass

The fish pass at Russian River Falls was constructed during the winter of 1978-79 and employed for the first time on a limited basis during the 1979 sockeye salmon migration. It was concluded at this time that given an option at normal water flows, sockeye salmon would ascend the falls rather than utilize the fish pass (Nelson, 1980). The author (1981) noted that, during high water in 1980, mean passage rate through the fish pass was 510 fish/hour and that the structure was operating as designed. He also indicated operation or inoperation of the fish pass during high water years could be employed to increase or decrease the rate of sockeye salmon migration. The structure could therefore be considered a management tool, as the migrational rate of the stocks affect the degree to which the sport angler is capable of exploiting the resource.

Figure 4 indicates total discharge through Russian River Falls in 1981 approximated 380 cfs during a portion of the early run and exceeded 400 cfs during a segment of the late run migration. Nelson (1978) indicated that velocities which approximated 400 cfs presented a barrier to sockeye salmon migration. These velocities therefore necessitated use of the fish pass during both the early and late runs. Observation on June 20 indicated the majority of the early run was unable to ascend the falls. As the fish that massed at the base of the falls were not in a stressful situation at this time, the fish pass remained closed. Anglers enjoyed several days of high catch rates as salmon began to concentrate in historic resting areas within

Table 12. Kenai River Sonar Counts Compared to Russian River Late Run Sockeye Salmon Escapements and Period of Travel Between Sonar Site and Russian River Weir, 1968-1981.*

Year	Sonar Count	Date 50% Passed	Russian River Escapement**	Date 50% Passed	Sonar to Weir (Days)
1968	88,000	7/19	48,800	7/30	11
1969	53,000	6/30	28,920	8/2	34
1970	68,000	7/25	28,200	8/6	13
1972	335,000	7/24	79,000	8/4	12
1973	368,000	7/22	24,970	7/31	10
1974	157,000	7/17	24,650	8/6	23
1975	143,000	7/24	31,970	8/5	13
1976	381,000	7/20	31,950	8/2	13
1978	399,000	7/18	34,230	7/30	12
1979	322,000	7/19	87,920	7/29	10
1980	464,000	7/19	83,980	7/30	11
1981	408,000	7/14	44,530	7/28	14
1968-80					
Mean	252,545	7/19	45,872	8/2	14.7

* 1971 and 1977 data deleted due to high water which resulted in atypical migrational timing.

** Escapement passed weir only.

Table 13. Kenai River Sonar Counts, Total Late Russian River Sockeye Salmon Run and Percent of Kenai River Late Run Escapement to Enter Russian River, 1968-1981.*

Year	Sockeye Salmon Sonar Count*	Total Late Russian River Run**	Percent Kenai Run to Russian River
1968	88,000	58,900	66.9
1969	53,000	31,170	58.8
1970	68,000	31,000	45.6
1972	335,000	101,050	30.2
1973	368,000	40,590	11.0
1974	157,000	35,360	22.5
1975	143,000	41,050	28.7
1976	381,000	49,120	12.9
1977	757,000	65,940	8.7
1978	399,000	77,090	19.3
1979	322,000	118,670	36.9
1980	464,000	120,690	26.0
1981	408,000	72,410	17.7
1968-80			
Mean	294,583	64,219	30.6

* 1971 data deleted due to sonar failure.

** Includes escapement past weir, sport harvest and fish spawning below the Falls.

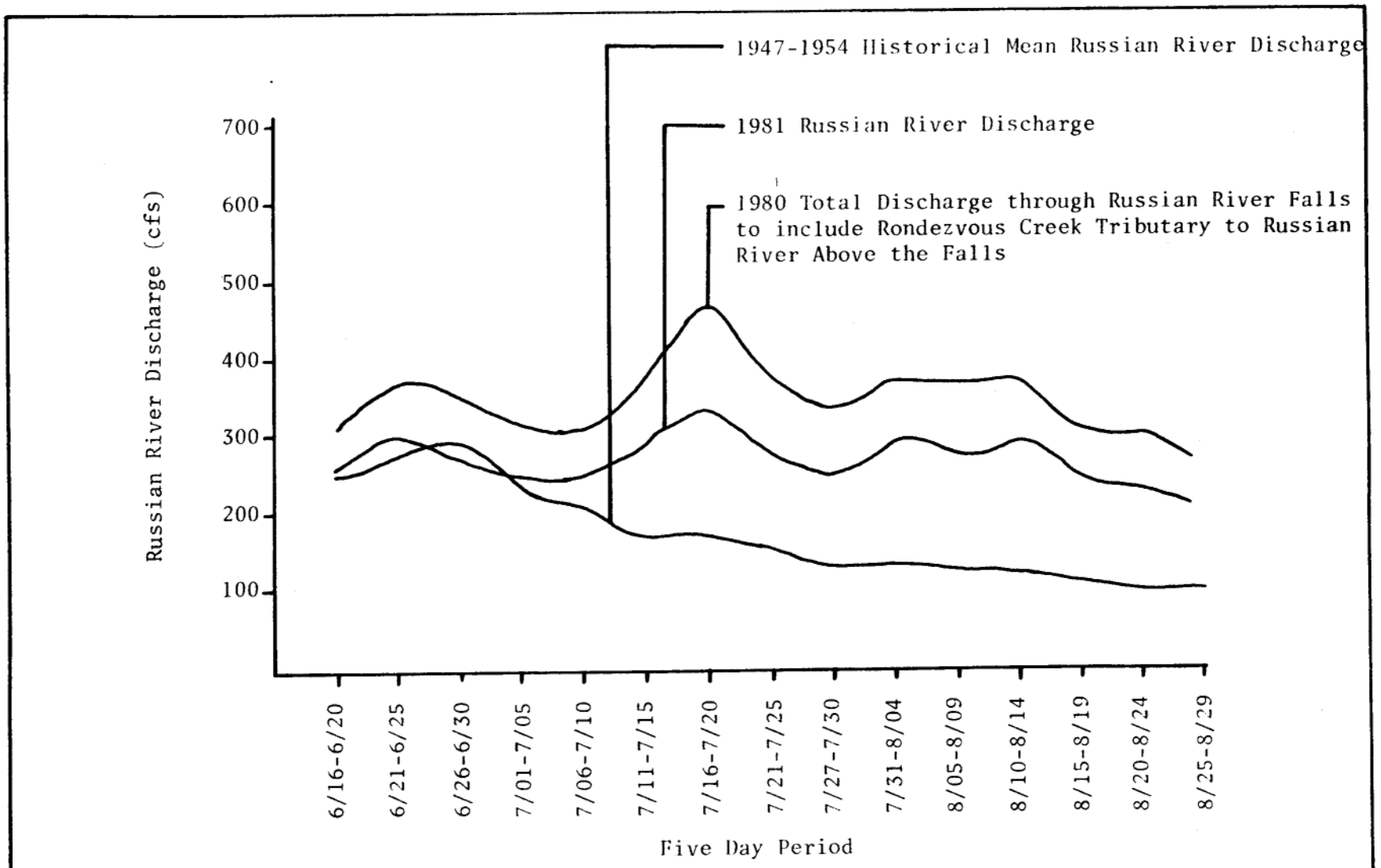

Fig. 4. Mean (eight year) Russian River Discharge Rates by Five Day Mean Recorded by United States Geological Survey from 1947 through 1954 Compared to 1981 Discharge Rates.

the "fly fishing only area". Daily monitoring of the Falls revealed that by June 24 further crowding and prolonged migrational delay could result in the decreased reproductive capability of the stock. The fish pass was therefore opened for 24 hours on this date. It was not again required during the early run migration as flow rates thereafter decreased until the arrival of the late run at the falls on July 18. The fish pass was again opened on July 20 and remained operational until July 23 when the water level again receded. As occurred during the early run, anglers experienced several days of increased catch rates prior to operation of the fish pass during the late run. Pools in the Russian River Falls were at capacity and late run fish concentrated in the lower Russian River where they were subject to capture by sport fishermen.

Counts conducted at the fish pass during the early run revealed passage rates approximated 550 fish/hour which is similar to 1980 data. On June 24, over 5,500 early run fish passed the weir and it is assumed the majority circumvented the falls via the fish pass. Observation indicated more than 13,000 late run fish (29.2% of the escapement) ascended the fish pass again indicating it is capable of providing an alternative route to the spawning grounds for Russian River sockeye salmon during high water periods. No observable mortality occurred at the falls during the early or late run.

Figure 5 indicates that, although conservative use of the fish pass temporarily slowed both runs, the migration rate in 1981 exceeded historical mean passage rates. Reasons for accelerated migrational rates are not known.

Smolt to Adult Survival

In 1978 and 1979, sockeye salmon smolts were enumerated by weir at the outlet of Lower Russian Lake. Out-migrants enumerated during these years returned to Russian River as adults in 1980 and 1981. Survival rates from smolts to adults for the progeny of the 1975 and 1976 spawning escapements were 14.0 and 9.4%, respectively, averaging 11.3%. These survival rates are minimal and exclude the contribution of the late run to the Cook Inlet commercial fishery (Table 14).

Ken Tarbox (Research Biologist, ADF&G, Commercial Fish Division, pers. comm.) indicates the exploitation rate in the mixed stock commercial fishery is thought to be 50-60%. If it is assumed the late run Russian River stocks contribute 50% to the commercial harvest, the smolt to adult survival would increase proportionately. Adding the estimated 1981 commercial harvest of Russian River late run fish (91,362) to the value in Table 14 yields an adult return of 198,670 or a smolt to adult survival rate for the 1975 year class of 25.9%. Similar calculations reveal the smolt to adult survival rate of the 1978-79 out-migrants would therefore be 20.4%.

Foerster (1968) compiled a hypothetical mortality table employing data from a variety of sources. He assumes the presence of a commercial fishery. He further notes that survival at the various life history stages show annual fluctuation depending on environmental parameters and that these survival rates vary between sockeye salmon populations. The hypothetical mortality

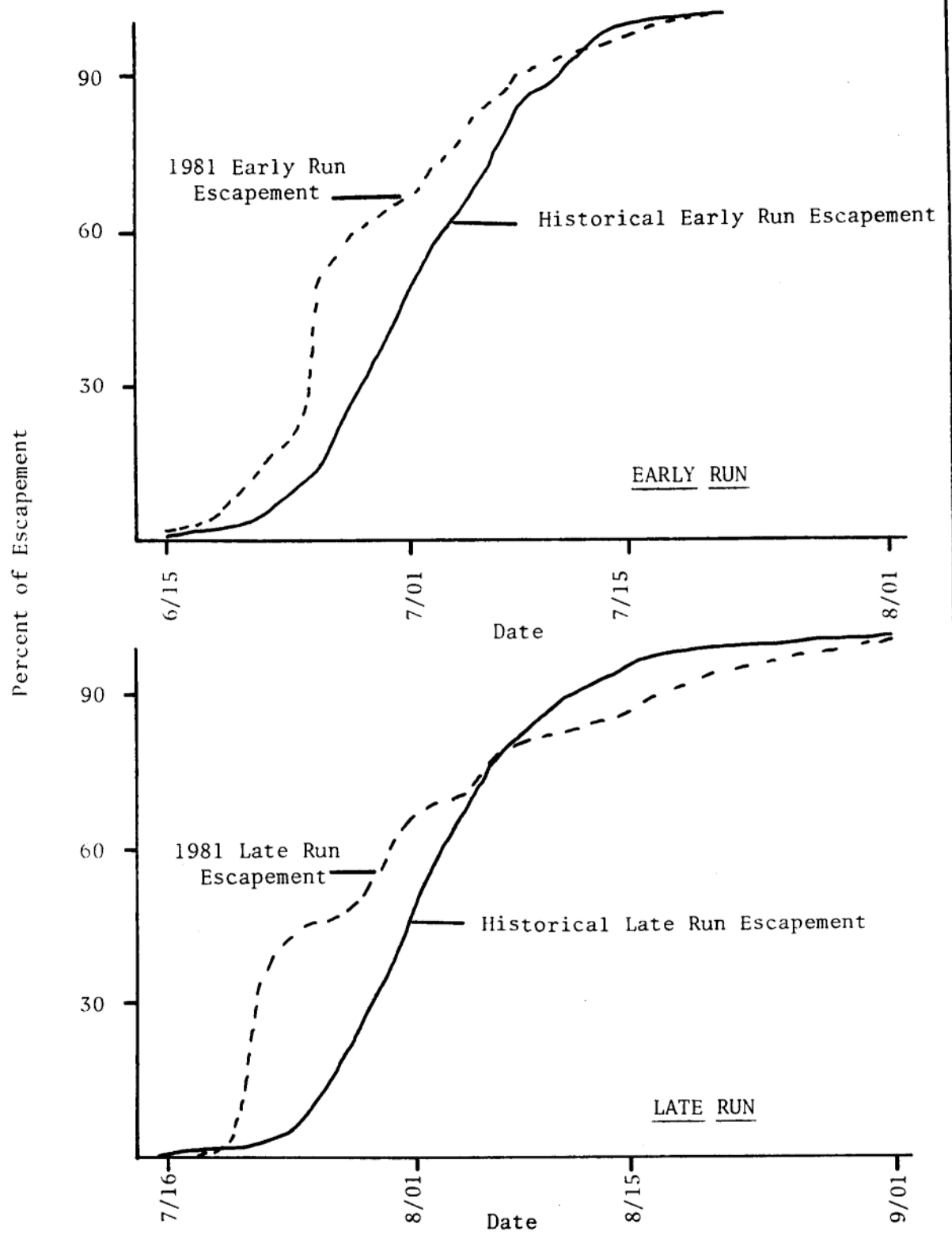

Fig. 5. Migrational Timing of the 1981 Early and Late Run Russian River Sockeye Salmon Run as Determined by Weir Counts Compared to Historical Escapement Rates.

Table 14. Sockeye Salmon Smolt Out-Migration, Adult Return and Percent Survival from Smolt to Adult for the Progeny of the 1975 and 1976 Early and Late Run Spawning Escapements.

Parent Year	Smolt Out-Migration	Adult Return*	% Survival From Smolt to Adult
1975	765,813	107,308	14.0
1976	1,100,952	103,086	9.4
Total/Mean	1,866,765	210,394	11.3

* Exclusive of late run sockeye salmon harvested by the commercial fishery. The contribution of late run fish to this fishery is not known.

table suggests smolt to adult survival approximates 10%. The survival of the 1978-79 Russian River out-migrants is in close agreement with this figure.

Enumeration of smolts in 1978-79 and the return of these fish in 1980-81 afforded the first opportunity since the inception of the "Russian River Sockeye Salmon Study" to evaluate smolt to adult survival. Although the results are of interest and approximate the generally accepted survival rate of 10%, practical application of these data is limited. Enumeration of smolts was discontinued in 1980 and it will therefore not be possible to determine the annual variability of smolt to adult survival in Russian River. Furthermore, smolt to adult survival as outlined above is a composite of the early and late run out-migrants. No means are presently available to separate early and late run smolts as they pass Russian River weir (Nelson, 1979). Since smolts cannot be apportioned between early and late runs nor related to known spawning escapements of the respective runs, a knowledge of the total out-migration is of limited value in determining escapement goals or predicting future returns. A smolt enumeration program at Russian River would have value only if: (1) the program was conducted annually; (2) the total smolt out-migration could be apportioned between early and late runs and; (3) the contribution of these stocks to the Cook Inlet commercial fishery could be accurately estimated.

Age Class Composition

Scale samples collected at Lower Russian Lake weir revealed sockeye salmon in their fifth year of life comprised 65.4% of the early run return. Salmon in their sixth year of life contributed 28.3% and the remaining 6.3% were 4-year fish.

Early run age class composition in 1981 was atypical and contradicted data from all previous years in which scale samples were analyzed except 1977. Historically, early run fish are age class 2.3 in their sixth year of life. This age class has contributed an average of 70.0% to the early run. In 1977, the contribution of this age class was 23.4% and, in 1981, 28.3%. Age class 1.3's average contribution to the early run is 15.3%. In 1977 and 1981, this age class dominated the early run comprising 60.7% and 46.5%, respectively. Reasons for the dominance of this age class in 1977 and 1981 are not known.

Early run salmon averaged 588.7 mm (23.2 in) in length. Mean lengths of 2- and 3-ocean fish were 549.8 mm (21.6 in) and 601.8 mm (23.7 in), respectively. Male to female sex ratio was 1:0.8.

Late run stocks were dominated by fish which resided 2 years in freshwater (79.1%). The majority of the run (74.5%) spent 2 years in saltwater prior to returning to their natal stream. Male to female sex ratio (excluding jacks) was 1:1.4. Late run sockeye salmon averaged 560.5 mm (22.1 in) in length, 28.2 mm (1.1 in) less than the average early run fish. This length differentiation is attributable to the age structure of the respective runs. Most early run fish remain in the marine environment 3 years, as opposed to 2 years for the majority of late run fish.

Two- and 3-ocean adult late run fish averaged 544.8 mm (21.4 in) and 608.9 mm (24.0 in), respectively. Two- and 3-ocean late run fish are somewhat larger than early run fish of the same age class as the late run remains in the marine environment approximately 1 month longer than the early run fish during their final year of life. Lengths of early and late run fish sampled from 1975-1981 are presented in Table 15. Age class composition data for the 1981 migration are presented in Table 16.

Table 17 summarizes historical early and late run Russian River sockeye salmon age class data. The dominance of age class 2.3 in the early and 2.2 in the late run is clearly shown. The exception to the annual dominance of age class 2.3 in the early run has been discussed. Age class 2.2 has consistently dominated the late run.

Length-frequency of 190 early run sockeye salmon is presented in Figure 6. This figure indicates 61.6% of these fish exceeded 580 mm (22.8 in), whereas Figure 7 reveals 70.9% of the late run was less than 580 mm (22.8 in). This length differential is again a function of the age structure of the population.

Examination of Figures 6 and 7 suggests a possible division of 2- and 3-ocean salmon based on length. Figure 6 indicates a division of early run fish at 569 mm (22.4 in), and Figure 7 suggests a division of ocean ages for late run fish at 599 mm (23.6 in). If the respective runs were aged by length, the early run would be 22.6% 2-ocean and 77.4% 3-ocean. Scale analysis revealed this run was composed of 25.2% 2-ocean and 74.8% 3-ocean sockeye salmon. Calculating the ocean age of late run fish by length reveals 80.6% of the run would be 2-ocean and 19.4% 3-ocean. Scale analysis revealed this run was comprised of 74.5% 2-ocean and 25.5% 3-ocean salmon. Length could therefore be employed as an indicator of both early and late run stocks' ocean residency in 1981.

Nelson (1979) concluded that accurately determining the ocean ages of Russian River sockeye salmon is not always possible employing length as the sole criterion. He indicated that, during 1978, a division based on length was not definitive nor in agreement with age composition data obtained by scale analysis.

Early Run Return Per Spawner

Table 18 presents the numbers of fish produced for each early run fish in the parent year spawning escapement. From 1963-1975, the return per spawning fish in the parent year escapement averaged 2.6, ranging from 0.2 to 10.6. The significance of a return of 10.6 fish for each salmon in the escapement has been discussed (Nelson, 1979). The author also noted a large spawning escapement does not necessarily ensure a high return rate. The lowest return per spawner (0.2) was produced by one of the largest parent year escapements (21,510). Conversely, the return rate of 10.6 originated with a relatively low spawning escapement in 1972 of 9,270.

Foerster (1968) indicates that irrespective of the level of escapement, the fluctuations in the numbers of returning adult fish are quite marked. The Fraser River return per spawner from 1938 to 1954 ranged from 2.2 to 13.0, averaging 5.4. This author concludes most of the variability in production

Table 15. Early and Late Run Russian River Sockeye Salmon Total Returns, Mean Total Length of Fish Sampled and Mean Lengths of Two- and Three Ocean Salmon, 1975-1981.

Year	Total Return*	Mean Length (mm) 2-Ocean Salmon	3-Ocean Salmon	Combined
		Early Run		
1981	31,860	549.8	601.8	588.7
1980	55,890	543.5	597.1	591.5
1979	28,100	550.1	610.8	598.2
1978	71,870	551.5	604.5	602.0
1977	36,470	559.6	610.5	605.3
1976	18,090	562.4	609.4	595.8
1975	7,040	542.1	600.7	588.3
		Late Run		
1981	68,250	544.8	608.9	560.5
1980	117,480	544.2	600.9	562.7
1979	114,750	541.6	610.3	548.0
1978	58,760	549.8	602.7	566.9
1977	48,850	553.7	614.9	570.5
1976	45,650	571.5	618.6	585.0
1975	40,360	552.2	603.2	561.3

* Late run total run is exclusive of fish spawning below the Falls.

Table 16. Age Class Composition, Sample Size, Parent Year and Mean Length of Adult Sockeye Salmon in Respective Age Classes for Early and Late Run Russian River Escapements, 1981.

Age Class	Estimated No. In Escapement	Sample Size	Estimated Percent of Escapement	Parent Year	Mean Length (mm)*	S.D.**
			Early Run			
1.2	1,332	11	6.3	1977	561.5	25.9
1.3	9,830	99	46.5	1976	601.5	18.5
2.2	3,995	37	18.9	1976	546.3	19.9
2.3	5,983	43	28.3	1975	602.5	19.0
Combined	21,140	190	100.0		588.7****	29.9
			Late Run			
1.2	5,782	27	13.8	1977	539.4	25.3
1.3	2,765	13	6.6	1976	610.8	21.9
2.2	25,221	118	60.2	1976	546.1	20.1
2.3	7,918	37	18.9	1975	608.2	20.5
3.2	210	1	0.5	1975	410.0	--
Combined	41,896***	196	100.0		560.5****	36.6****

* Length is from mid-eye to fork of tail.

** Standard Deviation.

*** Excludes 2,630 jacks.

**** Mean length and standard deviation calculated from the total sample.

Table 17. Age Class Composition by Percent of Early and Late Run Adult Russian River Sockeye Salmon Escapements, 1970-1981.

Year	1.2	1.3	1.4	2.2	2.3	2.4	3.2	3.3
				Early Run				
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		
1976	16.8	1.5		11.4	61.1		0.9	1.3
1977	1.9	60.7		14.0	23.4		0.8	8.4
1978	0.9	3.0		1.6	95.3			
1979		4.5		20.9	74.6			
1980	6.2	8.1	0.4	4.3	81.0			
1981	6.3	46.5	___	18.9	28.3	___	___	___
1970-80 Mean*	3.1	15.3	0.1	9.9	70.0	0.5	0.1	1.0
				Late Run				
1970	2.5	2.9		87.3	7.3			
1971	1.9	5.3		61.5	30.3			
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			
1978	0.9	5.3		58.8	35.0			
1979	2.1	0.4		88.2	8.2		0.9	0.2
1980	25.2	7.4		56.6	10.8			
1981	13.8	6.6		60.2	18.9		0.5	___
1970-80 Mean**	6.8	5.1		67.7	19.9		0.4	0.1

* 1973 deleted from computations, Ten year mean.

** 1972 and 1973 deleted from computations. Nine year mean.

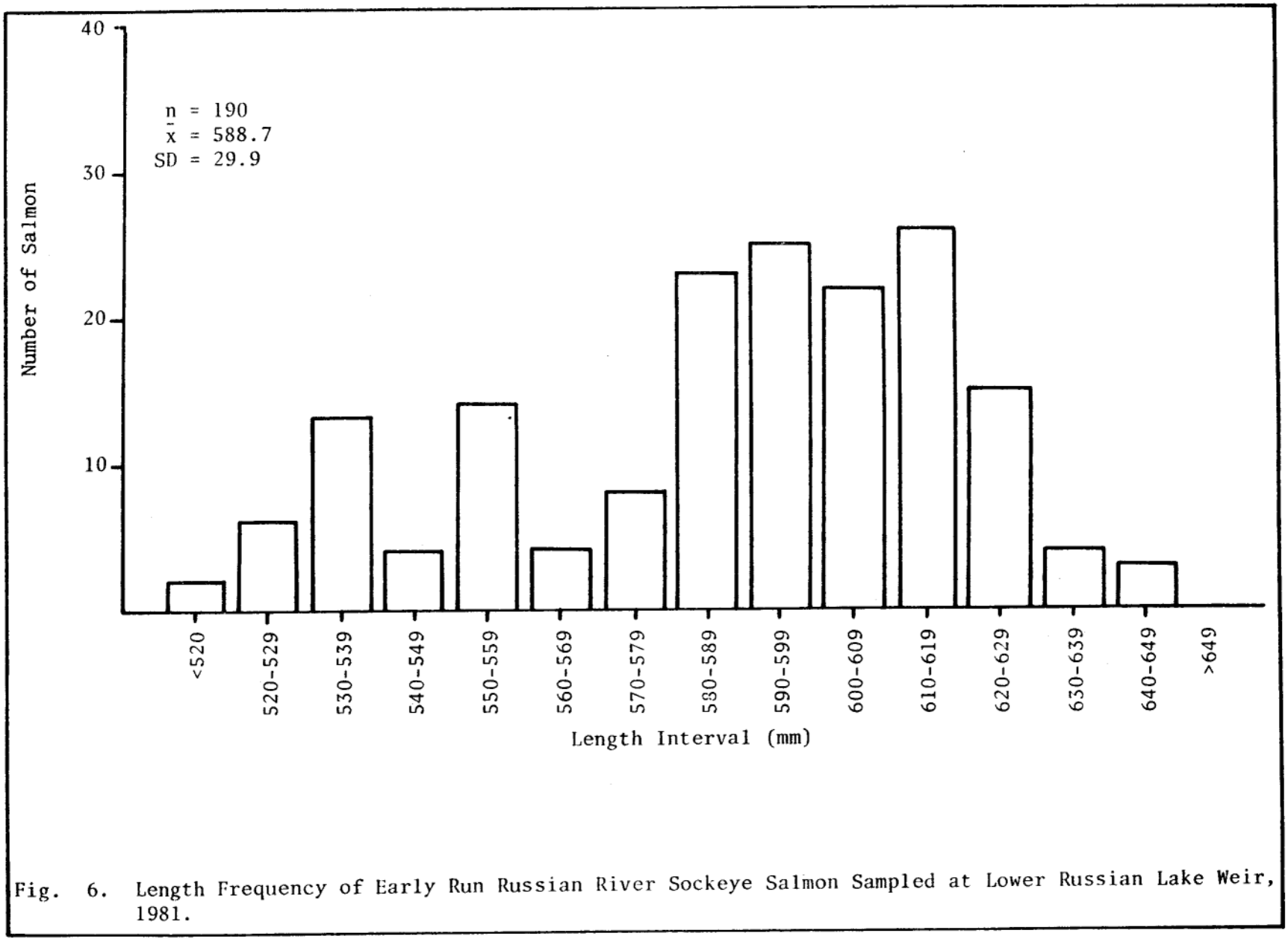

Fig. 6. Length Frequency of Early Run Russian River Sockeye Salmon Sampled at Lower Russian Lake Weir, 1981.

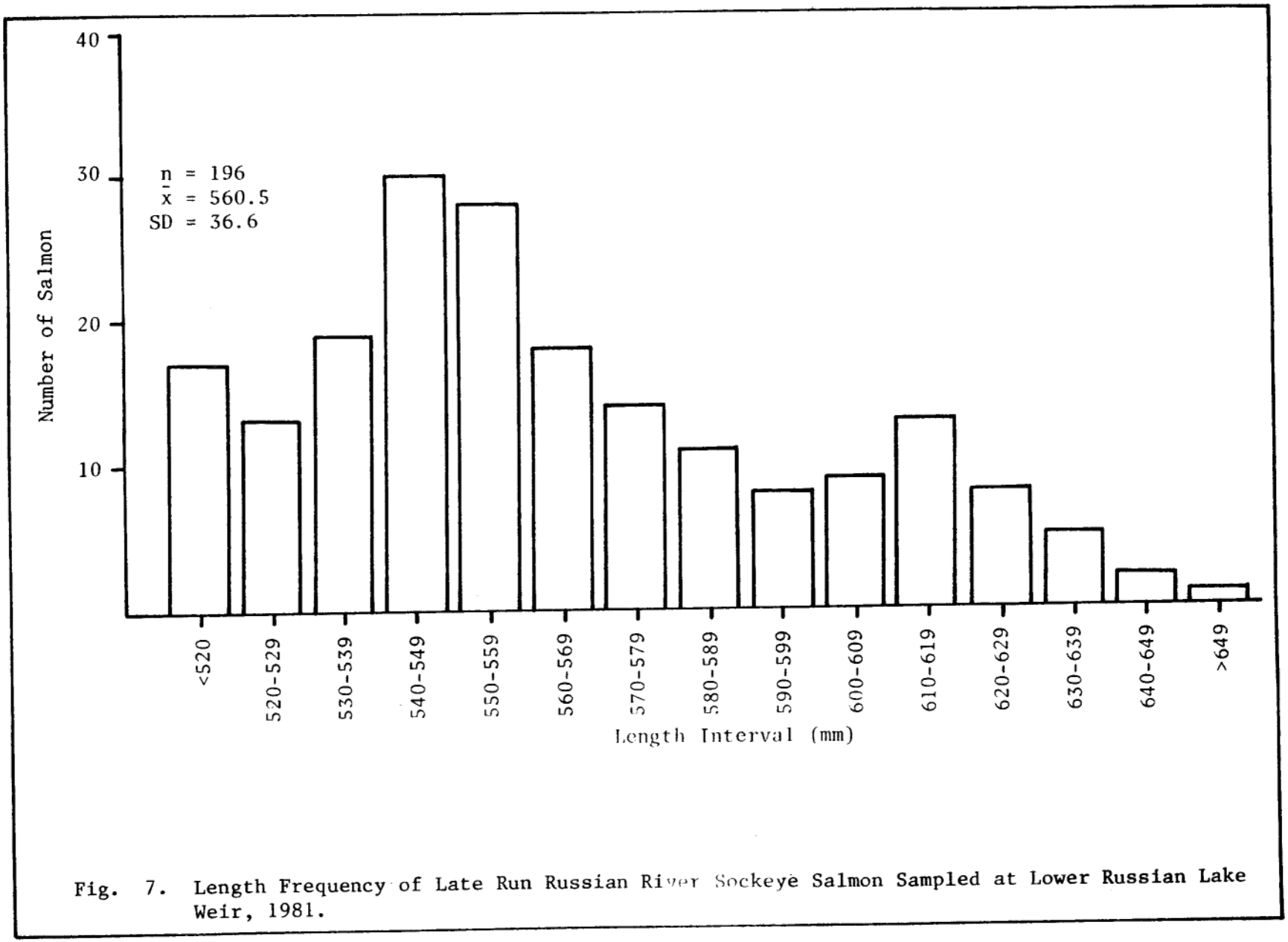

Fig. 7. Length Frequency of Late Run Russian River Sockeye Salmon Sampled at Lower Russian Lake Weir, 1981.

Table 18. Estimated Production from Known Escapements of Early Run Russian River Sockeye Salmon.

Parent Year	Parent Year Escapement	Total Return* (Production)	Return Per Female**	Return Per Spawner
1963	14,580	10,870	1.5**	0.7
1964	12,700	11,200	1.8**	0.9
1965	21,510	4,875	0.4**	0.2
1966	16,660	8,183	1.0	0.5
1967	13,710	19,628	2.8	1.4
1968	9,200	18,946	4.0	2.0
1969	5,000	14,508	5.8	2.9
1970	5,450	12,810	5.3	2.3
1971	2,650	10,896	8.7	4.1
1972	9,270	98,775	26.6	10.6
1973	13,120	24,962	3.8	1.9
1974	13,150	52,704	9.7	4.0
1975	5,640	15,947	4.6	2.8
Total	142,640	304,304	76.0	34.3
Mean	10,972	23,408	5.8	2.6

* Return equals sport harvest plus escapement. A negligible commercial harvest is assumed.

** Assumes a male to female sex ratio of 1:1.0 in the parent year escapement. Sex ratios for succeeding years determined by sampling.

is attributable to environmental conditions during the freshwater developmental stages. Available data collected since the early 1970's coupled with observations suggest early run sockeye salmon production may be related to stream velocities present at Upper Russian Creek during spawning and egg incubation.

Return per spawner for the 1975 parent year which returned as adults in 1980 and 1981 was 2.8. This compares favorably with the historic mean return per spawner of 2.6.

Fecundity Investigations

Fecundity investigations initiated in 1973 were continued during the 1981 season. Results are presented in Table 19.

Fecundity of early run salmon ranged from 2,857 to 4,398 with a mean of 3,412.3. Mean weight and length of females sampled were 2.32 kg (5.13 lb) and 570.4 mm (22.5 in), respectively. These fish averaged 1,471 eggs/kg of body weight and 6.0 eggs/mm of body length. Late run sockeye salmon averaged 3,267.8 eggs/female with a range of 2,558 to 4,249. Mean weight of late run fish sampled was 2.15 kg (4.75 lb). Mean length was 551.7 mm (21.7 in). These fish averaged 1,520 eggs/kg of weight and 5.0 eggs/mm of length. Table 20 compares these data with results from prior investigations.

Table 20 indicates the average early run female in 1981 was smaller (both length and weight) than those sampled in prior years. Mean eggs/female is also the lowest recorded, although eggs/mm and eggs/kg are comparable to historical data. Reasons for the decrease in length and weight of early run fish are not known. This is the second consecutive year the size of early run fish sampled during fecundity investigations has decreased. Nelson (1981) noted a similar trend in 1980. Fecundity values recorded in 1981 for female late run sockeye salmon are within the range of historic fecundity data for this stock.

Egg Deposition

Assuming the mean fecundity of early run fish sampled is representative of early run stocks, the potential number of eggs available for deposition in Upper Russian Creek may be calculated. Losses between weir and spawning grounds, females which perish without spawning and mean number of eggs retained per spent female must be considered. Nelson (1981) has presented a detailed discussion of these criteria and the methodology employed to calculate potential early run egg deposition. Deposition in 1981 was estimated at 32 million. Table 21 presents early run potential egg deposition estimates since 1973.

Inspection of Table 21 reveals the greater the spawning escapement, the greater the potential egg deposition. However, some variability in reproductive potential will occur annually irrespective of the number of salmon in the spawning escapement, in that mean fecundity and male to female sex ratio are not constant (Hartman and Conkle, 1960). It should also be noted that neither a definitive nor direct relationship is evident for deposition and adult return. Factors other than eggs available for

Table 19. Fecundity of Early and Late Run Russian River Sockeye Salmon as Determined by Sampling at Lower Russian Lake Weir, 1981.

Sample Number	Weight kg	Weight (lb)	Length (mm)	Number of Eggs Right Skein	Number of Eggs Left Skein	Number of Eggs Combined
			Early Run			
1	2.15	4.75	535	1,378	2,184	3,562
2	2.04	4.50	520	1,478	1,518	2,996
3	2.72	6.00	615	1,828	2,231	4,059
4	2.38	5.25	585	1,659	2,127	3,786
5	2.38	5.25	595	1,183	2,045	3,228
6	2.49	5.50	605	2,167	2,231	4,398
7	2.15	4.75	555	1,142	1,844	2,986
8	2.04	4.50	530	1,511	1,624	3,135
9	2.27	5.00	565	1,311	1,546	2,857
10	2.61	5.75	595	1,562	1,726	3,288
11	2.04	4.50	550	1,353	1,681	3,034
12	2.61	5.75	595	1,728	1,891	3,619
Mean	2.32	5.13	570.4	1,525.3	1,887.3	3,412.3
			Late Run			
1	1.81	4.00	510	1,137	1,421	2,558
2	1.93	4.25	540	1,193	1,542	2,735
3	1.93	4.25	530	1,379	1,617	2,996
4	2.04	4.50	560	1,436	1,322	2,758
5	2.15	4.75	560	1,829	1,457	3,286
6	2.49	5.50	590	1,952	2,287	4,239
7	1.81	4.00	535	1,465	2,035	3,500
8	2.15	4.75	545	1,948	2,197	4,145
9	2.38	5.25	555	1,512	1,789	3,301
10	2.49	5.50	575	1,642	1,976	3,618
11	2.27	5.00	555	1,498	1,739	3,237
12	2.38	5.25	565	1,314	1,527	2,841
Mean	2.15	4.75	551.7	1,525.4	1,742.4	3,267.8

Table 20. A Comparison of Fecundity Data Collected at Lower Russian Lake Weir During Early and Late Run Russian River Sockeye Salmon Migrations, 1973-1981.

Year	Mean Fecundity	Mean Length (mm)	Mean Weight (kg)	Eggs/ Kilogram	Eggs/ Millimeter
			Early Run		
1973	4,630	627.0	2.97	1,559	7.4
1974	3,569	603.0	2.60	1,373	5.9
1975	3,952	600.0	2.54	1,556	6.6
1976	3,558	596.0	2.61	1,405	6.1
1977	4,313	602.7	2.85	1,513	7.1
1978	3,815	608.1	2.82	1,353	6.3
1979	3,842	577.0	2.49	1,543	6.7
1980	3,534	572.9	2.42	1,460	6.2
1981	3,412	570.4	2.32	1,471	6.0
			Late Run		
1973	3,190	569.0	2.19	1,457	5.6
1974	3,261	558.0	2.30	1,418	5.8
1975	3,555	555.0	2.26	1,573	6.4
1976	3,491	587.0	2.53	1,380	5.9
1977	3,302	567.1	2.44	1,353	5.8
1978	2,865	584.0	2.67	1,073	4.9
1979	3,314	542.0	2.20	1,506	6.1
1980	2,740	543.7	1.98	1,384	5.0
1981	3,268	551.7	2.15	1,520	5.9

Table 21. Potential Egg Deposition From Known Early Run Sockeye Salmon Escapements in Upper Russian Creek and Known Returns Produced by These Escapements, 1972-1981.

Year	Escapement	Potential Egg Deposition (millions)	Adult Return
1972	9,270	15.0	98,773
1973	13,120	29.6	24,962
1974	13,150	17.7	52,704
1975	5,640	12.7	15,947
1976	14,700	23.5	
1977	16,070	18.2	
1978	34,150	62.8	
1979	19,700	30.9	
1980	28,670	44.2	
1981	21,140	32.0	

total deposition therefore exert a significant influence on the adult return of early run sockeye salmon. Foerster (1968) believes these factors are manifest primarily during freshwater residency and are environmentally related.

Egg sampling to determine actual egg deposition and survival of early run eggs in Upper Russian Creek was conducted October 3. Sampling permits an evaluation of spawning success as it relates to environmental parameters during spawning and the early portion of the incubation period. Sampling was conducted in all sections of Upper Russian Creek as described by Nelson (1977). Numbers of eggs dug per sampling point ranged from 0 to 258, averaging 17.9. Mean egg density was estimate at 97.3 eggs/M^2. Egg survival was 59.9% at time of sampling (Table 22).

Environmental factors are of paramount importance when considering egg deposition estimates in Upper Russian Creek. Nelson (1978) indicated Upper Russian Creek may have been subject to extremely high water in 1976 and 1977 which washed eggs from the gravel resulting in low deposition estimates. This same author (Nelson, 1979) indicated moderate water flows were observed in 1978. Egg deposition estimates were relatively high that year. Egg sampling was not conducted in 1979 due to high water and it is assumed eggs were washed from the gravel. Observation in 1980 indicated flood conditions occurred after sampling was conducted. Density estimates for this year may be too high and not a true reflection of the numbers of eggs available for incubation during moderate flows. Russian River drainage received heavy rain in August and September, and eggs may have been lost prior to sampling as density estimates for 1981 are relatively low in relation to numbers of spawning fish.

Egg density data to date suggest a relationship between numbers of eggs in the gravel of Upper Russian Creek and the adult return. High egg densities were recorded in 1972 and 1973. The adult return in 1978 and 1979 was similarly high. On the basis of egg density data, the author (1980) suggested the adult return in 1980 would be above average as egg density in 1974 was the highest recorded. This observation proved correct. Egg density in 1975 was the lowest recorded and on the basis of these data, the early run return in 1981 was expected to be less than average (Nelson, 1981).

However, the total 1981 return of 31,860 was one of the highest recorded. Predictions of future early run returns are apparently subject to factors other than egg density.

Predictions of early run sockeye salmon returns, based on egg density estimates, are based on the assumption that the majority of this stock will return as age class 2.3. This age class has consistently dominated the early run except in 1977 and 1981, when the majority of the run were 5-year fish of age class 1.3. Since there is currently no smolt enumeration program to assess the length of freshwater residence, the predictions regarding 1977 and 1981 returns were erroneous. Future predictions regarding returning early run fish must therefore be qualified by acknowledging the possibility of the dominant age class being other than 2.3.

Table 22. Early Run Russian River Sockeye Salmon Egg Densities in Upper Russian Creek and Known Adult Returns from These Densities, 1972-1981.

Year	Total Eggs Dug	Mean Eggs Per Point	Percent Survival	Density (Eggs/M^2)	Adult Return
1972	3,790	75.8	81.1	407.8	98,773
1973	2,967	59.3	93.0	319.6	24,962
1974	8,229	84.0	64.2	455.6	52,704
1975	605	6.2	84.3	33.3	15,947
1976	901	12.7	91.6	61.3	
1977	981	12.6	55.0	67.7	
1978	4,415	48.0	87.6	226.1	
1979	- - - - - - - NO SAMPLE - HIGH WATER - - - - - - -				
1980	5,102	58.0	68.6	315.5	
1981	1,862	17.9	59.9	97.3	

Data presented therefore suggest that environmental factors present at Upper Russian Creek during the spawning and incubation period exert a greater influence on numbers of returning adults than do actual numbers of early run fish in the parent year escapement. It is therefore the recommendation of the author that serious consideration be given to investigating methods whereby the stream flow in Upper Russian Creek could be stabilized during the critical spawning and incubation period. If this recommendation cannot be pursued and evaluated, it is suggested other mitigating measures, such as fry stocking in Upper Russian Lake, be investigated. Fry should be stocked only if egg sampling indicates high egg loss and/or minimal egg survival. This approach will maintain the stocks in as natural a state as is possible while maintaining current early run population levels.

Climatological Observations

Climatological data recorded at Lower Russian Lake were grouped by 6-day periods to facilitate analysis (Table 23). No correlation was found between air and water temperatures and sockeye salmon migration. Air and water temperatures in 1981 were comparable to prior year's data. Total precipitation recorded was 191.2 mm (7.5 in). Although this total rainfall was 70.0% less than the 325 mm (12.8 in) recorded during the 1980 migration, it undoubtedly contributed to high discharge rates through Russian River Falls during a portion of both early and late runs. The effect of high flows on the early and late run migration has been discussed earlier in this report.

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Table 23. Climatological and Hydrological Observations by Six-Day Periods Recorded at Lower Russian Lake Weir, June 13-September 4, 1981.

Period	Water Temperature* Max°C	Water Temperature* Min°C	Air Temperature* Max°C	Air Temperature* Min°C	Rainfall (mm)**	Russian River Discharge (cfs)	Rondezvous Creek Discharge (cfs)
June 13-18	9.0	8.4	20.8	5.1	1.1	243.7	51.0
June 19-24	10.0	9.5	20.9	8.1	2.1	296.0	69.5
June 25-30	10.1	10.0	16.2	6.7	17.4	273.4	74.3
July 1-6	10.1	9.9	16.4	5.8	4.0	244.6	69.0
July 7-12	10.1	10.0	17.6	6.9	5.7	278.5	89.5
July 13-18	9.9	10.0	16.2	10.7	19.4	323.3	122.3
July 19-24	10.0	10.0	17.2	11.6	20.2	285.3	101.7
July 25-30	10.4	10.2	17.2	9.4	10.3	249.7	87.7
July 31-August 5	10.5	10.5	17.7	9.9	39.0	268.5	84.5
August 6-11	10.5	10.5	15.0	9.9	13.4	294.3	81.3
August 12-17	10.5	10.5	13.6	6.9	33.2	262.3	88.7
August 18-23	10.6	10.5	13.8	7.3	22.0	230.7	62.3
August 24-29	11.1	11.1	18.3	7.4	0.0	213.0	52.0
Aug. 30-Sept. 4	11.1	11.1	15.0	7.2	3.4	177.6	44.7

* Air and water temperatures for the respective periods are the mean of the daily recordings.

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

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