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STUDY AFS-44-1

STATE OF ALASKA

Jay S. Hammond, Governor

Annual Performance Report for

RUSSION RIVER
RED SALMON STUDY

by

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RESEARCH PROJECT SEGMENT

State: Alaska

Study No.: AFS 44 Study Title: ANADROMOUS FISH STUDIES

Job No.: AFS 44-1 Job Title: Russian River Red Salmon Study

Period Covered: July 1, 1974 to June 30, 1975.

ABSTRACT

Creel census estimates during the Russian River red salmon, Oncorhynchus nerka, sport fishery revealed 21,120 man-days of effort were expended to harvest 14,940 salmon. Early and late runs contributed 6,440 and 8,500 salmon, respectively, to the harvest. Seasonal success rate was 0.131 red salmon per hour. Anglers harvested 28.3 percent of the red salmon to reach Russian River.

Early and late run escapements were 13,150 and 24,650 red salmon, respectively. Early run escapement is considered excellent. Late run escapement is one of the lowest recorded. Precocial males comprised 3.0 percent of the late run escapement. Data are presented which suggests a relationship between numbers of jacks returning and late run magnitude the following year.

The Alaska Department of Fish and Game's Division of Commercial Fisheries Kenai River sonar counts from 1968 through 1974 were examined. Comparison of sonar and weir counts indicated migrational time of late run fish from sonar site to Russian River weir ranged from 10 to 32 days, averaging 17. Migrational time determined by a tagging program was not in agreement with this data and was of a briefer duration. Factors contributing to this disparity are presented and discussed as is Russian River's contribution to total Kenai River red salmon escapement.

Creel census data from 1967 through 1974 revealed 58.1 percent of the anglers at Russian River are unsuccessful. One, two and three salmon are taken by 20.4, 9.7 and 12.0 percent of the anglers, respectively. It was estimated a bag limit reduction from three to one fish would reduce early run harvests by 41.2 percent and late run harvests by 45.9 percent.

Fecundity investigations revealed early and late run salmon averaged 3,569 and 3,261 eggs per female, respectively. A comparison of actual egg count to volumetric estimates indicated minimal error and justifies use of volumetric estimates in future studies. Early and late run fish examined averaged 2.60 and 2.30 kg in weight, respectively.

A weir at the outlet of a small spring-fed tributary (Bear Creek) to Upper Russian Lake revealed 5,386 late run fish (21.8 percent of the escapement) spawned in this area. Tagging data to determine stream life (days fish spent in the stream) in this system was inconclusive as were attempts to determine if these fish could be induced to spawn in the shoal area of the lake. Average number of eggs retained per female in this area was estimated at 80.5.

Age analysis of early and late run fish revealed both runs were dominated by salmon which spent two years in fresh water. Early run fish were primarily 3-ocean (95.6 percent) while late run was dominated by 2-ocean salmon (64.1 percent). Mean length of early and late runs were 601.7 and 557.1 mm, respectively.

Direct egg sampling in Upper Russian Creek revealed early run deposition to be 455.6 eggs/M^2. Egg survival was 64.2 percent. Sampling in Bear Creek indicated late run egg deposition at 563.6 eggs/M^2. Survival was 17.4 percent. Calculations by indirect methods (fecundity/mortality) indicate appreciable differences exist between this method and hydraulic sampling. Results and application of direct versus indirect sampling are presented and discussed.

Hydraulic sampling in Bear Creek suggests a relationship between egg deposition and late run escapements enumerated at Russian River weir. This relationship is discussed and the theoretical Bear Creek escapements in 1972 and 1973 are calculated. Escapement counts conducted in other spawning areas utilized by late run fish are presented. These counts, coupled with Bear Creek escapement, indicate Upper Russian Lake proper was utilized by 59.5 percent of the late run.

RECOMMENDATIONS

1. Extend sanctuary area by 200 yards from its existing limits to a marker approximately 100 feet below ferry crossing on Kenai River to a marker 700 yards upstream on Russian River. This would afford increased protection to early stocks.

2. Reduce limit on early run salmon from three to one fish daily or in possession. Data indicate returns for 1975 through 1977 are expected to be below average and require increased protection.

3. Temporary weir at the mouth of Bear Creek should be improved and modified to facilitate capture of late run fish to this system.

4. Tagging program should be conducted at Bear Creek weir to determine stream life. Red Floy tags should be used to reduce predation on study fish.

5. Efforts should be made to determine numbers of late run red salmon spawning in various areas within the Bear Creek system.

6. Basic climatological data (rainfall, stream discharge, water and air temperature) should be collected at Lower and Upper Russian Lake when personnel are stationed in the respective areas.

7. Number of samples collected at Upper Russian Creek to determine egg deposition should be established at 100. Investigation should continue to determine if numbers of samples in section should be apportioned by area or numbers of fish in the respective section.

8. Construct a fishway at Russian River Falls to prevent delay of migrating salmon.

OBJECTIVES

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

2. To determine age composition of adult and juvenile red salmon.

3. To determine sport harvest of Russian River red salmon.

4. To determine spawning area utilized by late run red salmon in Upper Russian Lake drainage, the relative proportion of the late run which utilizes a given area, and the average stream life of a spawning red salmon in these areas.

5. To determine egg and fry deposition in various areas of Upper Russian Lake. Egg densities, percent viable eggs and survival from egg to fry will be correlated with the number of red salmon which utilized a given area.

6. To determine the number of viable smolt produced from a known red salmon escapement to Upper Russian Lake.

7. To determine the fecundity of early and late run female red salmon and to determine if a relationship exists between body weight, skein weight and number of eggs.

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

TECHNIQUES USED

Russian River creel census was a modification of the method described by Neuhold and Lu (1957). Sampling procedures and analysis were identical to those outlined by Engel (1965, 1970, 1972) and Nelson (1973) except total stream counts on weekend days were increased from one to two per week. Increased counts effected more accurate estimates of angler participation on weekends. Time devoted to additional angler counts did not affect accuracy in computing catch per hour. As analysis of 1972 data indicated, angler contacts could be decreased 50 percent without altering estimated harvest rates.

When analyzing census data, early and late runs and weekday and weekend days were treated as separate entities. This permitted a more accurate harvest and effort estimate while compensating for variable success rates during these four periods.

Escapements were enumerated at a temporary weir at the outlet of Lower Russian Lake. Weir construction and location have been previously described (Engel, 1970).

Fecundity investigations were conducted at the Russian River weir. Female red salmon were randomly selected throughout early and late runs. Total weight and length (mid-eye to fork of tail) were also obtained. Skeins were boiled until eggs could be removed. Total egg content was obtained by direct count and/or volumetrically. Procedures for volumetric enumeration were:

1. Fill 250 ml graduated cylinder with 100 ml water.

2. Directly enumerate eggs required to displace 10 ml of water.

3. Deposit remaining eggs into graduated cylinder and note total displaced.

4. Eggs displaced by 10 ml water X total water displaced = total eggs.

Volumetric estimates were compared to direct enumerations by calculating percent error of volumetric enumerations as below:

$$\frac{\text{(Total direct) count} - \text{(Total volumetric) count}}{\text{(Total Direct) Count}} \times 100 = \text{percent error}$$

Negative error indicated estimate was above direct count; positive error indicated estimate was below direct count.

A temporary weir was constructed 175 feet above outlet of Bear Creek (Upper Russian Lake) on August 30. Weir allowed total enumeration of late run salmon entering this system. Weir construction was identical to that employed at Upper Russian Creek in 1972 and has been previously described (Nelson, 1973).

Eighty-nine salmon (48 males and 41 females) were tagged at the Bear Creek weir site to determine stream life. Tagging was conducted from September 25 through 27. Four tag types were employed: 17 Floy, blank, gray; 25 Floy, blank, red; 19 Petersen disc, blank, white, 1" diameter and 28 Petersen disc, numbered, yellow, 5/8" diameter. Application of Petersen disc tags has been previously described (Nelson, 1973). Floy tags were inserted immediately below the dorsal fin utilizing an FD-67 Mark II tag gun. Recovery was by daily ground surveys above weir.

On October 10, the weir was moved downstream to the outlet. Weir was closed to determine if approximately 200 remaining salmon would spawn if denied access to their parent stream. One hundred thirty-two (98 females and 34 males) late run fish were seined from shoal area of Upper Russian Lake with a 50-foot beach seine. Study fish were tagged with red, yellow and blue Floy internal anchor tags.

Late run female carcasses were opened in conjunction with spawning ground surveys. Method(s) of enumerating retained eggs have been previously described by Nelson (1974).

Late run red salmon spawning in tributaries (except Bear Creek) and between Upper and Lower Russian Lakes were enumerated by ground surveys.

Late run fish spawning in Upper Russian Lake proper were estimated to be total escapement passed Lower Russian Lake weir minus the sum of tributary spawners (including Bear Creek).

Egg density in Bear and Upper Russian creeks was determined by hydraulic sampler patterned after equipment described by McNeil (1964). Sampling in Bear Creek was identical to prior years and has been described (Nelson, 1973). Methodology employed in Upper Russian Creek was similar to prior years except number of points dug was increased from 50 to 98 and number of points dug in a given section was proportionate to the relative percent of the escapement spawning in that section (i.e. 30 percent spawning in a section, 30 points dug).

Total eggs deposited by early and late run fish in Upper Russian and Bear creeks was determined by both direct and indirect methods. Direct estimation was calculated by multiplying average eggs/M^2 (determined by hydraulic sampler) by total square meters in the respective creek. Indirect egg deposition estimates were calculated by multiplying total number of females by average fecundity. Correction factors were introduced to compensate for mortality egg retention, etc.

Scale samples from early and late run salmon were collected at Lower Russian Lake weir. Scales were impressed on cellulose acetate and read on a Bruning 200 microfiche projector.

FINDINGS

Introduction

Area description and prior information relating to the Russian River red salmon, Oncorhynchus nerka, sport fishery has been presented in Alaska Department of Fish and Game, Federal Aid in Fish Restoration, Annual Progress Reports by Lawler (1963, 1964), Engel (1965 through 1972), and Nelson (1973, 1974). Activities during early years of the project (1962 through 1968) emphasized collection and evaluation of harvest, effort and escapement data. Management activities during this period were minimal as early

and late run red salmon escapements were high, averaging 17,351 and 39,290, respectively. Although the fishery was popular with residents and non-residents alike, effort was relatively low, averaging 11,720 man-days annually.

Research activities initiated in 1969 were directed toward evaluation of regulatory measures to eliminate snagging, a common angling practice since the inception of the fishery. Emphasis was placed on determining the degree of delayed mortality incurred when a red salmon was hooked elsewhere than head, mouth or gills and released.

In 1972 an intensive tagging program was conducted at the confluence of Russian and Kenai rivers and at the Lower Russian Lake weir. The program was designed to assess delayed mortality which may result when a salmon was foul hooked and released. Emphasis was directed toward early run stocks as this segment of the population received the most intense angling pressure. Results indicated negligible mortality occurred below Russian River Falls. Maximum mortality between weir and spawning grounds was estimated at 5.1 percent.

It was concluded that although limited mortality does occur when a fish is foul-hooked and released, it does not pose a biological problem in the management of the fishery (Nelson, 1973a). This phase of the investigation was, therefore, terminated.

Average angler participation from 1969 through 1974 increased to 19,693 man-days. Effort became so intense that the fishery was capable of harvesting the bulk of the red salmon to reach Russian River. A fishery of this magnitude requires an intensive management program to insure adequate escapement while allowing maximum harvest. This is evidenced in that the Sport Fish Division has closed all or part of the fishery on nine different occasions since 1968. Prior to this date, emergency closures were not deemed necessary.

Definitive information regarding escapement levels which return maximum numbers of fish to the system while permitting maximum harvest was required. The project has, therefore, proceeded in this direction since 1969.

Efforts are presently directed toward determining numbers of salmon which utilize respective spawning areas of Upper Russian Lake. This is effected by ground counts and a temporary weir on the largest tributary (Bear Creek) utilized by late run fish. Numbers of eggs and their survival in these areas are determined by annual hydraulic sampling following the cessation of spawning. Indirect methods employing fecundity data and known mortalities at various stages of migration are also utilized. Early and late run carcasses are examined annually and egg retention determined.

Investigations in 1974 were directed toward Bear Creek, a spring-fed tributary in Upper Russian Lake used exclusively by late run fish. A weir was constructed and salmon tagged to determine stream life. As egg survival had been exceptionally low in 1973, an experiment was designed to determine if a portion of the escapement destined for this stream could be induced to spawn in the shoal area of the lake.

It is anticipated investigations relating to optimum escapement levels and production will be continuous. To determine total production from a known escapement will necessitate smolt enumeration. A weir which will replace the existing structure at Lower Russian Lake should be operational by spring, 1975. Although it will not initially have smolt capabilities, it is anticipated that it will augment investigations through more rapid enumeration of escapement and refined capture apparatus.

Annual escapement data will be correlated with known survival data from the parent year. It is anticipated this will provide insight regarding desired escapement levels and also enable evaluation of management pratices currently applied to the Russian River sport fishery.

Creel Census

In accordance with the Sport Fish Division's anti-snagging philosophy in freshwaters of the Kenai Peninsula, the fly-only and foul-hook regulations remained mandatory in 1974. The fly-only area, extended by 1,800 yards in 1972, and sanctuary area at confluence of Kenai and Russian rivers also established in 1972, remained in effect. A regulation promulated by the Alaska Board of Fish and Game in 1973 extended the effective date of the sanctuary closure by 14 days. All fishing was prohibited in this area from June 1 through July 14. This area is an historic resting site for early run fish which are especially vulnerable during this period.

Early run escapement levels recorded at Lower Russian Lake weir lagged below historical levels during the first 20 days of the fishery and the fly-only area was closed to red salmon fishing on July 1. Escapement levels immediately responded to increased protection and the fishery reopened on July 6 after the majority of the run passed the weir.

Late run salmon entered the fishery on July 16. Escapement levels during the initial ten days of migration indicated a smaller than average run. The fishery was, therefore, closed on July 31. It was not reopened until all late run fish had passed the weir.

Creel census to evaluate management and regulatory measures was in effect from June 8 through June 30 and from July 6 through July 31. All angling effort on red salmon was sampled. Projected counts indicated anglers expended 108,624 hours or 21,120 man-days. Effort on early and late run stocks was estimated at 11,090 and 10,030 man-days, respectively. Based on interviews with 1,748 anglers who reported fishing 9,089 hours and caught 1,198 red salmon, total harvest was estimated at 14,940 fish. Early and late runs contributed 6,440 and 8,550 salmon, respectively, to the harvest. Mean hourly early and late run success rates were 0.105 and 0.188, respectively. Harvest rates were higher on weekdays (0.165) than weekend days (0.086) due to greater angler congestion during weekend periods. Harvest, effort and catch per hour estimates since 1962 are summarized in Table 1.

Table 1. Red Salmon Harvest, Effort and Success Rates on Russian River, 1962-1974.

Year	Harvest			Effort (man-days)	Catch/ Hour	Census Period
	Early Run	Late Run	Total			
1962	3,410	1,290	4,700	6,600	0.220	6/15-8/12
1963	3,670	1,390	5,060	7,880	0.190	6/ 8-8/15
1964	3,550	2,450	6,000	5,330	0.321	6/20-8/16
1965	10,030	2,160	12,190	9,730	0.265	6/15-8/15
1966	14,950	7,290	22,240	18,280	0.242	6/15-8/15
1967	7,240	5,720	12,960	16,960	0.141	6/10-8/15
1968	6,920	5,820	12,740	17,270	0.134	6/10-8/15
1969	5,870	1,150	7,020	14,930	0.094	6/ 7-8/15
1970	5,750	600	6,350	10,700	0.124	6/11-7/27*
1971	2,810	10,730	13,540	15,120	0.192	6/17-8/20**
1972	5,040	16,050	21,090	25,700	0.195	6/17-8/21
1973	6,740	8,930	15,670	30,590	0.102	6/ 9-8/19***
1974	6,440	8,500	14,940	21,120	0.131	6/ 8-7/30****
1962-1973 Average	6,332	5,298	11,630	14,924	0.185	

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

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

*** Census active from June 9 through July 4 and from July 15 through August 19.

**** Census active from June 8 through June 30 and from July 6 through July 31.

Total angler effort decreased 31.0 percent compared to 1973 estimates. Reduced effort is not attributed to decline in angler interest but rather extensive closures during 1974. Red salmon fishing was prohibited 24 of approximately 60 days when these fish were available. Had closures not been in effect and effort remained constant, estimates indicate man-days expended would have approximated 35,000.

In 1974, weekday counts averaged 123.8 anglers and weekend counts averaged 144.4 anglers. Counts are the second highest recorded and were exceeded only in 1973. Although definitive data is not available, similarity between weekday and weekend counts suggest anglers may be attempting to circumvent congested weekends and are utilizing the fishery to a greater extent on weekdays. Similarity between counts may also indicate greater tourist participation than in prior years (Nelson, 1974).

Each angler fished an average of 4.7 and 5.7 hours on weekdays and weekends, respectively. Catch per hour on weekdays and weekends are comparable to 1973 estimates. Fisheries statistics since 1964 are presented in Table 2.

Table 2. Differences Between Weekday and Weekend Day Fishing Pressures and Rates of Success at Russian River, 1964-1974.

Year	Angler Counts		Catch/Hour		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
1964-1973 Average	71.1	125.8	0.213	0.146	4.7	5.1

Stream counts revealed 68.0 and 67.4 percent of the anglers enumerated during total stream counts fished the confluence area of Kenai and Russian rivers during early and late runs, respectively. Distribution was similar during weekdays and weekend days. This indicates the confluence area received proportionately greater angling pressure than in 1972 or 1973. Average effort during these years at the confluence was 52.5 and 52.4 percent during early and late runs, respectively.

Tendency for anglers to favor the confluence area in 1974 is probably related to: (1) Extended closures during the fishery. During the early segment of both runs, anglers concentrate at the confluence to intercept salmon prior to their entry into Russian River. During the mid and latter portion of the runs, fishing improves in lower Russian River and anglers follow fish upstream. In 1974 both runs were subject to total closure during their latter migrational period. (2) Rapid migration of both runs through clear water of Russian River to closed area at base of Russian River Falls. Observations indicated that when salmon left the confluence area, migration was rapid and afforded limited fishing opportunity. A schematic diagram of Lower Russian River and the Kenai and Russian River confluence is presented in Figure 1.

During the census, an estimated 1,466 Dolly Varden, Salvelinus malma, 171 rainbow trout, Salmo gairdneri, and 57 round whitefish, Prosopium cylindraceum, were harvested incidental to red salmon. One silver salmon, O. kisutch, was creel checked. It is assumed that had the red salmon fishery not been closed, harvest of these fish would have been appreciable as silver salmon escapement was the highest recorded. No pink salmon, O. gorbuscha, were recorded during the census. Observation on August 27, however, indicated a small but active fishery seeking this species at the confluence area. Few pink salmon were observed in Russian River and it is assumed the majority of fish taken were of Kenai River origin.

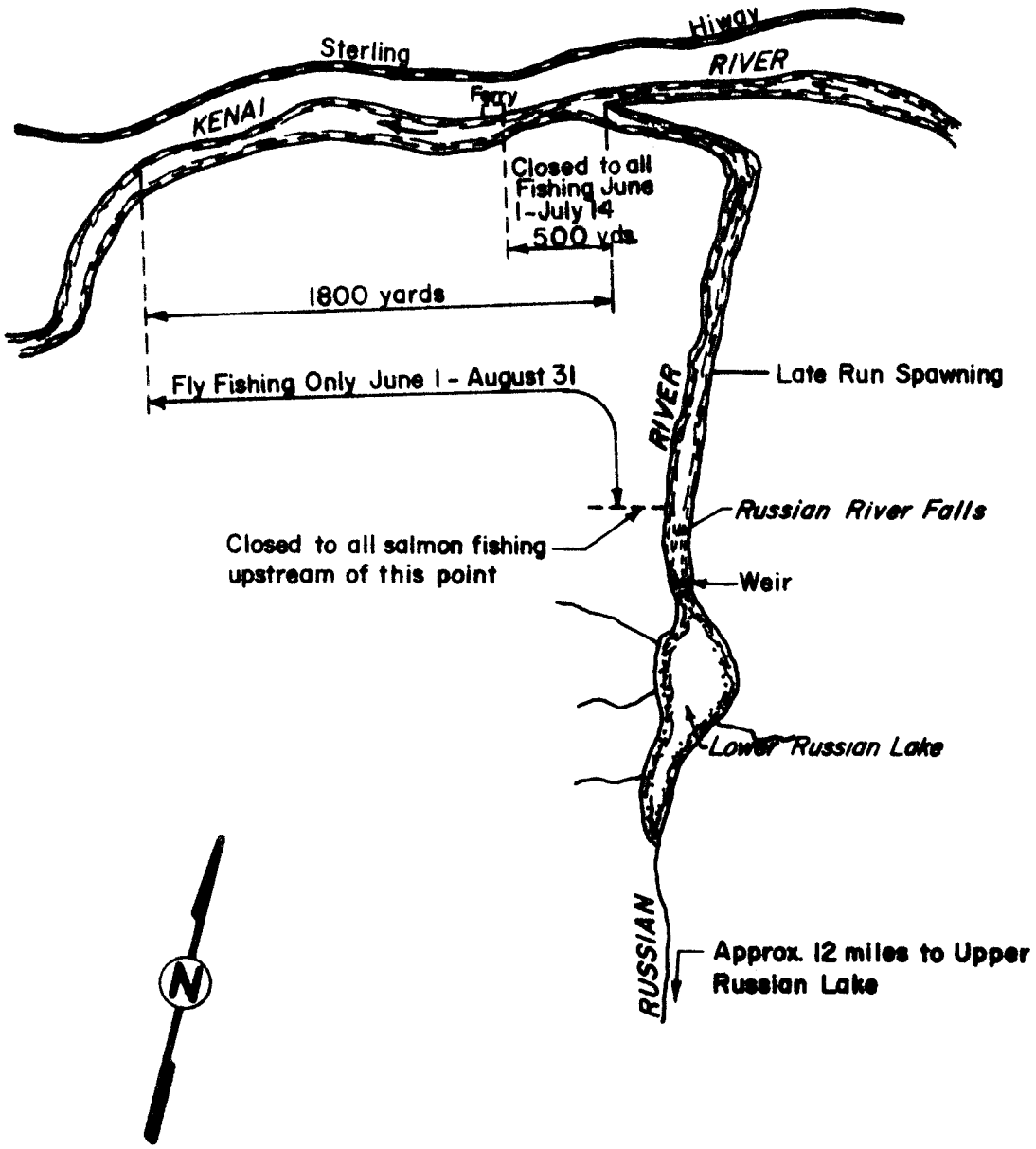

Figure 1. Schematic Diagram of Lower Russian River and Kenai and Russian River Confluence (Not To Scale).

Bag Limit Reduction

In recent years harvest and effort have varied with abundance of red salmon entering Russian River. A major factor dictating harvest and effort levels has been emergency closures issued by the Sport Fish Division.

Closure of the fishery, while at times unavoidable due to low returns, is a management measure which should be used with discretion because of its impact on recreational opportunity (Engel, 1971). Several alternatives to total closure are available: (1) Restrict gear or limit methods by which red salmon may be taken, (2) Limit area available to the angler and close areas of salmon concentration, (3) Reduce bag and possession limits.

Russian River red salmon sport fishery presently has the most restrictive gear and method regulations in Alaska. Anglers are limited to coho or streamer flies with gap between point and shank no greater than 3/8 inch. Weights must be a minimum of 18 inches ahead of the fly. Only fish hooked in the mouth may be retained and an anti-snagging regulation is in effect. Areas available to sport anglers are presently limited and the two major areas of salmon concentration (Kenai/Russian River confluence and Russian River Falls) are closed to salmon fishing. All salmon fishing is prohibited above a marker 600 yards below Russian River Falls. The confluence area is closed to all fishing from June 1 through July 14 to protect milling early run salmon. This restriction is not required during the late migration as this segment of the population passes rapidly through the fishery.

The remaining management measure is to reduce bag and possession limits. To evaluate effects of a reduced limit, creel census data were examined from 1967 through 1974. This evaluation compliments analysis initiated by Engel (1971). Although significant regulatory changes have occurred during this period, findings indicate data are comparable. The Russian River sport fishing harvest distribution is present in Table 3.

This table indicates that during early and late run fisheries 62.7 and 47.7 percent of the anglers, respectively, fail to catch a salmon per man-day of effort. Combining data for early and late runs reveals 20.4, 9.7 and 12.0 percent catch one, two and three salmon, respectively. Only 21.7 percent of the anglers to fish Russian River harvest two or more red salmon during a man-day of effort.

Table 4 presents calculated harvest reduction during early and late runs if bag limit were reduced to one or two red salmon. This table indicates a reduction to two red salmon would result in decreasing harvest by approximately 16 percent.

A reduction of this magnitude would have little effect on escapement levels and benefits derived from this reduction could easily be negated by increased angler effort. Reduction from three to one red salmon would decrease harvest rates by 43.9 percent and would significantly affect harvest and escapement levels.

Table 5 presents early and late run escapements since 1960. Scale analysis indicates early run salmon are primarily six year fish. Returns in

Table 3. Distribution of Russian River Red Salmon Harvest, 1967-1974.

Year	Run	Anglers Interviewed	Percent Effort			
			No Salmon	One Salmon	Two Salmon	Three Salmon
1967	Early Run	730	62.0	21.0	7.8	9.2
	Late Run	295	48.1	21.0	12.6	18.3
	Combined	1,025	58.0	21.0	10.2	11.8
1968	Early Run	1,101	62.3	20.0	8.4	9.3
	Late Run	617	44.2	23.7	13.3	18.8
	Combined	1,718	55.8	21.3	10.1	12.8
1969	Early Run	966	64.4	21.0	7.1	7.5
	Late Run	198	68.2	18.7	7.1	6.0
	Combined	1,164	65.0	20.7	7.1	7.2
1970	Early Run	1,313	61.0	19.5	8.8	10.7
	Late Run	117	59.0	24.8	7.7	8.5
	Combined	1,430	60.8	19.9	8.7	10.6
1971	Early Run	568	62.9	19.5	8.8	8.8
	Late Run	189	34.4	17.5	9.0	39.1
	Combined	757	55.7	19.0	8.9	16.4
1972	Early Run	389	61.2	21.6	8.2	9.0
	Late Run	248	34.7	19.4	15.7	30.2
	Combined	637	50.9	20.7	11.1	17.3
1973	Early Run	286	67.8	18.2	9.1	4.9
	Late Run	400	59.7	21.7	9.3	9.3
	Combined	686	63.1	20.3	9.2	7.4
1974	Early Run	198	60.1	16.2	13.1	10.6
	Late Run	148	49.3	25.7	10.1	14.9
	Combined	346	55.5	20.2	11.9	12.4
MEAN	Early Run		62.7	19.6	8.9	8.7
	Late Run		49.7	21.6	10.6	18.1
	Combined		58.1	20.4	9.7	12.0

Table 4. Theoretical Percent Reduction of Russian River Early and Late Run Harvests if Daily Limits Reduced to One and Two Red Salmon, Respectively.

Year	Run	Percent Reduction of Catch: Two Fish Limit	Percent Reduction of Catch: One Fish Limit
1967	Early Run	14.3	40.8
	Late Run	18.1	48.7
	Combined	15.8	43.9
1968	Early Run	14.4	41.8
	Late Run	17.6	47.7
	Combined	16.0	44.6
1969	Early Run	12.9	38.2
	Late Run	11.9	37.6
	Combined	12.8	38.1
1970	Early Run	15.4	44.1
	Late Run	13.0	37.7
	Combined	15.2	43.6
1971	Early Run	13.9	41.5
	Late Run	25.6	57.1
	Combined	19.0	48.5
1972	Early Run	13.8	40.3
	Late Run	21.3	53.8
	Combined	18.2	48.2
1973	Early Run	9.6	37.0
	Late Run	13.6	40.8
	Combined	12.2	39.5
1974	Early Run	14.2	46.3
	Late Run	16.4	44.0
	Combined	15.3	45.2
MEAN	Early Run	13.6	41.2
	Late Run	17.2	45.9
	Combined	15.6	43.9

1975, 1976 and 1977 are, therefore, progeny of escapements in 1969, 1970 and 1971, respectively. Escapements during these years are the lowest recorded and returns are also expected to be below average. Reducing the early run bag limit to one salmon daily or in possession would affect only an estimated 17.6 percent of the fisheries participants and may enable the fishery to remain open during years of anticipated low return.

Average late run escapement is more than three times that of the early run and anglers harvest proportionately fewer fish. This run is also harvested by the Cook Inlet commercial fishery and numbers of fish returning to Russian River are proportional to magnitude of the commercial catch. Management of the commercial fishery has been restrictive in recent years and it is anticipated Russian River returns will reflect limited commercial exploitation. A reduction in recreational bag and possession limits during the late run is, therefore, unnecessary at the present time.

Escapement

Red salmon escapements have been enumerated by counting tower since 1960 and by weir at the outlet of Lower Russian Lake since 1969. This site allows total red salmon enumeration after stocks have been harvested by Cook Inlet commercial and Russian River sport fisheries. Prior to 1974, total escapement enumerated at the counting tower/weir averaged 51,281 and ranged from 26,470 (1961) to 88,270 (1972) red salmon (Table 5).

Table 5. Russian River Red Salmon Escapement Estimates and Harvest Rates for Early and Late Runs, 1960-1974.

Year	Escapement			Percentage of Run Caught by Sport Fishery*		
	Early Run	Late Run	Total	Early Run	Late Run	Combined
1960	9,120	34,850	43,970	-	-	-
1961	7,790	18,680	26,470	-	-	-
1962	33,300	22,370	55,670	9.3	5.4	7.8
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
1960-1973 Average	12,419	38,863	51,281	36.2***	10.4***	17.7***

* Based on escapement passed weir; commercial harvest and fish spawning downstream from weir are not considered.

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

*** Twelve year mean.

The Russian River weir was installed June 13 and was functional June 14, 1974. Early run fish were passed on this date - eight days earlier than in 1973. It was estimated 500 red salmon remained below weir when operations terminated August 27. Early run red salmon escapements averaged 12,419 (1960-1973) and have ranged from 2,650 (1971) to 33,300 (1962). Escapement in 1974 was 13,150 or 5.9 percent greater than the historical average. As these salmon are primarily six year fish, total run (harvest plus escapement) exceeded 1968 parent year by 3,470 salmon (21.5 percent).

Late run Russian River escapements have ranged from 18,680 (1961) to 79,000 (1972), averaging 38,863 (1960-1973). The 1974 escapement of 24,650 (to include 1,008 precocial males) is one of the lowest recorded. Ground survey between Russian River Falls and confluence of Kenai and Russian rivers revealed an additional 2,210 late run fish spawning in this area. This count is also relatively low as ground surveys conducted in 1969, 1971, 1972 and 1973 revealed escapements of 1,100, 10,000, 6,000 and 6,685, respectively. Total late run escapement to Russian River is, therefore, estimated at 26,860 salmon.

Early run escapements are characterized by few precocial males or jacks. Jacks are relatively more abundant during the late run comprising between 0.2 percent and 9.0 percent of the escapement (1969-1974). Late run harvest, escapement, total return and number of returning jacks since 1969 is presented in Table 6.

Table 6. Late Run Russian River Red Salmon Harvest, Escapement and Returning Jacks, 1969-1974.

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	27,800	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

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

** Excludes an estimated 10,000 fish which perished below Russian River Falls due to a velocity barrier.

Table 6 indicates that numbers of jacks returning in a given year may reflect run magnitude the following year. In 1969, 1972 and 1973 escapements of precocial males were less than 500. Escapements of respective succeeding years (1970, 1973 and 1974) were among lowest recorded, averaging 25,940 or 29.5 percent less than the 15 year mean (37,915). Conversely, jack escapement in 1970, 1971 and 1974 exceeded 1,000 fish. Escapements in 1971 and 1972 were the highest recorded at Russian River, averaging 66,715 salmon or 75.9 percent greater than the 15 year mean.

Table 7 presents adults per jack based on the preceding year's jack escapement. This table indicates a range from 25.6 to 211.9 adults for every jack which returns to the system. The range for two years of high escapement is 25.6 to 66.5, averaging 46.1 adults/returning jack. Range for years of low escapement (1970, 1973, 1974) are between 81.8 and 211.9, averaging 131.2 adults/jack.

Table 7. Late Run Red Salmon Adults Per Returning Jacks as Calculated from Preceding Year's Jack Escapement, Russian River, 1969-1974.

Year	Total Return*	Preceding Year's Jack Escapement	Adults/Jack
1969	30,070	Unknown	Unknown
1970	28,800	352	81.8
1971	65,160**	2,542	25.6
1972	95,050	1,429	66.5
1973	33,900	160	211.9
1974	33,150	332	99.8

* Excludes commercial harvest and salmon spawning below the falls.
** Excludes an estimated 10,000 late run salmon which perished below the falls due to a velocity barrier.

It must be emphasized that although a general relationship appears to exist between numbers of jacks returning in a given year and magnitude of the succeeding year's total return, predictions cannot be made regarding future runs. At present, parameters are recognized for which adequate compensation cannot be made.

Contribution of late run Russian River stocks to the Cook Inlet commercial fishery is unknown. Whether or not the fishery harvests a proportionate or disproportionate percentage of the run annually is also unknown. Disproportionate commercial harvest of these fish would appreciably alter the jack to returning adult relationship as smaller jacks escape commercial gill nets. Late run Russian River red salmon jacks remain in the marine environment one year while adult fish remain two or three years. Although the marine environment is generally considered stable, it is conceivable that during the jacks' ocean residency conditions may be optimum allowing higher than average survival. Adults of the same year class may experience deteriorating environmental conditions during their additional one or two years of ocean residency and sustain higher mortality rates than did the jacks. Should this occur, it would also alter jack to returning adult relationship. The converse is also true and changing conditions may result in greater than average jack mortality.

Sport fishermen harvested 32.9 percent of the early run to reach Russian River. Although this approximates the 12 year mean of 36.2 percent, it is appreciably less than the 1969 through 1971 catch rate when over 50 percent of the early run to reach Russian River was caught. Factors contributing to reduced harvest rate have been discussed (Nelson, 1973).

Anglers harvested 25.6 percent of the late run (exclusive of salmon spawning below falls) to reach Russian River. This is an appreciable increase over the 12 year average (10.4 percent), reflecting not only the small size of the 1974 late run, but increased angler emphasis on this segment of the population (Table 8).

Table 8. Angler Effort Directed Toward Early and Late Run Russian River Red Salmon, 1962-1974.

Year	Effort (man-days)		Effort (Percent)	
	Early Run	Late Run	Early Run	Late Run
1962	5,070	1,520	76.9	23.1
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
1962-1973 Average	9,460	5,472	68.1	31.9

Table 8 indicates that prior to 1971 angler effort was directed toward early run stocks. From 1971 through 1973 over 50 percent of the effort was directed toward the more numerous late run fish. In 1974 effort reverted to the pattern established from 1962 through 1970 with over 50 percent of the effort again directed toward early run fish. Increased effort during the early run was due to an extensive closure protecting late run fish. The late run fishery was closed continuously for 19 days during the migrational period.

A total of 124 king, O. tshawytscha, and 1,508 silver salmon were enumerated at Lower Russian Lake weir. An additional 59 king salmon were observed spawning below Russian River Falls. Annual king salmon escapements are comparable as their migrational period approximates that of the late red salmon run. Silver salmon escapements are not comparable (Nelson, 1973) but are indicative of relative abundance. Partial escapement counts in 1974 indicate an excellent run was in progress exceeding the previous high count of 957 silver salmon by 57.8 percent. A summary of silver and king salmon escapement counts since 1969 is presented in Table 9.

Table 9. Silver and King Salmon Escapements Enumerated at Russian River Weir, 1969-1974.

Year	Silver Salmon	King 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
1969-1973 Average	546	159		

Scale analysis indicated six-year-old fish comprised 63.6 percent of the early run, whereas 67.6 percent of the late run consisted of salmon in their fifth year of life. Both runs were dominated by fish which migrated to the marine environment after two years in fresh water. Age class information is summarized in Table 10. Male to female sex ratio of 264 early and 166 late run salmon was 1:0.7 and 1:1.1, respectively.

Table 10. Age Analysis of Early and Late Run Russian River Escapements Sampled at Lower Russian Lake Weir, 1974.

Age Class	No. in Sample	Percent of Sample	Parent Year	Average Length (cm)*
EARLY RUN				
1.2	1	0.5	1970	590.0
1.3	66	32.0	1969	603.3
2.2	7	3.4	1969	546.4
2.3	131	63.6	1968	604.8
2.4	1	0.5	1967	610.0
LATE RUN				
1.2	8	5.5	1970	558.1
1.3	13	9.0	1969	597.7
2.2	85	58.6	1969	556.3
2.3	39	26.9	1968	591.9

* Length is from mid-eye to fork of tail. Average early run = 601.7 cm. Average late run = 577.1 cm.

The Cook Inlet commercial salmon fishery did not open until June 28, 1974 in the Central District. Early run red salmon first arrived at the confluence of the Kenai and Russian rivers on June 8. It is, therefore, assumed the majority of early Russian River red salmon were in the Kenai River system by June 28 and did not appreciably contribute to the commercial harvest. Data are not available regarding the late run's contribution to the Cook Inlet commercial fishery.

Migrational Timing

Data since 1964 show that early run red salmon arrive at the confluence of the Kenai and Russian rivers between June 8 and 20. Eliminating these two extremes, arrival time occurs during the nine day period June 9 through 17. Tagging experiments performed by Engel in 1970 indicated early run fish require 14 days to migrate from confluence area to weir approximately 2.5 miles upstream. Similar investigations by Nelson (1973) revealed early run migrational time between confluence and weir ranged from 8 to 15 days, averaging 10.8. Low water facilitated fish passage in 1972 and may account for the disparity in results obtained by above investigators.

Russian River escapements have been enumerated by counting tower since 1960 and by weir since 1969. Early run red salmon generaly begin to pass the site by June 15. Analysis of 13 years tower/weir data revealed 50 percent of the early run escapement negotiates Russian River Falls and passes tower/weir site between June 26 and July 7[1/]. Average date of passage was July 2.

During eight years of tower operation the average date when 50 percent had passed the site was July 1. Average date of passage during four years of weir enumeration was July 4. This suggests weir operations may delay migration of early run salmon two or three days.

Late run fish generally enter the sport fishery at the confluence of the Russian and Kenai rivers between July 10 and 15. Investigations by Engel (1971) indicated late run fish required six days to migrate from the confluence area to the weir. These fish usually begin to pass tower/weir site by July 15 although they have been as late as July 30 (1972). Analysis of tower counts (1960-1968) revealed 50 percent of the late run passed the site between July 20 and August 6. Average date of passage was July 31. During five years of weir enumeration average passage date was August 3. This again suggests the weir may delay migrational timing for a few days.

Although quantitative data are not available, observation suggests both early and late runs traverse the estimated 12 miles between Lower and Upper Russian lakes in a relatively short period of time. Both runs spend varying amounts of time maturing in Upper Russian Lake. Early run fish spawn exclusively in Upper Russian Creek. Majority of spawning occurs between July 27 and August 25. Nelson (1973) indicated spawning peaked during the five day period August 11 through 15.

1/ Escapement counts for 1971 were deleted from the calculations as a velocity barrier, a Russian River falls, disrupted normal migrational timing (Engel, 1972). Data from 1969 was omitted due to weir failure.

Late run salmon spawn in five tributaries to Upper Russian Lake, in Upper Russian Lake and between Upper and Lower Russian lakes. A small segment of this population also spawns below Russian River Falls. Observation and weir enumeration in 1974 indicate late run salmon begin entering tributaries by September 10. Investigation in 1974 and prior years (Nelson, 1973, 1974) revealed spawning was essentially complete by November 1. Observations suggest periods of lake spawning correspond to tributary spawning activity. Spawning between Upper and Lower Russian lakes and below Russian River Falls occurs somewhat earlier than at Upper Russian Lake. Spawning is complete in these areas by September 29 and September 10, respectively. A schematic diagram of the Upper Russian Lake system is presented in Figure 2.

Although migrational timing and movements within Russian River drainage have been documented, little is known of migrational movements of early and late runs within the main stem Kenai River. The only data available during this period of migration is from Alaska Department of Fish and Game's sonar counter operated by the Commercial Fish Division. Counter has been operational since 1968 and, excepting 1971, has provided estimates of total Kenai River red salmon migrations. The counter is located approximately one mile below Soldotna River bridge and is operational only during late run migration.

Counts were examined for the years 1968-1973 to determine the average number of days required by late run Russian River red salmon to negotiate approximately 55 miles between sonar site and Russian River weir. Data which indicate when 50 percent of the late run passes these respective sites may prove a useful management tool as it may provide approximate estimates as to arrival time at Russian River as well as gross estimate of run size. Sonar counts, late run Russian River escapement and migrational period are presented in Table 11.

Table 11. Kenai River Sonar Counts Compared to Russian River Late Run Escapements and Period of Travel Between Sonar Site and Weir, 1968-1974.*

Year	Sonar Count**	Date 50% Passed	Russian River Escapement***	Date 50% Passed	Sonar to Weir (days)
1968	87,000	7/19	48,880	7/30	11
1969	42,000	6/30	28,920	8/ 2	34
1970	61,000	7/25	28,200	8/ 6	13
1972	267,000	7/24	79,000	8/ 4	12
1973	363,000	7/22	24,970	7/31	10
1974	200,000****	7/16	24,650	8/ 6	22
Average	136,667	7/18	39,103	8/ 3	17

* 1971 deleted due to sonar failure.
** All counts represent red salmon counts. Count begins on 6/20.
*** Escapement reflects weir counts only and is exclusive of fish spawning in lower Russian River.
**** Preliminary data.

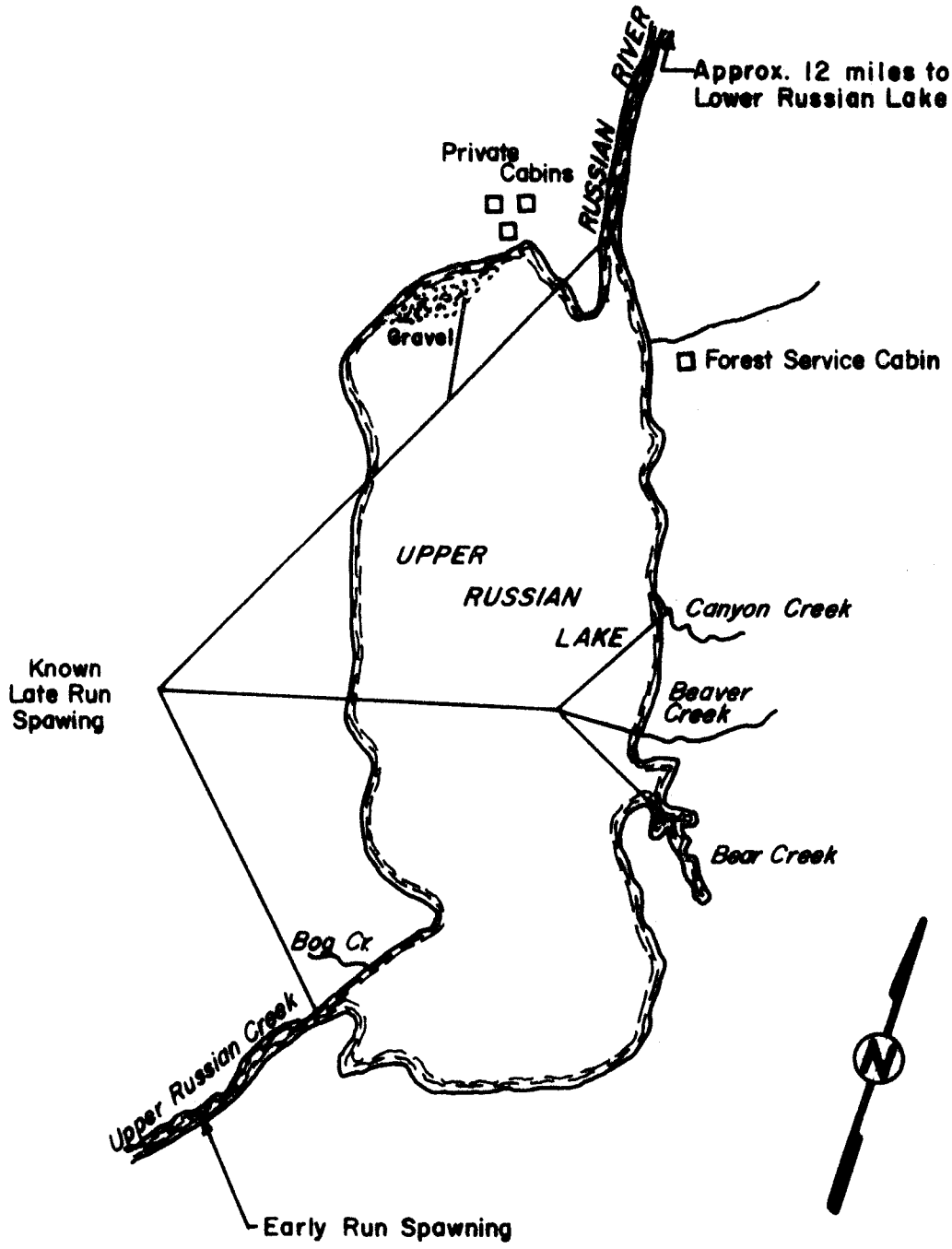

Figure 2. Schematic Diagram of Upper Russian Lake (Not To Scale).

Table 11 indicates elapsed time between sonar site and weir ranged from 10 to 34 days, averaging 17. Excepting the 1969 extreme of 32 days, the migrational period ranges from 10 to 22 days with a mean of 14. Fifty percent of the estimated Kenai River escapement passed the sonar site between July 2 and July 25 with a median of July 18.

A tagging experiment conducted by the Commercial Fish Division in 1970 (Davis, 1971) indicated 14.8 days was the average time required for a Russian River red salmon to traverse the distance between sonar site and weir. This is basically in agreement with data presented in Table 11. Similar investigations in 1972 and 1973 (Davis et al, 1973, 1974) revealed salmon required 18 and 30 days, respectively, to negotiate the 55 miles between these two points. Comparison of sonar and weir counts for these years do not agree with tagging data and indicated the red salmon migrational period between these points were 12 and 10 days, respectively.

Reason(s) for these discrepancies are not definitely known but may be related to the following: (1) tag returns may have been insufficient to represent the collective late Russian River run, (2) tagged fish may have experienced stress and migrated more slowly than did untagged salmon, (3) sonar counts may have been inaccurate, (4) numbers of Russian River red salmon may have been relatively low compared to Kenai River red salmon and migrational timing obtained by sonar counter may represent timing of the latter stock, (5) a combination of any or all of the above may have contributed to discrepancies between tagging data and a comparison of sonar/weir counts.

Above data indicate migrational timing derived from an analysis of tagging and sonar/weir counts are not consistent from year to year and that discrepancies exist within a given year. It is, therefore, concluded that although an "in season" analysis of sonar versus weir counts may indicate timing and relative abundance, additional parameters must be applied when rendering decisions affecting management of Russian River sport fishery.

Evaluation of sonar and Russian River harvest and escapement data also provides an estimate of the Russian River contribution to Kenai River red salmon escapements. Data indicate average Russian River contribution ranges from 11.3 to 68.1 percent, averaging 47.9 percent (Table 12). This table also indicates that in four of six years under consideration the percentage of Kenai River escapement to enter the Russian River exceeded 38.0 percent.

It is recognized percentages in Table 12 are dependent on: (1) an arbitrary date (June 20) when only late run fish pass sonar counter, (2) accuracy of sonar counter, (3) accuracy of Russian River estimated sport harvest, (4) accuracy of red salmon escapement counts spawning below Russian River Falls, (5) accuracy of 1968 tower count (weir was functional from 1969 through 1974). However, data presented do establish Russian River as the major contributor to the Kenai River system in an average year.

Table 12. Kenai River Sonar Counts, Total Late Russian River Red Salmon Run, and Percent of Kenai River Red Salmon to Enter Russian River, 1968-1974.*

Year	Red Salmon Sonar Count**	Total Late Russian River Run***	Percent Kenai Run to Russian River
1968	87,000	59,520	68.4
1969	42,000	31,160	74.2
1970	61,000	28,800*****	47.2
1972	267,000	102,120	38.2
1973	363,000	40,985	11.3
1974	200,000****	35,357	17.7
1968-1973 Average	164,000	52,517	47.9

* 1971 data was deleted due to sonar failure.
** Sonar counts have been apportioned and are considered red salmon counts only.
*** Includes escapement passed weir, fish spawning below falls and harvest.
**** Preliminary data.
***** Data are not available regarding salmon spawning below falls.

Fecundity Investigations

Limited fecundity investigations initiated in 1973 were continued at the Russian River weir during early and late runs. Sampling results are presented in Tables 13 and 14.

Fecundity of early run salmon ranged from 2,606 to 4,351, averaging 3,569 eggs/female. Average weight and length of females sampled was 2.60 kg and 60.5 cm, respectively. Early run salmon averaged 1,371 eggs per kilogram of body weight and 59.2 eggs per centimeter of body length. Late run fish averaged 3,261 eggs/female with a range of 2,437 to 3,669 eggs/female. Average length and weight of late run salmon was 55.8 cm and 2.30 kg, respectively. Salmon which had spent two and three years in the marine environment comprised 21.4 and 78.6 percent, respectively, of the early run sample. Two and three ocean fish represented 44.4 and 55.6 percent, respectively, of late run fish sampled.

Investigations in 1973 and 1974 agree with conclusions of other studies (Foerster, 1968) in that positive correlation is established between fish size (weight and length) and egg content (Nelson, 1974). Average early run weight and length in 1974 was 13.1 percent (0.30 kg) and 8.1 percent (4.5 cm) greater than late run salmon. Early run fish also averaged 9.4 percent (307.9) more eggs per female than late run fish. It is of interest to note that in 92.3 percent of fish sampled, the left ovary contained a greater number of eggs than the right. As indicated by Rounsefell (1957), the probable explanation of this phenomonon was advanced by Brown and Kamp (1942). These investigators (discussing brown trout, Salmo trutta) indicated the posterior portion of the intestine usually bends strongly to the right, crowding the ovaries at the caudal end. The left ovary, therefore, has more room for expansion and contains a greater number of eggs.

Although direct enumeration is the most accurate determination of egg content, it is a time consuming method and restricts numbers of fish which may be examined. In an effort to increase sample size while maintaining a high degree of accuracy, volumetric estimation was introduced (Tables 13, 14). Evaluation of the method indicated over-counts in both early and late run studies. Average percent error was -1.27 and -3.48 during early and late runs, respectively. The percent of over-count was 1.3 and 3.5 percent, respectively, during early and late run investigations. It is concluded that volumetric estimates are justified in future investigations and that the relatively small error incurred is negated by permitting larger samples which more accurately represent average egg content of fish within the population.

Fecundity investigations compiled by Rounsefell (1957) and Foerster (1968) indicated average red salmon fecundity ranged from 2,175 (Port John, B.C., 1950) to 5,165 eggs per female (Bolshaya River, Siberia, 1947). Foerster concluded red salmon from the latter area appeared to be the greatest known egg producers. Average fecundity of early Russian River red salmon in 1973 was 4,630 eggs/female. This tentatively suggested fecundity of early Russian River stocks approached egg content of fish in the Bolshaya area. Average early run egg content in 1974 was 1,061 eggs less than in 1973. This indicates fecundity of these stocks will probably display annual variation dependent on age structure and average size of mature salmon.

Table 13. Fecundity of Early Run Russian River Red Salmon as Determined by Actual Count and Volumetric Estimate, Lower Russian Lake Weir, 1974.

EARLY RUN

Sample Number	Weight (kg)	Age Class	Number of Eggs (Actual Count) Right Skein	Left Skein	Total	Number of Eggs (Volumetric Estimate) Right Skein	Left Skein	Total	Percent Error
1	2.381 (5.25 lb)	Unknown	1,406	1,814	3,220	-	-	-	-
2	2.495 (5.50 lb)	Unknown	-	-	-	1,628	1,904	3,532	-
3	2.495 (5.50 lb)	2.3	-	-	-	1,411	1,704	3,115	-
4	2.381 (5.25 lb)	2.3	-	-	-	1,286	1,320	2,606	-
5	2.835 (6.25 lb)	2.3	-	-	-	1,696	1,861	3,557	-
6	2.608 (5.75 lb)	1.3	2,038	2,285	4,323	1,941	2,190	4,131	4.44
7	2.948 (6.50 lb)	1.3	1,852	2,287	4,139	1,752	2,254	4,006	3.21
8	2.495 (5.50 lb)	2.3	2,065	2,113	4,178	1,980	2,371	4,351	-4.14
9	2.381 (5.25 lb)	2.3	1,484	1,616	3,100	1,512	1,659	3,171	-2.29
10	3.289 (7.25 lb)	1.3	2,005	2,113	4,118	2,088	2,058	4,146	-0.68
11	2.835 (6.25 lb)	1.3	1,767	1,966	3,733	1,830	2,016	3,846	-3.03
12	2.722 (6.00 lb)	1.3	1,540	1,575	3,115	1,604	1,774	3,378	-8.44
13	2.327 (5.13 lb)	1.2	1,710	1,727	3,437	1,541	1,677	3,218	6.37
14	2.268 (5.00 lb)	1.2	1,190	1,411	2,601	1,188	1,460	2,648	-1.81
15	2.808 (6.19 lb)	2.3	1,519	1,733	3,252	1,642	1,809	3,451	-6.12
16	2.381 (5.25 lb)	2.2	1,306	1,466	2,772	1,299	1,617	2,916	-5.20
Average	2.603 (5.74 lb)		1,679.6*	1,844.7*	3,524.4*	1,670.6*	1,898.6*	3,569.3*	-1.61

* Averages computed on samples 6 through 16 only.

Table 14. Fecundity of Late Run Russian River Red Salmon as Determined by Actual Count and Volumetric Estimate, Lower Russian Lake Weir, 1974.

LATE RUN

Sample Number	Weight (Kg)	Age Class	Number of Eggs (Actual Count) Right Skein	Left Skein	Total	Number of Eggs (Volumetric Estimate) Right Skein	Left Skein	Total	Percent Error
1	2.835 (6.25 lb)	1.3	1,581	1,633	3,214	1,613	1,709	3,322	-3.36
2	1.982 (4.37 lb)	2.3	1,399	1,483	2,882	1,483	1,501	2,984	-3.54
3	1.982 (4.37 lb)	2.3	1,530	1,585	3,115	1,598	1,610	3,208	-2.99
4	2.155 (4.75 lb)	2.2	1,514	1,616	3,130	1,638	1,730	3,368	-7.60
5	2.381 (5.25 lb)	Unknown	1,622	1,795	3,417	1,588	1,837	3,425	-0.23
6	2.608 (5.75 lb)	2.2	-	-	-	1,346	1,609	2,955	-
7	2.268 (5.00 lb)	2.3	-	-	-	1,154	1,283	2,437	-
8	2.381 (5.25 lb)	2.3	-	-	-	1,749	1,920	3,669	-
9	2.041 (4.50 lb)	2.2	-	-	-	1,336	1,614	2,950	-
10	2.381 (5.25 lb)	2.2	-	-	-	1,564	1,603	3,167	-
Average	2.301 (5.07 lb)		1,529.2*	1,622.4*	3,151.6*	1,584.0*	1,677.4*	3,261.4*	-3.54

* Averages computed on samples 1 through 5 only.

Assuming average fecundity of the sample is representative of early run stocks, the potential number of eggs which may be deposited by these fish in Upper Russian Creek can be estimated. The following assumptions as outlined by Nelson (1974) must be applied: (1) sampling indicates male to female sex ratio of 1:0.7, (2) annual mortality between weir and spawning grounds is constant and estimated at 5.1 percent, (3) mortality between weir and spawning grounds is non-selective and males and females perish in direct proportion to their numbers in the population, (4) numbers of females which reach spawning grounds and perish without spawning should be ascertained and incorporated into the estimate. Nelson (1973) reported 1.1 percent of early run females to reach the spawning area failed to spawn in 1972. Limited investigations by this author in 1973 indicated all females spawned successfully. It is probable, however, that an undetermined number of females perish annually without spawning. Cause of death may be predation, disease, hook wounds or injuries incurred negotiating Russian River Falls. For estimation purposes, it is assumed annual female spawning ground mortality approximates 1.1 percent as determined in 1972. Spawning success in 1972 was estimated at 98.0 percent and is also incorporated in 1974 calculations.

The following estimate may then be derived for the 1974 early run escapement by applying above parameters:

Early run escapement	13,150
Early run female escapement	5,415
Mortality between weir and spawning grounds	5.1%
Female red salmon to reach spawning grounds	5,139
Female red salmon which perished without spawning	57
Average eggs per female	3,569
Total possible eggs deposited	18,137,658
Percent eggs deposited per female	98.0
Estimated egg deposition	17,774,904

It is interesting to note that although escapement in 1974 exceeded 1973 escapement by only 30 fish, estimated potential egg deposition in 1974 decreased more than 11 million. Factors responsible for this decrease are: (1) sex ratio in which males dominated 1974 escapement. In 1973 and 1974 male to female sex ratio was 1:1.1 and 1:0.7, respectively, (2) average fecundity in 1973 and 1974 was 4,630 and 3,569 eggs per female, respectively.

Egg sampling to determine survival and egg deposition of early run fish in Upper Russian Creek was conducted September 8 and 9. Sampling procedures were identical to those described by Nelson (1973) except that sampling was increased from 50 to 98 points. Numbers of points dug in each section was proportionate to percentage of the run which spawned in that section. Egg deposition was estimated at 455.6 eggs/M^2. Egg survival was 64.2 percent at time of sampling. Density estimates for 1972 through 1974 are presented in Table 15.

Table 15. Early Run Russian River Red Salmon Egg Densities Determined by Hydraulic Sampler in Upper Russian Creek, 1972-1974.

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	8,299	84.7	64.2	455.6

Egg density and survival compared to estimated percentage of the run which spawned in each section is presented in Table 16. This table indicates early run spawning activities were concentrated in Section VI through IX. Estimates revealed 70.6 percent of the early run utilized these areas. Egg sampling indicated 87.7 percent of all eggs were deposited in these sections. This suggests sampling should continue to be conducted proportionate to numbers of fish spawning in each section.

Table 16. Upper Russian Creek Egg Densities, Egg Survival and Percentage of Total Eggs Dug in Each Section Compared to Numbers of Early Run Red Salmon Enumerated in Each Section, 1974.

Section	No. Points Dug	Total Eggs	Egg Density (M^2)	Egg Survival	Percent of Total Eggs	Salmon Observed	Percent of Total Salmon
I	0	-	-	-	-	20	.6
II	0					90	2.7
III	3	0	-	-	0.0	90	2.7
IV	10	170	91.5	21.4	2.1	309	9.1
V	10	556	299.1	77.9	6.7	330	9.7
VI	23	2,493	583.2	74.6	30.0	772	22.9
VII	18	1,300	388.6	61.2	15.7	614	18.2
VIII	14	2,010	772.4	66.6	24.2	469	13.9
IX	15	1,478	530.1	49.7	17.8	526	15.6
X	5	292	314.2	45.5	3.5	157	4.6
Total/ Average	98	8,299	455.6	64.2	100.0	3,377	100.0

Egg deposition estimates obtained by hydraulic sampler may also be used to estimate total egg deposition in Upper Russian Creek. Investigations in 1972 divided the stream into ten 200-yard sections. Total spawning area in each section was estimated at 90 percent of total area available. Multiplying average egg density/M^2 by estimated M^2 of spawning area in the creek yields an estimated egg deposition of 6,300,950 in 1974. Similar estimates for 1972 and 1973 revealed estimated egg deposition to be 5,639,875 and 4,420,070 eggs.

Table 17 compares early run egg deposition estimates derived by hydraulic sampler (hereafter referred to as direct method) and fecundity/mortality

(hereafter referred to as indirect method) findings. Only comparable sections have been examined and totals presented, therefore, do not represent total estimates for entire stream.

Table 17. Upper Russian Creek Early Run Red Salmon Egg Deposition as Calculated by Direct (Hydraulic Sampler) and Indirect (Fecundity X Number of Females) Methods, 1972-1974.

	1972 Deposition		1973 Deposition		1974 Deposition	
Section	Direct (Sampler)	Indirect (Fecundity)	Direct (Sampler)	Indirect (Fecundity)	Direct (Sampler)	Indirect (Fecundity)
0						
I						
II						
III					0.0	450,450
IV	636,210	1,922,400	651,750	2,448,900	125,810	1,559,250
V	75,465	2,971,710	122,675	3,401,250	524,920	1,663,200
VI	855,915	4,457,565	800,445	6,326,325	1,253,880	3,898,125
VII	704,780	2,735,415	697,705	3,968,125	509,070	3,083,850
VIII	760,490	2,415,015	193,440	4,126,850	957,775	2,373,525
IX					832,255	2,650,725
X					174,380	796,950
Total	3,032,860	14,502,105	2,466,015	20,271,450	4,378,090	16,476,075

Calculations involving deposition by direct means are basic, i.e., average eggs/M^2 times number of M^2 in the respective section. Calculations by indirect means are more complex and depend upon the following assumptions:

(1) Females sampled at Lower Russian Lake weir to determine fecundity are representative of the population. Fecundity in 1972 is assumed to be average of 1973 and 1974 fecundity or about 4,100.

(2) Sex ratios for years under consideration as determined at Lower Russian Lake weir are representative of the population.

(3) Mortality between weir and spawning grounds is 5.1 percent annually (Nelson, 1973). It is further assumed mortality is non-selective and males and females perish at similar rates.

(4) Investigations in 1972 revealed 1.1 percent of the females to reach spawning grounds perished without spawning. It is assumed this approximated conditions experienced by stocks in 1973 and 1974 and has been employed in calculations for these years.

(5) In 1972 average egg retention per spent female was about 95. This figure was used in 1973 and 1974 calculations.

(6) Mortality from predation is known to occur when early run fish enter Upper Russian Creek. As no quantitative data are available, no correction could be made.

(7) Counts conducted in each section represent percent of the escapement to spawn in that section.

Table 17 indicates major discrepancies exist between direct and indirect methods of estimating egg deposition. Indirect estimation yielded consistently higher results than did direct sampling.

To determine which technique provides the most accurate estimate of egg deposition, the theoretical adult return from the 1972-1974 early run spawning populations was calculated employing the hypothetical mortality Table of Foerster (1968, p. 67). Computations to determine return for 1972 based on indirect methods are:

(1) Sex ratio of 1:1.5 or 2,440 males and 3,660 females = 6,100 red salmon in Section IV-VIII.

(2) Egg deposition based on indirect method = 14,502,105.

(3) Egg loss during spawning and incubation - 50% or 7,251,050 alevins remaining.

(4) Alevin loss after emergency and migration to lake - 75% or 5,438,290 fry; remainder 1,812,760 rearing fry.

(5) During lake residence - 92% or 1,667,740 fry; remainder 145,020 smolt.

(6) Ocean mortality - 90% of 130,520 rearing fish - remainder 14,500 adults.

(7) Return per spawning fish - 2.4.

(8) Total return to the system (stream counts showed 69.3% of the salmon spawned in Sections IV-VIII) = 20,925.

Similar calculations were made for 1972 utilizing data from direct sampling. Remaining years under consideration were also subject to above analysis. Results are presented in Table 18.

Table 18. Hypothetical Return of Progeny (After Foerster 1968, p. 67) from Early Run Russian River Escapements Determined by Direct and Indirect Methods, 1972-1974.*

Year	Spawning Salmon	Egg Deposition	Freshwater Mortality	Marine Mortality	Returning Adults	Adults/ Spawner
			DIRECT (Hydraulic Sampling)			
1972	6,100	3,032,860	3,002,530	27,300	3,030	0.5
1973	8,535	2,466,015	2,441,355	22,195	2,465	0.3
1974	11,660	4,378,090	4,334,310	39,400	4,380	0.4
			INDIRECT (Fecundity)			
1972	6,100	14,502,100	14,357,080	130,520	14,500	2.4
1973	8,535	20,271,450	20,068,735	186,500	16,215	1.9
1974	11,660	16,476,080	16,311,320	148,285	16,475	1.4

* Return from 1972-1973 spawning populations are based on data from Section IV-VIII only.
Returns for 1974 escapement are based on data from Section III-X only.

It should be emphasized that Foerster's mortality table is hypothetical and may not approximate mortalities of early Russian River red salmon at various life history stages. In fact, Foerster indicates that this table may not truly reflect mortalities in any natural red salmon system. It is designed as a model and mortalities at various stages have been derived from different investigations in numerous geographic areas.

It, therefore, does not necessarily follow that because discrepancies exist between direct and indirect sampling techniques, that one or the other method is incorrect. Indirect estimation yields the potential number of eggs which are available for deposition, and does not necessarily reflect the eggs which are in the stream. Direct estimation (providing sampling design is correct) should indicate the number of eggs in Upper Russian Creek at time of sampling.

The indirect method does not take into account predation on adult fish prior to spawning. It also does not compensate for eggs which are not deposited in the redd, eggs washed out of the gravel, or eggs lost to predation.

Indirect estimates presented in Table 18, therefore, reflect the maximum number of eggs which have the potential to be deposited in Upper Russian Creek. Direct estimates are believed to reflect numbers of eggs which were actually deposited. If this is true, survival of eggs/fry must be greater at later developmental stages than Foerster's model suggests. This point will remain unresolved until such time as the magnitude of the early run smolt migration can be determined.

Bear Creek Investigations

Bear Creek is a relatively small spring-fed tributary on the east side of Upper Russian Lake (Figure 3). This area is utilized exclusively by a segment of the late run and has been under investigation since 1972 when Nelson (1973) suggested the majority of the late run spawned here. Prior information and a description of this system has been presented (Nelson, 1973, 1974).

Efforts to enumerate late run red salmon in this system by ground counts and tagging programs in 1972 and 1973 were unsuccessful. Intense brown, Ursus arctos, and black, U. americanus, bear predation complicated tag recovery. Successive spawning waves and spawning duration (approximately 1.5 months) negated data obtained from ground counts. Stream life of these fish was also unknown.

To determine numbers of fish which utilized the stream in 1974, a temporary weir was established 175 feet upstream from the mouth. Escapement into the system was 5,386 red salmon or 21.8 percent of total late run escapement (Table 19). Table 19 indicates salmon entered the stream in two waves - September 12-13 and again, September 18-20. These waves contributed 71.3 percent of the total immigration into Bear Creek. Whether or not the weir disrupted normal migration pattern is not known.

Eighty-nine red salmon (48 males and 41 females) were tagged at the weir to determine stream life. Recovery was effected by daily ground surveys of spawning areas. Operations were severely hampered by bear predation which seemed to be more intense than in prior years. Six tags were recovered - two in carcasses and four from the bottoms of ponds. These limited recoveries indicated stream life ranged from 18 to 34 days averaging 24.2 (Table 20).

Table 20. Stream Life of Late Run Red Salmon in Bear Creek, Upper Russian Lake, Determined by Tag Recovery, 1974.

Date Tagged	Type of Tag	Date Recovered	Stream Life (Days)
9/25	Floy (red)	10/12	18
9/25	1" P.D. (yellow)*	10/13	17
9/26	1" P.D. (white)	10/16**	21
9/26	5/8" P.D. (yellow)	10/16**	21
9/27	5/8" P.D. (yellow)	10/30**	34
9/27	5/8" P.D. (yellow)	10/30**	34
Average			24.2

* Petersen disc.

** Tags were recovered from spawning ponds and were not in carcass at time of recovery.

Table 19. Daily Late Run Russian River Red Salmon Weir Counts Conducted at Bear Creek (Upper Russian Lake), September 6 through October 10, 1974.

Date*	Daily Red Salmon	Cumulative Red Salmon
9/ 6	0	0
9/ 7	0	0
9/ 8	0	0
9/ 9	0	0
9/10	0	0
9/11	0	0
9/12	357	357
9/13	283	640
9/14	0	640
9/15	8	648
9/16	0	648
9/17	3	651
9/18	270	921
9/19	926	1,847
9/20	2,006	3,853
9/21	13	3,866
9/22	0	3,866
9/23	63	3,929
9/24	0	3,929
9/25	0	3,929
9/26	0	3,929
9/27	418	4,347
9/28	0	4,347
9/29	0	4,347
9/30	80	4,427
10/1	0	4,427
10/2	414	4,841
		4,841
		100**
		225***
		200****
	Total	5,386

* Weir constructed August 30 and tended from September 6 through October 27.
** Fish which had entered stream prior to weir construction.
*** Estimated fish passed when weir moved.
**** Fish held for access denial.

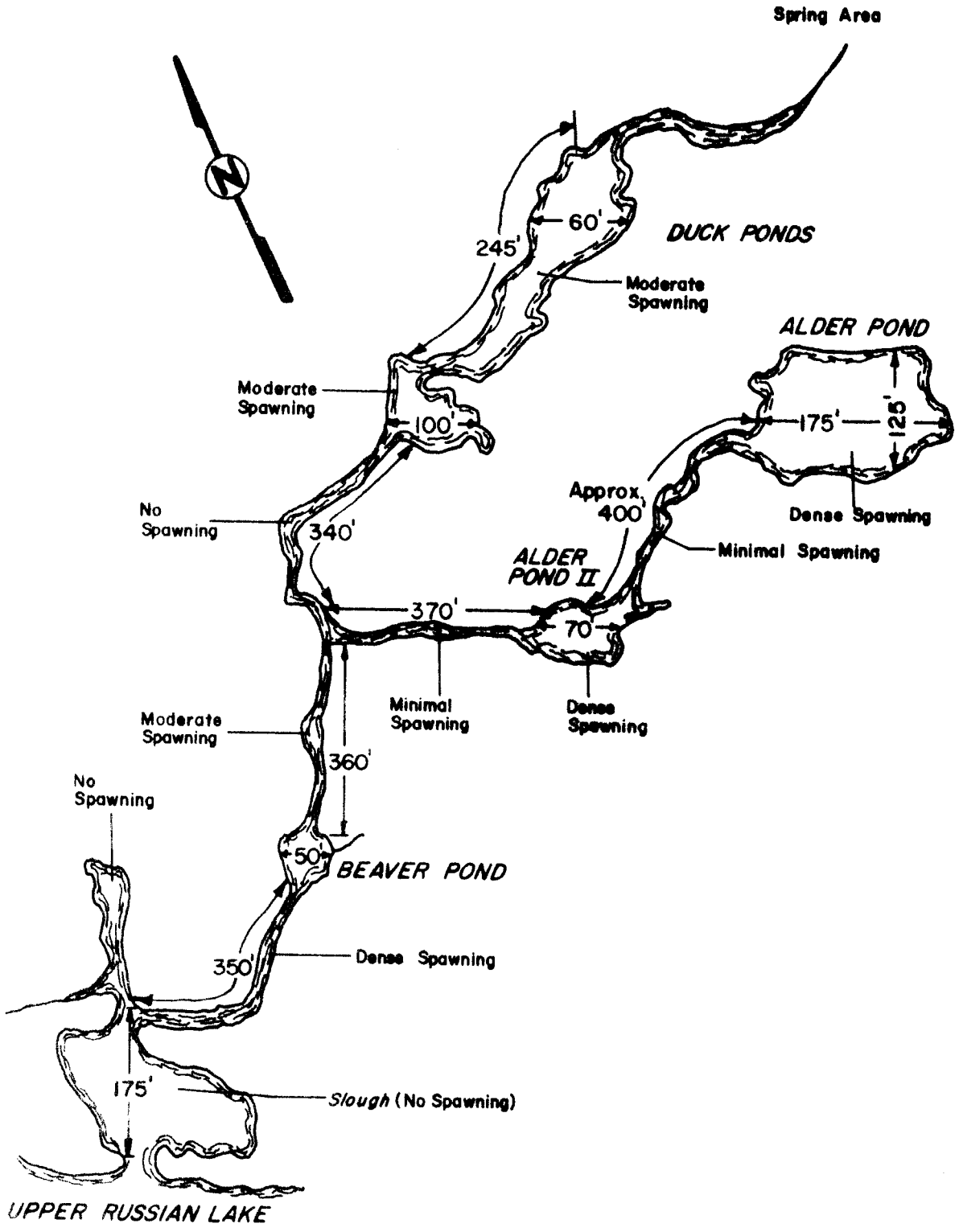

Figure 5. Schematic Diagram of Bear Creek, Upper Russian Lake (Not To Scale).

Recoveries of this magnitude are insufficient to justify definitive conclusions regarding stream life in this system. Subjective observations, however, suggest stream life may be of appreciable duration and approximate results indicated in Table 20. On October 10, the weir was closed and access denied to an estimated 200 salmon to determine if they could be induced to spawn in the shoal area of Upper Russian Lake. On project termination (October 30), an estimated 1,500 red salmon remained in Bear Creek.

Fifty-one late run carcasses above the weir were opened to determine spawning success. No eggs were found in 41.1 percent of the carcasses and only one fish examined perished without spawning. Average egg retention was 80.5 eggs per female (Table 21). Carcasses subjected to predation were not considered.

Table 21. Egg Retention of Untagged Late Run Russian River Red Salmon in Bear Creek, Upper Russian Lake, 1974.

Eggs Retained (Range)	Average Eggs Retained	Number of Red Salmon	Percent of Total Sample
0	0.0	21	41.1
1-50	6.4	25	49.0
51-100	66.5	2	3.9
101-150	-	0	-
151-200	188.0	1	2.0
201-250	-	0	-
251-400	365.0	1	2.0
Unspawned	3,261.4*	1	2.0
Total/Average	80.5**	51	100.0

* Eggs retained calculated as average fecundity of late run females.
** Weighted average.

Late run carcasses were also examined in Upper Russian River (area between Upper and Lower Russian Lake) and in the shoal area of Upper Russian Lake. Average egg retention in Upper Russian River was 383.4 eggs/female. Two salmon (11.1 percent) perished without spawning. Thirteen females examined in Upper Russian Lake were totally spent. One female perished without spawning. Average egg retention in this area was 119.1 eggs per female (Table 22).

Table 17. Egg Retention of Late Run Russian River Red Salmon Examined in Upper Russian River (between Upper and Lower Russian Lakes) and in the Shoal Area of Upper Russian Lake, 1974.

Eggs Retained (Range)	Average Eggs Retained	Number of Red Salmon	Percent of Total Sample
UPPER RUSSIAN RIVER			
0	0.0	6	33.3
1-50	8.3	9	50.0
50 plus	304.0	1	5.6
Unspawned	3,261.4*	2	11.1
Total/Average	383.4**	18	100.0
UPPER RUSSIAN LAKE			
0	0.0	13	38.3
1-50	7.5	17	50.1
51-100	86.0	1	2.9
101-150	125.0	1	2.9
151-450	437.0	1	2.9
Unspawned	3,261.4*	1	2.9
Total/Average	119.1**	34	100.0

* Eggs retained calculated as average fecundity of late run females.
** Weighted average.

On October 10 the weir was moved from the original location to the mouth of Bear Creek. The weir was closed denying an estimated 200 late run red salmon access to their natal stream. Fish were seined in the shoal area of the lake and 152 tagged. The remainder served as controls. Purpose of this investigation was to determine if late run red salmon which were denied access to their parent stream could be induced to spawn in the shoal area of Upper Russian Lake. If these fish would spawn successfully, it would have important management implications as the system could then be managed for optimum spawner density (i.e. production).

Logistical considerations prevented Department personnel from reaching Upper Russian Lake between October 19 and 23. Heavy rain during this period raised the water level of Bear Creek an estimated 12 inches allowing all salmon to circumvent the weir. Red salmon were successfully denied access to the system for nine days. During this period no spawning was observed in the vicinity of the weir. On October 24, all tagged salmon were observed actively spawning in Bear Creek. This phase of the investigation was, therefore, deferred until the 1975 field season when appropriate weir modification has been made.

During the five day period July 8-July 12, 15 members of the United States Forest Service Youth Conservation Corps (YCC) assisted the Department of Fish and Game in turning gravel in Bear Creek. The purpose of this effort was to attempt to restore the productivity of the system by removal of decaying organic materials. Productivity of the system was low in 1973 as egg survival was 4.6 percent.

To evaluate efforts of YCC personnel and determine egg survival, the system was again examined with a hydraulic sampler (Table 23). Egg density was estimated at 1,146/M^2 and survival was 11.4 percent. Although survival is somewhat higher than 1973 estimates, it is considered poor and does not approach 1972 survival estimates. Factors causing the limited survival in 1974 are not known as observation suggested environmental conditions were excellent.

Table 23. Bear Creek (Upper Russian Lake) Late Run Red Salmon Egg Densities and Percent Viable Eggs by Area, 1972-1974.

	YEAR					
	1972		1973		1974	
	Density	% Viable	Density	% Viable	Density	% Viable
Alder Pond I	3,239	92.2	979	1.2	1,067	30.3
Duck Pond	2,668	97.9	874	11.1	361	9.4
Beaver Pond	1,905	94.6	534	0.0	263	12.5
Alder Pond II	-	-	-	-	2,900	4.2
Total Stream	2,623	94.8	796	4.6	1,146	11.4

Table 23 also indicates considerable care must be taken when estimating egg deposition by hydraulic sampling. In 1972 and 1973 three ponds were sampled to determine deposition and survival. In 1974 a fourth pond (Alder II) was examined. Density in this area was the highest recorded (2,900 eggs/M^2). If this area were deleted, egg deposition and survival would be 564 eggs/M^2 and 17.4 percent, respectively. These data are then comparable to 1972-1973 estimates and may be useful as an index to survival and density.

Potential egg deposition in Bear Creek may be calculated indirectly applying the following parameters:

(1)	Bear Creek escapement	5,386
(2)	Jack escapement (3.0%)	162
(3)	Adults to system	5,224
(4)	Females to system (sex ratio of 1:1.1)	2,736
(5)	Fecundity of late run females	3,524
(6)	Theoretical egg deposition	9,641,664
(7)	Eggs retained/female (80.5 X 2,736)	220,248
(8)	Potential egg deposition	9,421,416

It is recognized that mortality due to predation on adult fish does occur and that an unknown number of females perish when partially spent or unspawned. The above also does not compensate for eggs lost to predation or dislodged from the gravel by superimposition. Deposition estimates for late run red salmon are, therefore, somewhat greater than actually exist and reflect potential, not actual numbers of eggs in Bear Creek.

As suggested by Nelson (1974) a relationship appears to exist between late run escapements enumerated at Lower Russian River weir and egg deposition in Bear Creek determined by hydraulic sampling. This relationship was again evidenced in 1974 and data may be used to compute the theoretical Bear Creek escapement in 1972 and 1973 (Table 24).

Table 24. Russian River Late Run Escapement, Fish Spawning in Bear Creek (1974), Bear Creek Egg Density, and Theoretical Bear Creek Spawning Population, 1972-1974.

Year	Late Run Escapement	Bear Creek Escapement	Egg Density	Estimated Bear Creek Escapement
1972	79,000	Unknown	2,623	20,461
1973	24,970	Unknown	796	7,566
1974	24,647	5,386	564	5,299

Egg density for three ponds (excluding Alder II) sampled in 1974 was 21.5 percent of estimated 1972 density. Escapement in 1974 was 21.9 percent of the 1972 escapement. Egg deposition in 1973 was 30.3 percent of 1972 density estimates. Escapement in 1973 was 31.6 percent of the 1972 escapement. Assuming that average fecundity in 1972 approximated average fecundity in 1973 and 1974, these percentages suggest that during the three years under consideration, the number of fish spawning in Bear Creek were directly proportionate to total escapement. Additional data on Bear Creek escapement are necessary to confirm or refute this hypothesis.

Ground counts of other late run spawning areas at Upper Russian Lake were conducted in conjunction with Bear Creek investigations. Counts were made at Upper Russian Creek, between Upper and Lower Russian Lake, and on three small tributaries of minor important (Table 25).

Table 25. Surveys of Late Run Russian River Red Salmon Spawning Areas, Upper Russian Lake, 1974.

Area	Number of Counts Conducted	Red Salmon
Bear Creek	Weir Count	5,386
Canyon Creek	7	1,000
Beaver Creek	5	50
Bog Creek	5	25
Upper Russian Creek	1	2,500
Upper Russian River	1	1,180
Upper Russian Lake	None	14,509

Escapement estimates in Canyon, Beaver, Bog and Upper Russian creeks are somewhat subjective as all salmon did not simultaneously enter the creek. Late run salmon were first observed schooling off Canyon Creek, September 22 and off Upper Russian Creek, September 7. Spawning in these tributaries was not complete until late October. No appreciable numbers of schooling fish were observed off the mouths of Bog or Beaver creeks.

Salmon spawning in Upper Russian Lake cannot be visually enumerated. Estimates regarding spawning fish in this area were considered to be total red salmon escapement minus the sum of escapement counts in other spawning areas. It is estimated that in 1974 Upper Russian Lake was utilized by 59.5 percent of the late run.

Fry Sampling and Smolt Investigations

On April 4, 1974, Upper Russian Creek was examined to determine egg and/or fry development. The stream bed was turned with gravel shovels. On April 15 the stream was checked by hydraulic sampler. No eggs or fry were found by either method and it is concluded fry emerged and migrated to Upper Russian Lake prior to April 4. Sampling in Bear Creek on April 11 revealed eggs in the "eyed" stage. Weather and logistical considerations precluded determination of egg to fry survival at a later date. Smolt investigations were not conducted during this report period.

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