Fishery Data Series No. 97-1

Catch and Effort Statistics for the Sockeye Salmon Sport Fishery During the Late Run to the Russian River with Estimates of Escapement, 1995

by

Larry E. Marsh

February 1997

Alaska Department of Fish and Game **Division of Sport Fish**

Symbols and Abbreviations

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
metric ton	mt
milliliter	ml
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
ounce	oz
pound	lb
quart	qt
yard	yd

Spell out acre and ton.

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
hour (spell out for 24-hour clock)	h
minute	min
second	s

Spell out year, month, and week.

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

All commonly accepted abbreviations.	e.g., Mr., Mrs., a.m., p.m., etc.
All commonly accepted professional titles.	e.g., Dr., Ph.D., R.N., etc.
and	&
at	@
Compass directions:	
east	E
north	N
south	S
west	W
Copyright	©
Corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
et alii (and other people)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.,
id est (that is)	i.e.,
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
number (before a number)	# (e.g., #10)
pounds (after a number)	# (e.g., 10#)
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S. state and District of Columbia abbreviations	use two-letter abbreviations (e.g., AK, DC)

Mathematics, statistics, fisheries

alternate hypothesis	H_A
base of natural logarithm	e
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	F, t, χ^2, etc.
confidence interval	C.I.
correlation coefficient	R (multiple)
correlation coefficient	r (simple)
covariance	cov
degree (angular or temperature)	°
degrees of freedom	df
divided by	÷ or / (in equations)
equals	=
expected value	E
fork length	FL
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$\log_2$, etc.
mideye-to-fork	MEF
minute (angular)	'
multiplied by	x
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
standard length	SL
total length	TL
variance	Var

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by

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February 1997

This investigation was partially financed by the Federal Aid in Sport Fish Restoration Act (16 U.S.C. 777-777K) under project F-10-11, Job No. S-2-7.

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This document should be cited as:
Marsh, L. E. 1997. Catch and effort statistics for the sockeye salmon sport fishery during the late run to the Russian River with estimates of escapement, 1995. Alaska Department of Fish and Game, Fishery Data Series No. 97-1, Anchorage.

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

Appendix **Page**

ABSTRACT

A direct expansion creel survey of the late-run Russian River recreational fishery was conducted from 12 July-20 August 1995 to determine angler effort for and harvest of sockeye salmon *Oncorhynchus nerka*. Anglers expended 71,125 (SE = 6,015) hours to harvest 11,986 (SE = 1,072) sockeye salmon from the late run. The harvest rate for this fishery was 0.169 sockeye salmon per hour of angler effort. Approximately 85% of the total fish harvested during the late run were taken from the confluence area of the fishery.

During the late run, 61,982 sockeye salmon bound for spawning areas were counted through the weir at the outlet of Lower Russian Lake. This total exceeds the escapement goal of 30,000 sockeye salmon that has been established for the late run by the Board of Fisheries. An estimated 73,968 sockeye salmon returned to the Russian River during the 1995 late run.

Predominant age groups of the recreational harvest and the escapement were 2.3- and 2.2-age fish. The majority of the fish harvested in the confluence area were age 2.3 (45%) and 2.2 (30%). The river area harvest comprised ages 2.3 (38%) and 2.2 (36%). Sockeye salmon that escaped through the weir at the outlet of Lower Russian Lake were mainly age 2.2 (32%) and 2.3 (32%). The age composition of the harvest did not change significantly ($P > 0.23$) over time between the confluence and the river areas of the recreational fishery. However, the age composition of the river area harvest did vary significantly over time ($P = 0.05$). Data from the confluence area and the river area were not combined because of the significant differences in age class composition of the river harvest. Age composition of the escapement through the weir differed from that of the harvest ($P < 0.01$), and differed between the two temporal strata ($P < 0.01$). Estimated age composition of the total late return (harvest plus escapement) was predominantly age-2.2 and age-2.3 sockeye salmon (34% and 32%, respectively).

A stream survey indicated that a minimum of 12,479 sockeye salmon spawned in the Russian River downstream from the Russian River falls. Carcass sampling indicated that the most abundant age group (1.3) comprised 72.9% of the population that spawned downstream from the falls.

Key words: Russian River, sockeye salmon, *Oncorhynchus nerka*, creel survey, direct expansion, harvest, effort, weir, escapement, age composition, recreational fishery, mean length at age, harvest rate.

INTRODUCTION

The Russian River is a clearwater stream located in the central Kenai Peninsula near Cooper Landing, Alaska. The drainage includes two large clearwater lakes, Upper and Lower Russian lakes, and terminates in the Kenai River approximately midway between Kenai and Skilak lakes (Figure 1). The second largest recreational fishery for sockeye salmon *Oncorhynchus nerka* in Alaska occurs in the Russian River and at its confluence with the Kenai River (Mills 1979-1994, Howe et al. 1995). Annual effort by anglers in this fishery has exceeded 450,000 angler-hours and annual harvests have exceeded 190,000 fish. Prior information on this fishery was presented by Lawler (1963, 1964), Engel (1965-1972), Nelson (1973-1985), Nelson et al. (1986), Athons and McBride (1987), Hammarstrom and Athons (1988, 1989), Carlon and Vincent-Lang (1990), Carlon et al. (1991), and Marsh (1992-1995).

Sockeye salmon return to the Russian River in two temporal components, termed early and late runs. Historically, the total return of the late run has numbered nearly twice that of the total return of the early run. The late run typically arrives at the confluence of the Russian and Kenai rivers in mid to late July. Late-run fish typically move immediately into the Russian River and are present in the area open to fishing through August. Late-run fish comprise two segments based upon spawning location: (1) those spawning upstream of the Russian River falls, and (2) those spawning downstream from the falls. Most fish migrating through the falls spawn in Upper Russian Lake, but others spawn in the tributaries to Upper Russian Lake and in the river section

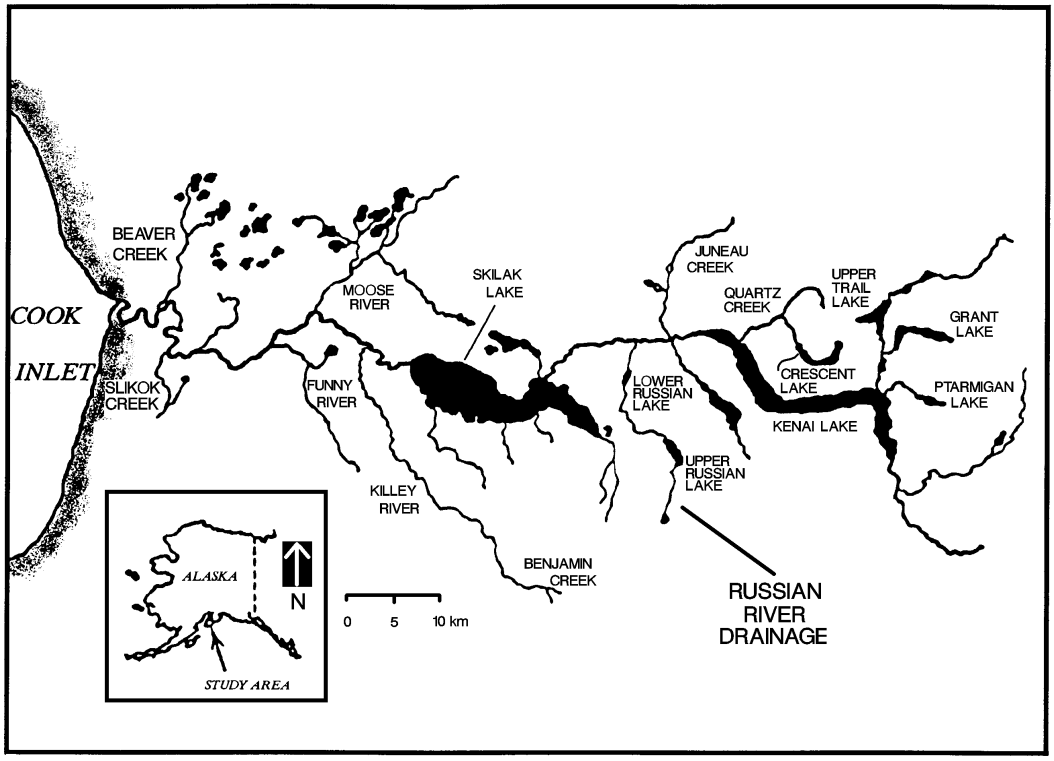

Figure 1.-Map of the Kenai and Russian River drainages.

between the two lakes. These fish are primarily 2-ocean fish and rear in the two lakes.[1] The other segment spawns in the Russian River downstream from the falls. These fish, primarily 3-ocean fish, are more closely associated with the age structure of sockeye salmon spawning in the mainstem Kenai River (Cross et al. 1983, 1985, 1986). These fish are believed to spend their fresh-water residency in Skilak Lake.

In addition to the sport fisheries described above, late-run sockeye salmon of Russian River origin are also harvested by a sport fishery in the mainstem Kenai River, a personal-use dip net fishery near the mouth of the Kenai River, and a commercial fishery in upper Cook Inlet. Estimates of the total sport harvest of sockeye salmon in the mainstem of the Kenai River have been reported annually since 1977 (Mills 1979-1994, Howe et al. 1995). The personal use dip net harvest has been estimated in the Statewide Harvest Survey since 1983 (Mills 1984-1994, Howe et al. 1995). The commercial catch and total return of sockeye salmon to the Kenai River have been reported by Cross et al. (1983, 1985, 1986).

The Division of Sport Fish of the Department of Fish and Game manages the recreational fishery to ensure that a minimum escapement of 30,000 late-run sockeye salmon migrate through a weir at the outlet of Lower Russian Lake (Figure 2). This escapement goal, established in 1979, is based upon an evaluation of returns from past brood years.

With the exception of 1977 when the spawning escapement was 21,410 (Nelson 1978), the escapement goal has been achieved each year since 1975. Because the recreational fishery for sockeye salmon at the

[1] Juvenile sockeye salmon have been captured in nets in both lakes.

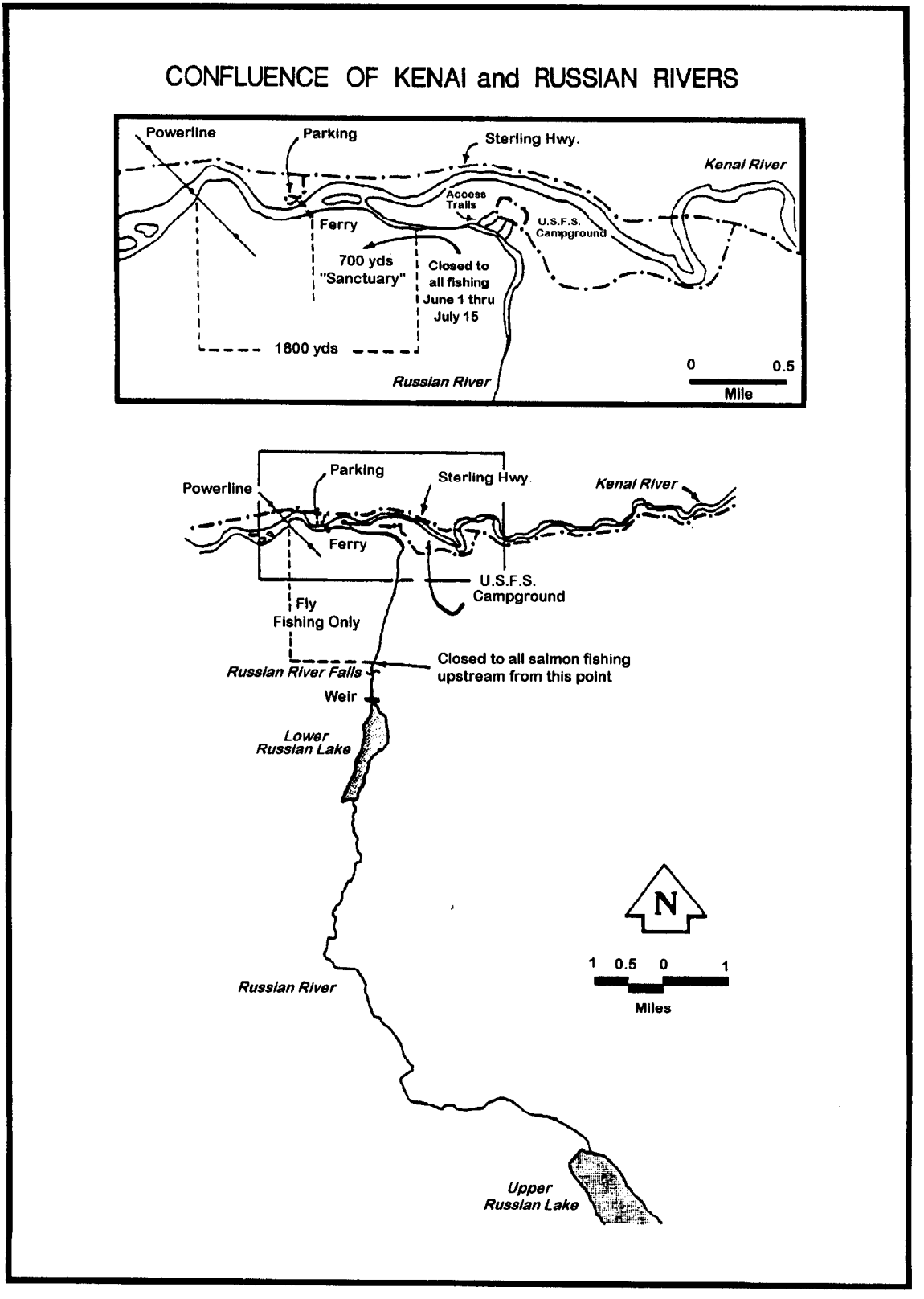

Figure 2.-Detailed map of the Kenai River and Russian River study area.

Russian River has one of the highest levels of angler participation in the state, there is a potential for overharvest. Accurate and timely management decisions are required to ensure that an adequate spawning escapement is obtained. The data necessary for these decisions are provided by a creel survey and a counting weir. The creel survey provides estimates of angler effort and harvest in the recreational fishery. This recreational fishery occurs in the Kenai and Russian river "fly-fishing-only" area (Figure 2). Weir operations census the daily escapement. Estimates of the total inriver return (harvest plus escapement) and the age, sex, and size compositions of the return provide information to evaluate overall production and to estimate optimum spawning escapement levels.

From 11 June through 20 August 1995, the daily bag and possession limit for sockeye salmon taken from the Kenai/Russian River fly-fishing-only area was three fish of 406 mm (16 in) or more in length. Within this area, from a marker located 540 m (600 yd) downstream from the Russian River falls to a marker located on the Kenai River 1,620 m (1,800 yd) downstream from the confluence with the Russian River, only a single-hook unbaited, unweighted fly with a point-to-shank measurement of 9.5 mm (3/8 in) or less constituted legal terminal tackle. Any weights attached to the line were required to be a minimum of 457 mm (18 in) above the hook.

This report presents estimates for the 1995 late run: (1) effort and harvest for the recreational fishery; (2) spawning escapement; and (3) the age, sex, and length distributions of the harvest and escapement.

METHODS

STUDY AREA

The recreational fishery occurs in two areas (Figure 3): (1) the confluence, which extends from the upper limit marker of the sanctuary area[2] downstream approximately 1.6 km to a marker on the Kenai River identifying the downstream limit of the "fly-fishing-only" area; and (2) the river, which extends from the upper limit of the sanctuary area upstream approximately 3.2 km on the Russian River to a marker identifying the upper limit of the "fly-fishing-only" area.

Access to the two fishing areas occurs at two locations. A United States Forest Service (USFS) campground located on the east side of the Russian River provides four short trails which intersect the main riverside trail affording access to the river. The trails serve four camping/parking areas within the Russian River Campground. These areas are designated with the following names: (1) Grayling, (2) Rainbow Trout, (3) Pink Salmon, and (4) Red Salmon. Access to the confluence is primarily through a parking area administered by the United States Fish and Wildlife Service (USFWS) and located on the north bank of the Kenai River directly across from the Russian River confluence. Immediately adjacent to the USFWS parking area is a cable ferry which traverses the Kenai River. Most anglers fishing the confluence use the ferry to reach the south bank of the Kenai River. Both the parking area and the ferry are operated privately under a concession administered by the USFWS. Some anglers also use the ferry to cross the Kenai River and then walk upstream to fish

[2] The sanctuary area begins in the Russian River 137 m upstream of the confluence with the Kenai River and extends downstream to a marker placed approximately 25 m (75 ft) immediately down river of the ferry cable crossing (approximately 640 m).

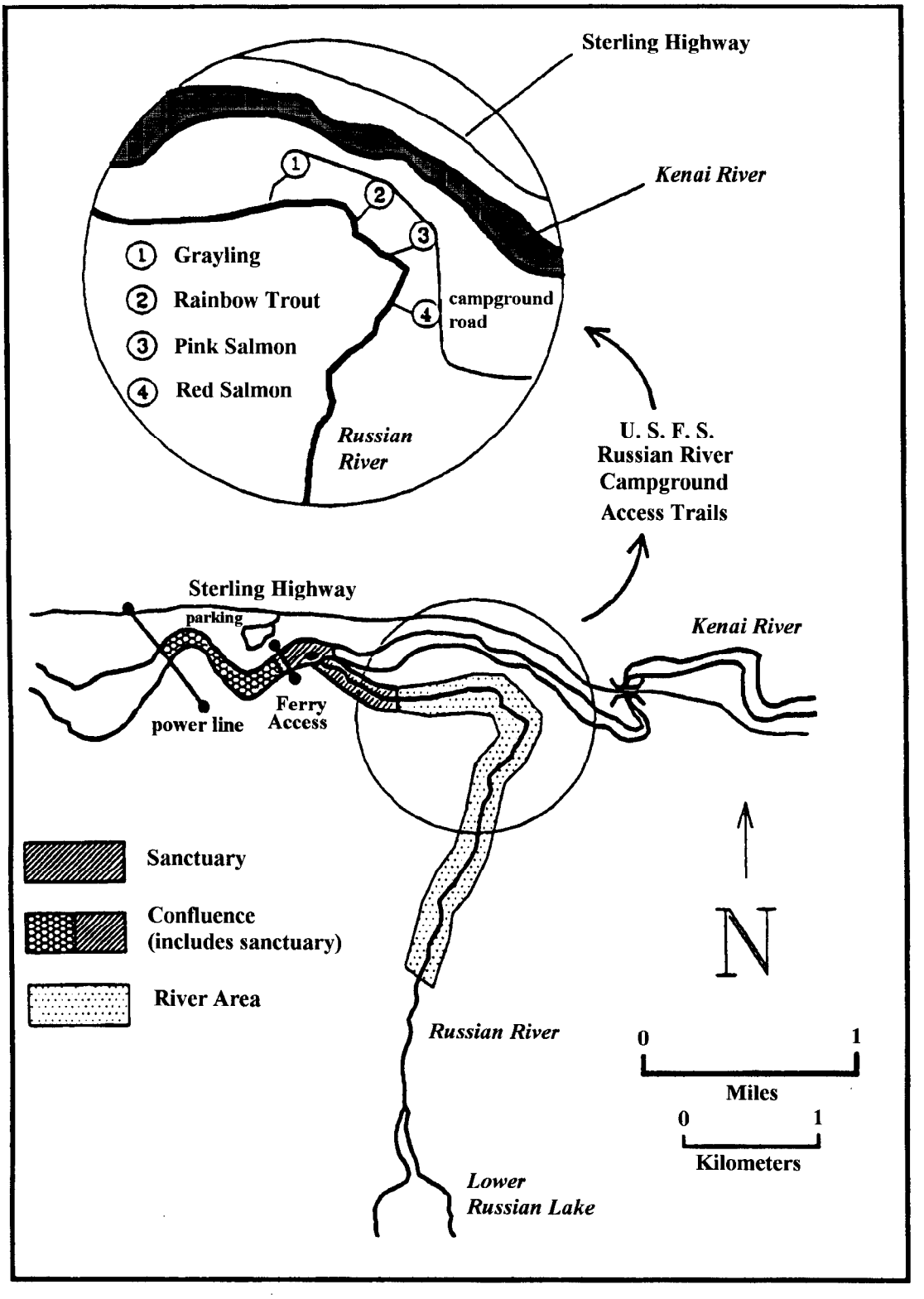

Figure 3.-Map of the Russian River sockeye salmon recreational fishing areas and fishing access locations sampled during the 1994 creel survey.

the Russian River. Anglers may also use the USFS campground trails to gain access to the confluence.

A stationary weir, constructed of metal and wood, is located just downstream from the outlet of Lower Russian Lake and approximately 360 m (400 yd) upstream from the Russian River Falls (Figure 2). The weir has been described in detail (Nelson 1976) and provides a complete count of the late-run spawning escapement.

STUDY DESIGN

Creel Survey

Inseason management of the sport fishery utilizes the daily harvest rates as an index of fish abundance as well as the cumulative total harvest to track the harvest potential of the recreational fishery. These estimates, used in concert with the cumulative weir counts and migratory timing statistics from the historical weir counts, allow fishery managers to project the final escapement that accounts for the potential harvest (Vincent-Lang and Carlon 1991).

A direct expansion creel survey was utilized during the 1995 late run. Sampling was stratified by access location to estimate harvest and effort. Area-specific (river or confluence) harvest and effort were estimated by recording the area fished for each interviewed angler. Three of the five main access locations for the Russian River sockeye salmon fishery, (the Ferry, Grayling and Pink Salmon) were sampled. The fishery was surveyed from 12 July to 20 August. Because the age distribution of sockeye salmon of the escapement and the sport harvest from the river changed over time, the data were post-stratified into two temporal components (Table 1).

The sampling day was 18 hours in length and was divided into six, 3-hour periods from 0600 to 2400 hours. A three-stage sampling design was used with days as primary units, periods as secondary units, and anglers as tertiary units. Days were systematically sampled, and within each sampled day, two 3-hour periods were selected from the six possible periods at random using a weighted selection procedure. All anglers exiting an access location during a sampled period were counted and as many as possible were interviewed for harvest and effort data by area fished (river or confluence). Thus, all interviews were of completed-trip anglers. Anglers exiting a location during a sampled period and not interviewed were prorated as river or confluence anglers based on proportions determined from anglers that were interviewed. Count and interview data were then expanded for each stratum to account for area-specific harvest and effort during periods and days that were not sampled.

Table 1.-Temporal components of the recreational harvest and escapement sampled for age composition during the 1995 late-run Russian River sockeye salmon return.

Return Component	Temporal Strata
Confluence-area harvest	7/12 - 8/05 8/06 - 8/20
River-area harvest	7/12 - 8/05 8/06 - 8/20
Escapement through weir	7/12 - 8/05 8/06 - 9/11
Escapement spawning between the confluence and the falls	8/28, 9/04

Creel data collected in 1991 and 1992 indicated that three major access sites (the Ferry, Grayling and Pink Salmon) accounted for more than 90% of the total harvest and effort and also contributed approximately 90% of the total variance of both these estimates (Carlon et al. 1991, Marsh 1992). Therefore, since 1992 only these three access sites have been sampled.

Using data collected in 1990-1994, sample effort was optimally allocated among the available sampling days at each access site (Cochran 1977). During the late run, the ferry was sampled every 2 days, Grayling every 4-5 days and Pink Salmon every 5-6 days.

The following formulae were applied to estimate angler effort and harvest for a stratified, three-stage (day/period/trip) direct expansion creel survey (Bernard et al. *In prep*). Total effort, harvest, and their variances were estimated for the entire run by summing the stratum (access location) estimates. In addition, the estimates were post-stratified by area fished (river or confluence) and by temporal stratum for the river.

At access location k on day i during sample period j, m_{kij} represents those completed anglers interviewed as they exited through location k and a_{kij} represents those anglers that exited and were counted but were not interviewed. Interviewed anglers were assigned to one of three groups:

m_{1kij} = anglers that fished the river only,

m_{2kij} = anglers that fished the confluence only, or

m_{3kij} = anglers that fished both areas, and

$$m_{kij} = m_{1kij} + m_{2kij} + m_{3kij}. \quad (1)$$

Area-specific harvest of missed anglers (a_{kij}) was estimated based on data obtained in interviews. The proportion of missed anglers that fished the river was estimated as:

$$\hat{P}_{rkij} = \frac{m_{rkij}}{m_{kij}}, \quad (2)$$

where:

m_{rkij} = the number of interviewed anglers fishing the river,

$= m_{1kij} + m_{3kij}$.

The number of missed anglers fishing the river ($\hat{a}_{rkij}$) was estimated as:

$$\hat{a}_{rkij} = a_{kij}\hat{P}_{rkij}. \quad (3)$$

The total number of anglers fishing the river and exiting the fishery at location k on day i during sample period j was estimated as:

$$\hat{M}_{rkij} = m_{rkij} + \hat{a}_{rkij} \quad . \quad (4)$$

The same procedure was used to estimate the missed anglers who fished the confluence area:

$$\hat{M}_{ckij} = m_{ckij} + \hat{a}_{ckij} \quad . \quad (5)$$

The mean river area harvest per interviewed angler was estimated as:

$$\bar{h}_{rkij} = \frac{\sum_{l=1}^{m_{rkij}} h_{rkijl}}{m_{rkij}}, \quad (6)$$

where:

h_{rkijl} = the river area harvest of angler l exiting at location k on day i during sample period j.

The variance of river area harvest among interviewed anglers was estimated assuming a normal variate as:

$$Var\left(\bar{h}_{rkij}\right) = \frac{\sum_{l=1}^{m_{rkij}} \left(h_{rkijl} - \bar{h}_{rkij}\right)^2}{m_{rkij} - 1} \quad . \quad (7)$$

The total river area harvest of anglers exiting through access location k on day i during sample period j was estimated as:

$$\hat{H}_{rkij} = \hat{M}_{rkij}\,\bar{h}_{rkij}\,. \tag{8}$$

The mean river area harvest per period was then estimated for location k on day i as:

$$\overline{H}_{rki} = \frac{\sum_{j=1}^{u_{ki}} \hat{H}_{rkij}}{u_{ki}}, \tag{9}$$

where:

u_{ki} = the number of sample periods at location k on day i (u = 2),

and the variance among sample periods was estimated as:

$$\mathrm{Var}\left(\overline{H}_{rki}\right) = \frac{\sum_{j=1}^{u_{ki}} \left(\hat{H}_{rkij} - \overline{H}_{rki}\right)^2}{u_{ki} - 1}. \tag{10}$$

The total river area harvest of anglers exiting through access location k on day i was estimated by expanding the mean river area harvest per period on day i by:

$$\hat{H}_{rki} = U_{ki}\overline{H}_{rki}\ , \tag{11}$$

where:

U_{ki} = the total number of periods at location k on a day (U = 6).

The mean river area harvest per day was estimated at location k as:

$$\overline{H}_{rk} = \frac{\sum_{i=1}^{d_k} \hat{H}_{rki}}{d_k}\ , \tag{12}$$

where:

d_k = the number of days sampled at location k.

The variance of river area harvest among days at location k was estimated using the variance for a systematic sample as:

$$\mathrm{Var}\left(\overline{H}_{rk}\right) = \frac{\sum_{i=2}^{d_k} \left(\hat{H}_{rki} - \hat{H}_{rk(i-1)}\right)^2}{2\left(d_k - 1\right)}. \tag{13}$$

The total river area harvest at location k was estimated by expanding the mean harvest per day by:

$$\hat{H}_{rk} = D_k\overline{H}_{rk}\ , \tag{14}$$

where:

D_k = the total number of days during the run at location k.

The variance of the total river area harvest at location k was estimated as:

$$\begin{aligned}\mathrm{Var}\left(\hat{H}_{rk}\right) = {} & \left(1 - f_1\right)D_k^{\,2}\,\frac{\mathrm{Var}\left(\overline{H}_{rk}\right)}{d_k} + \\ & D_k\,\frac{U_{ki}^{\,2}}{u_{ki}}\left(1 - f_2\right)\frac{\sum_{i=1}^{d_k}\mathrm{Var}\left(\overline{H}_{rki}\right)}{d_k} + \\ & D_k U_{ki}\sum_{i=1}^{d_k}\sum_{j=1}^{u_{ki}}\hat{M}_{rkij}^{\,2}\left(1 - f_3\right)\frac{\mathrm{Var}\left(\bar{h}_{rkij}\right)}{d_k u_{ki} m_{rkij}}\ ,\end{aligned} \tag{15}$$

where:

f_1 = the finite population correction factor for days (d_k/D_k),

f_2 = the finite population correction factor for periods (u_{ki}/U_{ki}), and

f_3 = the finite population correction factor for anglers (m_{rkij}/M_{rkij}).

These procedures (Equations 2 through 15) were also used to estimate the confluence-area harvest of anglers exiting through each access location. Likewise, the same procedures were used to estimate effort (in angler-hours) expended at the river and the confluence by substituting the area-specific hours of effort reported by interviewed anglers for the reported harvest in Equations 2 through 15.

Total harvest and effort were estimated for the run by summing the individual stratum estimates. The variances of the total estimates were calculated as the sum of the variances of the individual stratum estimates.

Daily harvest rates were estimated and used for inseason management as an indicator of sockeye salmon abundance. Regardless of access location, the daily confluence area harvest rate was based solely on confluence effort and the resultant harvest reported by interviewed anglers. The mean daily harvest rate of the confluence area was estimated as:

$$\overline{\mathrm{HPUE}_{ci}} = \frac{\sum_{l=1}^{m_{ci}} \mathrm{HPUE}_{cil}}{m_{ci}}, \qquad (16)$$

where:

HPUE_{cil} = confluence-area harvest per hour of effort for angler l.

The variance of this estimate was calculated as:

$$\mathrm{Var}\left(\overline{\mathrm{HPUE}_{ci}}\right) = \frac{\sum_{l=1}^{m_{ci}} \left(\mathrm{HPUE}_{cil} - \overline{\mathrm{HPUE}_{ci}}\right)^2}{m_{ci}\left(m_{ci} - 1\right)}. \qquad (17)$$

The same procedure was used to estimate river-area harvest rates.

The overall harvest rate for the late run was historically estimated to provide a general basis for comparing seasonal fishing success among years (Nelson 1985, Hammarstrom and Athons 1989). A harvest rate for the late run was estimated by dividing the total harvest estimate by the total effort estimate. The associated variance was then calculated as the variance of a quotient of two random variables. The same procedure was applied to estimate the harvest rate within each spatial component of the recreational fishery (confluence and river).

Spawning Escapement

The escapement of spawning sockeye salmon to the Russian River drainage was enumerated at the stationary weir at the outlet of Lower Russian Lake. Foot surveys were used to estimate the segment of the sockeye salmon return (as well as other salmonid species) that spawned in the river area below the weir. An adjustable gate system allowed fish to be passed individually and counted by the weir operator. During the period of overlap of early and late runs of sockeye salmon (mid to late July), fish from each run were subjectively identified by degree of external sexual maturation (body color and kype development) and counted separately. Early in each run, sockeye salmon adults have not yet developed the reddish body coloration and large green head with hooked jaws that is characteristic of more sexually mature fish passing through the weir later in each run. Therefore, during the period of run overlap at the weir, the last of the early-run fish typically exhibit the reddish body coloration and green head while the late-run fish have not yet developed these body characteristics. The period of overlap began on 24 July when late-run fish were intermixed with mature, early-run fish and continued through 31 July, after which early-run fish were no longer present.

Biological Data

Six time-and-area strata were sampled for biological data to estimate the age, sex, and length composition of the late run (Table 1). Differences in age composition over time among spatial strata have been demonstrated in the past (Carlon and Vincent-Lang 1990, Carlon et al. 1991, Marsh 1992-1995).

Scales were collected from the preferred area of each sampled fish and placed on adhesive-coated cards (Clutter and Whitesel 1956). Sex and length (measured from the mid-eye to the fork-of-tail to the nearest millimeter) of each sampled fish were also determined and recorded. Scale impressions were made in clear acetate and examined with a microfiche reader for aging. The European method of age description was used to record ages: the numeral preceding the decimal represents the number of freshwater annuli and the numeral following the decimal represents the number

of marine annuli. Total age is therefore the sum of the two numbers plus one.

Prior to 1990, age data of the sport harvest from the confluence were used to estimate the age composition of the harvest from both the confluence and river (Nelson et al. 1986, Carlon and Vincent-Lang 1990). This assumes that the age composition of the confluence harvest is the same as that of the river; however, significant differences in age composition were found among the three (confluence harvest, river harvest and weir escapement) sampled areas (Carlon et al. 1991, Marsh 1992-1995). Based on these results, each area was sampled during 1995. Chi-square tests were used to test the null hypotheses of equal age compositions among locations and time strata. These hypotheses were rejected if calculated tail-area probabilities (P values) were less than 0.05.

Age and sex composition of the run was estimated for each stratum. The proportion of fish of age-sex group g in stratum f was estimated as:

$$\hat{p}_{gf} = \frac{x_{gf}}{n_f}, \tag{18}$$

where:

x_{gf} = the number of legible scales read from sockeye salmon sampled during stratum f and interpreted as age g, and

n_f = the total number of legible scales read from sockeye salmon sampled during stratum f.

The variance of this proportion was estimated as (Scheaffer et al. 1979):

$$\mathrm{Var}\left(\hat{p}_{gf}\right) = \frac{\hat{p}_{gf}\left(1-\hat{p}_{gf}\right)}{n_f - 1} \quad . \tag{19}$$

The harvest of sockeye salmon by age-sex group within each stratum was estimated by:

$$\hat{H}_{gf} = \hat{H}_f \, \hat{p}_{gf} \ , \tag{20}$$

where:

H_f = the estimated total harvest of sockeye salmon during stratum f.

The variance of the harvest by age-sex group was estimated as the product of two independent random variables (Goodman 1960):

$$\begin{aligned} \mathrm{Var}\left(\hat{H}_{gf}\right) = \quad & \hat{H}_f^2 \, \mathrm{Var}\left(\hat{p}_{gf}\right) + \\ & \hat{p}_{gf}^2 \, \mathrm{Var}\left(\hat{H}_f\right) - \\ & \mathrm{Var}\left(\hat{p}_{gf}\right)\mathrm{Var}\left(\hat{H}_f\right) \ , \end{aligned} \tag{21}$$

where:

$\mathrm{Var}\left(\hat{H}_f\right)$ = the variance of the harvest estimate during stratum f.

Total harvest by age-sex group from the confluence and from the river was estimated by summing the estimates among the temporal strata. The total number of fish of age-sex g in the harvest from the river was estimated as:

$$\hat{H}_{rg} = \sum_{f=1}^{t} \hat{H}_{rgf} \ , \tag{22}$$

where:

t = the number of temporal strata in the run.

The variance of the estimate was calculated by summing the variances of the individual temporal stratum estimates as:

$$\mathrm{Var}(\hat{H}_{rg}) = \sum_{f=1}^{t} \mathrm{Var}\left(\hat{H}_{rgf}\right). \tag{23}$$

The proportion of sockeye salmon of age-sex g in the total sport harvest from the river was estimated as:

$$\hat{p}_{rg} = \frac{\hat{H}_{rg}}{\hat{H}_r} \ , \tag{24}$$

where:

$\hat{H}_r$ = the estimated total harvest of sockeye salmon from the river.

The approximate variance of this proportion was estimated using the delta method (Seber 1982:7-8) as:

$$\mathrm{Var}\left(\hat{p}_{rg}\right) \approx \frac{1}{\hat{H}_r^2}\left\{\frac{\mathrm{Var}\left(\hat{H}_{r1}\right)\left[\hat{H}_r\hat{p}_{rg1} - \hat{H}_{rg}\right]^2}{\hat{H}_r^2} + \mathrm{Var}\left(\hat{p}_{rg1}\right)\hat{H}_{r1}^2 + \mathrm{Var}\left(\hat{p}_{rg2}\right)\hat{H}_{r2}\right\}, \quad (25)$$

where:

$\hat{H}_{rf}$ and $\mathrm{Var}\left(\hat{H}_{rf}\right)$ = the estimates of harvest and variance of harvest from the river during temporal stratum f,

$\hat{p}_{rgf}$ and $\mathrm{Var}\left(\hat{p}_{rgf}\right)$ = the estimates of proportion and variance of proportion of fish of age g sampled from the harvest from the river during temporal stratum f, and

$\hat{H}_{rg}$ = the estimated harvest of fish of age g from the river.

This proportion and its variance were estimated similarly for the harvest of sockeye salmon from the confluence.

The number of sockeye salmon of age group g of stratum f in the escapement was estimated by sex using the estimates of the age group proportions defined previously:

$$\hat{E}_{gf} = E_f\hat{p}_{gf}, \quad (26)$$

where:

E_f = the total number of sockeye salmon enumerated during stratum f at the weir or spawning down-stream from the falls.

The variance of $\hat{E}_{gf}$ was estimated as:

$$\mathrm{Var}\left(\hat{E}_{gf}\right) = E_f^2\mathrm{Var}\left(\hat{p}_{gf}\right). \quad (27)$$

The age composition of the escapement through the weir was estimated by summing the stratum estimates. The total number of fish of age-sex g migrating through the weir was estimated as:

$$\hat{E}_g = \sum_{f=1}^{t}\hat{E}_{gf}. \quad (28)$$

Similarly, the variance was estimated as the sum of the variances as:

$$\mathrm{Var}\left(\hat{E}_g\right) = \sum_{f=1}^{t}\mathrm{Var}\left(\hat{E}_{gf}\right). \quad (29)$$

The proportion of sockeye salmon of age g in the total escapement migrating through the weir was estimated as:

$$\hat{p}_{eg} = \frac{\hat{E}_g}{\hat{E}_T}; \quad (30)$$

where:

E_T = the total escapement enumerated at the weir.

The variance of this proportion was estimated by:

$$\mathrm{Var}\left(\hat{p}_{eg}\right) = \frac{\mathrm{Var}\left(\hat{E}_g\right)}{E_T^2}. \quad (31)$$

The total return, total return by age-sex, and their respective variances were estimated by summing the estimates from the total harvest at the confluence and at the river, and from the escapement. The proportion of sockeye salmon of age-sex g in the total return was estimated as:

$$\hat{p}_g = \frac{\hat{N}_g}{\hat{N}_T}, \quad (32)$$

where:

$\hat{N}_g$ = the estimated total return of fish of age g, and

age g, and

$\hat{N}_T$ = the estimate of the total return.

The approximate variance of this proportion was estimated using the delta method (Seber 1982:7-8) as:

$$\mathrm{Var}\left(\hat{P}_g\right) \approx$$

$$\frac{1}{\hat{N}_T^2}\left\{\frac{\mathrm{Var}\left(\hat{H}_c\right)\left[\hat{p}_{cg}\left(\hat{H}_r + E\right) - \left(\hat{H}_{rg} + \hat{E}_g\right)\right]^2}{\hat{N}_T^2}\right.$$

$$+\frac{\mathrm{Var}\left(\hat{H}_r\right)\left[\hat{p}_{rg}\left(\hat{H}_c + E\right) - \left(\hat{H}_{cg} + \hat{E}_g\right)\right]^2}{\hat{N}_T^2} \qquad (33)$$

$$\left. + \mathrm{Var}\left(\hat{p}_{cg}\right)\hat{H}_c^2 + \mathrm{Var}\left(\hat{p}_{rg}\right)\hat{H}_r^2 + \mathrm{Var}\left(\hat{p}_{eg}\right)E^2\right\}$$

where:

$\hat{H}_\bullet$ and $\mathrm{Var}\left(\hat{H}_\bullet\right)$ = the estimates of total harvest and variance of total harvest from the river (r) or the confluence (c), and

$\hat{p}_{\bullet g}$ and $\mathrm{Var}\left(\hat{p}_{\bullet g}\right)$ = the estimates of proportion and variance of proportion of fish of age-sex g from the total harvest from the river (r) or the confluence, or from the escapement (e).

Mean length at age was estimated by sex for each spatial/temporal stratum of the return: the confluence harvest, the river harvest, and the weir escapement. To determine if mean length at age differed by area, temporal stratum, and sex, an analysis of variance (ANOVA) and Tukey's studentized multiple range test were utilized. The null hypothesis of no difference in mean length at age was rejected if the calculated tail-area probabilities (P values) were less than 0.05.

RESULTS

CREEL STATISTICS

Sampling at access locations began on 12 July. Sampling at Grayling and Pink Salmon continued until 20 August which is the normal regulatory closure date. The third access location (Ferry) also continued operation until 20 August.

A total of 2,056 anglers were counted as they exited sampled access locations (Table 2). Of these, 1,791 (87%) were interviewed and 265 (13%) were not interviewed. Most of the interviews (65%) were obtained at the ferry which typically accounts for the most effort (Appendix A1). The remaining interviews were collected at Grayling (26%) and at Pink Salmon (9%).

Nearly all the anglers exiting via the ferry location fished the confluence exclusively (99%) during the late run (Appendix A2). Campground access locations were used to fish both areas. However, the majority of anglers exiting the Grayling access site fished the confluence (66%), while the majority of anglers who exited at Pink Salmon fished the river (74%).

HARVEST AND EFFORT

Anglers exiting the fishery at the ferry accounted for most of the harvest (54%) and the corresponding effort (55%) during the late run (Table 3). The relative precision of the late-run harvest and effort estimates were 18% and 17%, respectively (Table 3). Estimates of harvest, effort, and variances are

Table 2.-Summary of the number of interviews collected during sampled periods for the late-run Russian River creel survey, 1995.

Exit Location	Area Fished: Confluence	Area Fished: River	Area Fished: Both	Total Interviews	Anglers Exiting and Not Interviewed	Total Anglers Exiting
Ferry	1,160	3	6	1,169	205	1,374
Grayling	305	117	42	464	44	508
Pink Salmon	19	117	22	158	16	174
Total	1,484	237	70	1,791	265	2,056

presented by stratum (temporal/access location) in Appendix A3.

The 1995 late-run harvest estimate was 11,986 (SE = 1,072) sockeye salmon (Table 4). The effort estimate for the late run was 71,125 (SE = 6,015) angler-hours. During the late run, 83% of the harvest was taken from the confluence and the remaining 17% was taken from the river (Table 4; Figure 4). Correspondingly, the effort during the late-run sport fishery was directed primarily at the confluence (81%) and less so at the river (19%).

The estimated HPUE for the late run was 0.169 (Table 5), which was a 42% decline in angler harvest efficiency from 1994 (Marsh 1995).

SPAWNING ESCAPEMENT

A total of 61,982 late-run sockeye salmon passed through the weir (Table 6, Appendix A4). The greatest daily counts at the weir occurred near the beginning of August (Figure 5). Transition between the two runs occurred from 24 July to 31 July. Weir enumeration ceased on 11 September.

Table 3.-Estimates of harvest, effort, and associated variances by access location for the late-run Russian River sockeye salmon recreational fishery, 1995.

Access Location	Harvest	(%)	Variance of Harvest	(%)	Relative Precision[a]	Effort[b]	(%)	Variance of Effort	(%)	Relative Precision[a]
Ferry	6,510	54	654,904	57	24%	39,331	55	22,654,995	63	24%
Grayling	3,952	33	313,790	27	28%	21,669	30	5,559,136	15	21%
Pink Salmon	1,524	13	180,976	16	55%	10,125	14	7,971,051	22	55%
Total	11,986	100	1,149,670	100	18%	71,125	100	36,185,182	100	17%

[a] $\alpha = 0.05$.

[b] Angler-hours.

Table 4.-Summary of estimated angler effort and harvest by component during the late run of Russian River sockeye salmon, 1995.

Component	Confluence Area	River Area	Total	95% Confidence Interval
Effort[a]	57,282	13,843	71,125	59,335 - 82,915
SE	5,303	2,840	6,015	
Harvest	9,947	2,039	11,986	9,884 - 14,088
SE	883	545	1,072	

[a] Angler-hours.

An estimated 12,479 sockeye salmon were counted during foot surveys of the Russian River downstream from the Russian River falls (Table 6).

We enumerated 1,673 coho salmon through the weir during the late run (Table 6 and Appendix A4). This was only a partial enumeration of the coho salmon return because the immigration of coho salmon continued after the weir was removed (Appendix A4).

BIOLOGICAL DATA

There was a significant difference in the age composition of sockeye salmon sampled at the weir relative to those harvested at the river and the confluence (Table 7). There was also a significant difference in the age composition of sockeye salmon at the weir among all the temporal strata (Table 8). The late-run escapement through the weir comprised five age groups (Table 9). Age-2.3 and -2.2 fish dominated the first temporal stratum (49% and 38%, respectively). However, the proportion of age-2.3 and 2.2 fish declined later in the return, representing only 18% and 27%, respectively, while the proportion of age-2.1 fish increased to 44% during the second temporal stratum.

The harvest at the confluence was not significantly different from the harvest in the river (Table 7). The late-run confluence harvest comprised predominantly age-2.3 (45%) and age-2.2 (30%) fish (Table 10). There were no significant temporal changes in the age composition of the harvest sampled at the confluence (Table 8). This allowed the biological data collected during the entire run at the confluence to be combined to estimate the harvest by age-sex group at the confluence.

The river harvest was also primarily age-2.3 (38%) and age-2.2 (36%) fish with age-1.3 and -1.2 contributing 13% and 9%, respectively, to the harvest (Table 11). However, the age composition of the river harvest differed significantly between the two temporal strata (Table 8). The harvest from the river was also largely age-2.3 (49%) and age-2.2 (26%) adults in the first temporal stratum. However, during the second temporal stratum the percentage of these two age groups nearly reversed with the percentage of age-2.2 adults increasing to 43% and that of age-2.3 adults declining to 30% (Table 11).

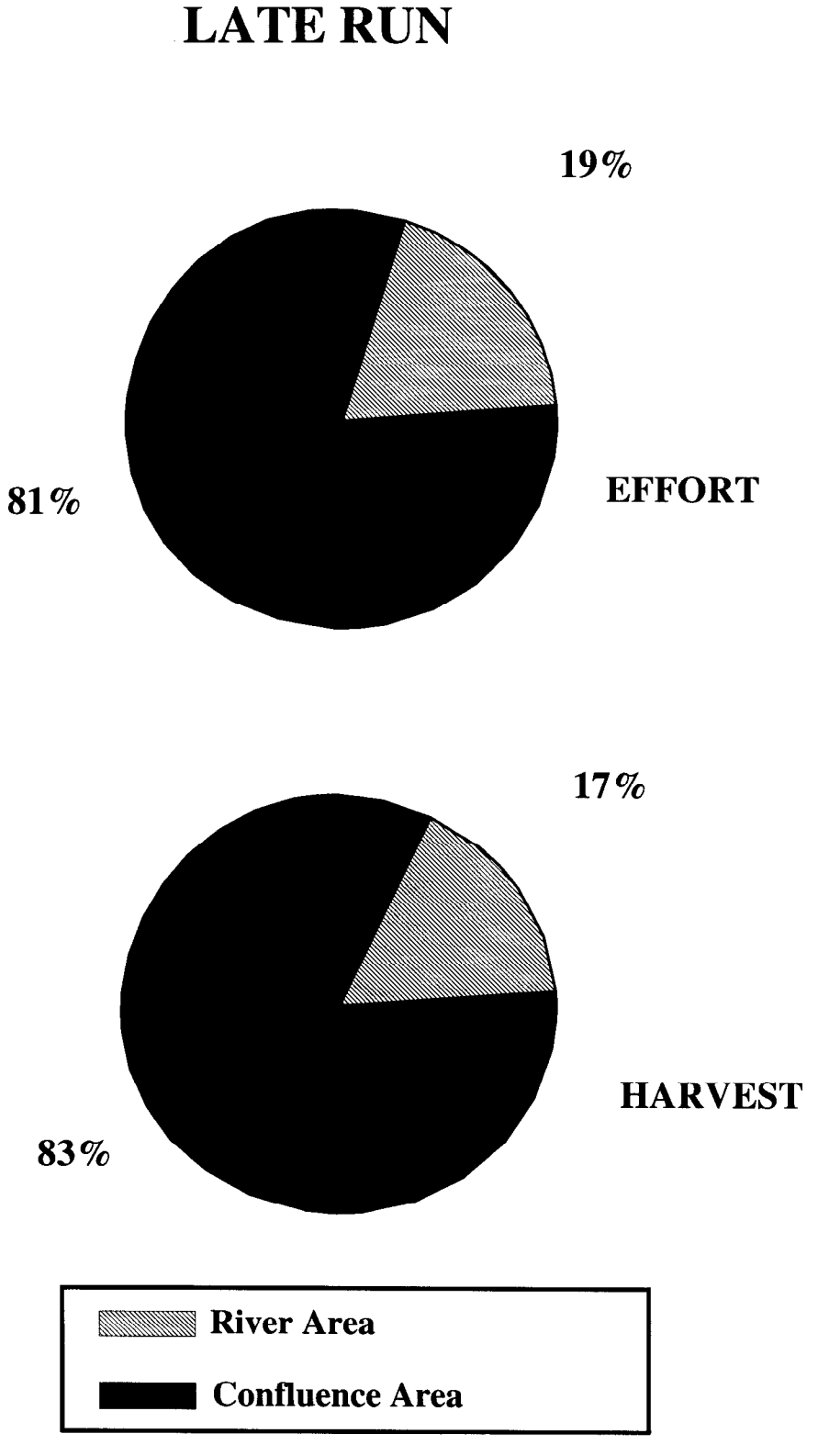

Figure 4.-Harvest and angler effort by area for the Russian River late-run sockeye salmon recreational fishery, 1995.

Table 5.-Estimated harvest per hour of angler effort (HPUE) by anglers interviewed during the late run of the Russian River sockeye salmon recreational fishery, 1995.

Area	Days n[a]	Days N[b]	Number of Interviews[c]	HPUE	Variance of HPUE
Confluence	28	40	1,519	0.174	0.0002
River	17	40	272	0.147	0.0016
Both			1,791	0.169	0.0002

[a] Number of days on which at least one angler reported fishing effort.

[b] Number of days possible for conducting interviews.

[c] Anglers who fished both areas are represented twice.

Table 6.-Escapements of sockeye, coho, and chinook salmon during the late run to the Russian River drainage, 1995.

Component	Dates	Sockeye Salmon	Coho Salmon	Chinook Salmon
Late run	07/12 - 9/11	61,982[a]	1,673	41
Downstream[b]	08/28[c]	12,479[d]		32[e]

[a] From 7/24 through 7/31, early-run fish were differentiated from late-run fish based on the degree of external maturation (color).

[b] Fish that spawned downstream from the Russian River falls.

[c] Two foot surveys (8/28 and 9/04) were made downstream from the Russian River falls. A greater number of fish were enumerated on 8/28. The tabulated values are for 8/28 only and represent a minimum estimate.

[d] 10,174 live fish and 2,305 dead fish that spawned downstream from the Russian River falls.

[e] 16 live fish and 16 dead fish enumerated downstream from Russian River falls.

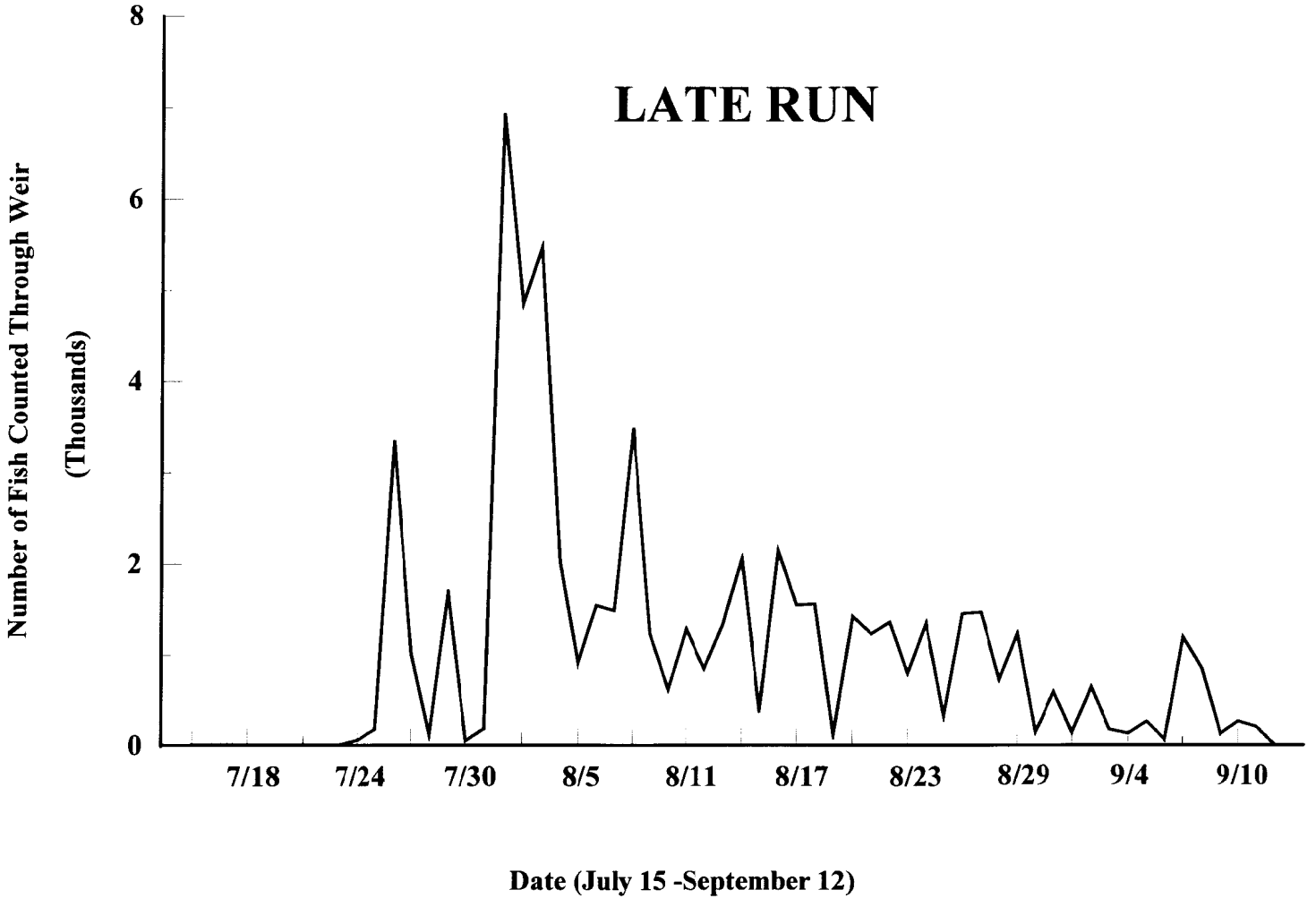

Figure 5.-Daily escapement of sockeye salmon though the Russian River weir during the late run, 1995.

Table 7.-Results of contingency test comparisons of age composition between spatial fishery components for the late-run Russian River sockeye salmon recreational fishery, 1995.

Temporal Stratum[a]	Spatial Component: Confluence Harvest vs. River Harvest	Spatial Component: Confluence Harvest vs. Weir Escapement	Spatial Component: River Harvest vs. Weir Escapement
1	df = 3, X^2 = 3.55, P = 0.31 NS[b] (P > 0.05)	df = 4, X^2 = 20.71, P = 0.001 S[b] (P < 0.05)	df = 4, X^2 = 20.21, P = 0.001 S[b] (P < 0.05)
2	df = 4, X^2 = 5.52, P = 0.24 NS[b] (P > 0.05)	df = 4, X^2 = 39.36, P = 0.001 S[b] (P < 0.05)	df = 4, X^2 = 34.80, P = 0.001 S[b] (P < 0.05)

[a] 1 = 7/12 - 8/05; 2 = 8/06 - 8/20 (8/06 - 9/11 for weir escapement).

[b] NS = no significant difference; S = significant difference.

Table 8.-Results of contingency test comparisons of age composition between temporal fishery components for the late-run Russian River sockeye salmon recreational fishery, 1995.

Spatial Component	Temporal Component: 12 July-5 Aug vs. 6 Aug-20 Aug[a]
Confluence Harvest	df = 4, X^2 = 7.13, P = 0.13 Not Significant, P > 0.05
River Harvest	df = 3, X^2 = 7.82, P = 0.05 Significant, P = 0.05
Weir Escapement	df = 6, X^2 = 173.87, P < 0.001 Significant, P < 0.05

[a] 8/06-9/11 for weir escapement.

Table 9.-Estimated age and sex composition of the late-run sockeye salmon escapement through the Russian River weir, 1995.

	Age Group					
	2.3	1.3	2.2	2.1	1.2	Total
July 12 - August 5						
Females						
Sample Size	34	7	34	0	1	76
Percent	19.1	3.9	19.1	0.0	0.6	42.7
Variance of Percent	8.7	2.1	8.7	0.0	0.3	13.8
Escapement	5,094	1,049	5,094	0	150	11,388
Variance of Escapement	621,022	151,831	621,022	0	22,451	983,284
Males						
Sample Size	54	4	34	8	2	102
Percent	30.3	2.2	19.1	4.5	1.1	57.3
Variance of Percent	11.9	1.2	8.7	2.4	0.6	13.8
Escapement	8,091	599	5,094	1,199	300	15,283
Variance of Escapement	849,338	88,282	621,022	172,506	44,649	983,284
Sexes Combined						
Sample Size	88	11	68	8	3	178
Percent	49.4	6.2	38.2	4.5	1.7	100.0
Variance of Percent	14.1	3.3	13.3	2.4	0.9	
Escapement	13,186	1,648	10,189	1,199	450	26,671
Variance of Escapement	1,004,594	233,010	948,783	172,506	66,592	
August 6 - September 11						
Females						
Sample Size	8	3	21	0	2	34
Percent	5.6	2.1	14.6	0.0	1.4	23.6
Variance of Percent	3.7	1.4	8.7	0.0	1.0	12.6
Escapement	1,962	736	5,150	0	490	8,337
Variance of Escapement	457,497	177,869	1,086,134	0	119,420	1,572,645
Males						
Sample Size	18	7	18	63	4	110
Percent	12.5	4.9	12.5	43.8	2.8	76.4
Variance of Percent	7.6	3.2	7.6	17.2	1.9	12.6
Escapement	4,414	1,717	4,414	15,449	981	26,974
Variance of Escapement	953,679	403,253	953,679	2,145,777	235,476	1,572,645
Sexes Combined						
Sample Size	26	10	39	63	6	144
Percent	18.1	6.9	27.1	43.8	4.2	100.0
Variance of Percent	10.3	4.5	13.8	17.2	2.8	
Escapement	6,376	2,452	9,563	15,449	1,471	35,311
Variance of Escapement	1,290,073	563,461	1,721,920	2,145,777	348,168	

-continued-

Table 9.-Page 2 of 2.

	Age Group					
	2.3	1.3	2.2	2.1	1.2	Total
Late Run Total						
Females						
Percent	11.4	2.9	16.5	0.0	1.0	31.8
Variance of Percent	2.8	0.9	4.4	0.0	0.4	6.7
Escapement	7,056	1,785	10,244	0	640	19,725
Variance of Escapement	1,078,518	329,699	1,707,156	0	141,871	2,555,929
Males						
Percent	20.2	3.7	15.3	26.9	2.1	68.2
Variance of Percent	4.7	1.3	4.1	6.0	0.7	6.7
Escapement	12,505	2,316	9,508	16,647	1,281	42,257
Variance of Escapement	1,803,017	491,536	1,574,700	2,318,283	280,125	2,555,929
Sexes Combined						
Percent	31.6	6.6	31.9	26.9	3.1	100.0
Variance of Percent	6.0	2.1	7.0	6.0	1.1	
Escapement	19,561	4,100	19,752	16,647	1,921	61,982
Variance of Escapement	2,294,667	796,471	2,670,703	2,318,283	414,761	

Table 10.-Estimated age and sex composition of late-run sockeye salmon harvested in the confluence area of the recreational fishery at the Russian River, 12 July-20 August 1995.

	Age Group					
	2.3	1.3	2.2	2.1	1.2	Total
Females						
Sample Size	45	12	25	1	17	100
Percent	25.4	6.8	14.1	0.6	9.6	56.5
Variance of Percent	10.8	3.6	6.9	0.3	4.9	14.0
Harvest	2,529	674	1,405	56	955	5,620
Variance of Harvest	160,750	39,140	84,601	3,158	56,249	408,978
Males						
Sample Size	34	5	28	3	7	77
Percent	19.2	2.8	15.8	1.7	4.0	43.5
Variance of Percent	8.8	1.6	7.6	0.9	2.2	14.0
Harvest	1,911	281	1,574	169	393	4,327
Variance of Harvest	117,936	15,979	95,543	9,531	22,503	298,248
Sexes Combined						
Sample Size	79	17	53	4	24	177
Percent	44.6	9.6	29.9	2.3	13.6	100.0
Variance of Percent	14.0	4.9	11.9	1.3	6.7	
Harvest	4,440	955	2,978	225	1,349	9,947
Variance of Harvest	307,481	56,249	193,318	12,746	80,991	852,139

Table 11.-Estimated age and sex composition of late-run sockeye salmon harvested in the river area of the Russian River recreational fishery, 1995.

	Age Group					
	2.3	1.3	2.2	2.1	1.2	Total
12 July - 5 August						
Females						
Sample Size	23	8	13	0	6	50
Percent	26.1	9.1	14.8	0.0	6.8	56.8
Variance of Percent	22.2	9.5	14.5	0.0	7.3	28.2
Harvest	226	78	127	0	59	490
Variance of Harvest	8,925	1,512	3,320	0	975	37,312
Males						
Sample Size	20	6	10	0	2	38
Percent	22.7	6.8	11.4	0.0	2.3	43.2
Variance of Percent	20.2	7.3	11.6	0.0	2.6	28.2
Harvest	196	59	98	0	20	373
Variance of Harvest	6,965	975	2,156	0	219	22,308
Sexes Combined						
Sample Size	43	14	23	0	8	88
Percent	48.9	15.9	26.1	0.0	9.1	100.0
Variance of Percent	28.7	15.4	22.2	0.0	9.5	
Harvest	422	137	226	0	78	863
Variance of Harvest	28,095	3,761	8,925	0	1,512	110,034
6 August - 20 August						
Females						
Sample Size	12	2	19	0	6	39
Percent	14.0	2.3	22.1	0.0	7.0	45.3
Variance of Percent	14.1	2.7	20.2	0.0	7.6	29.2
Harvest	164	27	260	0	82	533
Variance of Harvest	5,339	421	11,573	0	1,825	42,045
Males						
Sample Size	14	8	18	6	1	46
Percent	16.3	9.3	20.9	7.0	1.2	54.7
Variance of Percent	16.0	9.9	19.5	7.6	1.4	29.2
Harvest	191	109	246	82	14	643
Variance of Harvest	6,886	2,809	10,541	1,825	187	59,486
Sexes Combined						
Sample Size	26	10	37	6	7	86
Percent	30.2	11.6	43.0	7.0	8.1	100.0
Variance of Percent	24.8	12.1	28.8	7.6	8.8	
Harvest	356	137	506	82	96	1,176
Variance of Harvest	20,104	3,980	38,153	1,825	2,294	187,497

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Table 11.-Page 2 of 2.

	Age Group					
	2.3	1.3	2.2	2.1	1.2	Total
Late Run Total						
Females						
Percent	19.1	5.2	19.0	0.0	6.9	50.2
Variance of Percent	10.0	3.0	9.8	0.0	3.8	15.9
Harvest	390	106	387	0	141	1,024
Variance of Harvest	14,264	1,933	14,892	0	2,800	79,357
Males						
Percent	19.0	8.3	16.9	4.0	1.6	49.8
Variance of Percent	9.3	4.7	9.4	3.0	0.9	15.9
Harvest	388	168	344	82	33	1,015
Variance of Harvest	13,851	3,784	12,697	1,825	406	81,794
Sexes Combined						
Percent	38.1	13.4	35.9	4.0	8.5	100.0
Variance of Percent	16.5	6.9	16.1	3.0	4.6	0.0
Harvest	777	274	732	82	174	2,039
Variance of Harvest	48,199	7,741	47,078	1,825	3,806	297,531

The age composition of sockeye salmon that spawned in the Russian River downstream from the Russian River falls was primarily age-1.3 (73%) fish (Table 12). Ages-2.2 and -2.3 fish each contributed 13% and 10%, respectively. Mean length by age and sex was also estimated for this spawning component of the late run (Table 13).

Fish age-2.2 during the first temporal stratum were significantly larger ($F = 33.85$, $df = 2;208$, $P = 0.0001$) than those during the second stratum (Table 14). For fish age 2.3, males were significantly larger ($F = 13.94$, $df = 1;250$, $P = 0.0002$) than females.

TOTAL RETURN STATISTICS

Overall, an estimated 73,968 late-run sockeye salmon returned to the Russian River in 1995 (Table 15). Spawners below the falls were not included in this total. These fish, which are primarily 3-ocean fish, are more closely associated with the age structure of sockeye salmon spawning in the mainstem Kenai River (Cross et al. 1983, 1985, 1986) and are believed to spend their freshwater residency in Skilak Lake.

DISCUSSION

RELATIVE RUN STRENGTH

Total return of the 1995 late run was considerably less than the historical (1977-1994) average of 102,412 sockeye salmon (Figure 6). The 1995 late run, however, continued to follow a general trend, beginning

Table 12.-Estimated age and sex composition of sockeye salmon which spawned downstream from the Russian River Falls, 1995.

	Age Group				
	2.3	1.3	2.2	1.2	Total
24 August and 9 September [a]					
Females					
Sample Size	2	20	2	4	28
Percent	2.9	28.6	2.9	5.7	40
Variance of Percent	4.0	29.6	4.0	7.8	35
Number	357	3,565	357	713	4,992
Variance of Number	62,640	460,590	62,640	121,596	541,654
Males					
Sample Size	5	31	1	5	42
Percent	7.1	44.3	1.4	7.1	60
Variance of Percent	9.6	35.8	2.0	9.6	35
Number	891	5,526	178	891	7,487
Variance of Number	149,692	556,853	31,781	149,692	541,654
Sexes Combined					
Percent	10.0	72.9	4.3	12.9	100
Variance of Percent	13.6	65.3	6.1	17.4	
Number	1,248	9,092	535	1,604	12,479
Variance of Number	212,332	1,017,443	94,421	271,287	

[a] Indicates two distinct sampling dates.

Table 13.-Mean length at age, by sex, for sampled sockeye salmon which spawned below the falls area during the late run of sockeye salmon to the Russian River, 1995.

Component			Age Class 2.3	1.3	2.2	1.2
Downstream Escapement[a]						
	Female	Mean Length (mm)	530	556	527	515
		SE	5.0	4.8	6.0	4.6
		Sample Size	2	20	2	4
	Male	Mean Length (mm)	593	590	543	514
		SE	8.7	3.6		6.8
		Sample Size	5	31	1	5

[a] Fish that spawned downstream from Russian River falls.

Table 14.-Mean length (millimeters) at age, by sex, for the late run of sockeye salmon sampled from the Russian River, 1995.

		Age 2.3			Age 2.2			Age 2.1			Age 1.3			Age 1.2		
Component	Sex	n	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE
12 July - 5 August																
Confluence	F	31	568	4.1	16	528	6.0				7	564	8.0	11	503	4.0
	M	19	583	6.1	18	531	3.6				2	597	32.5	3	505	17.8
River	F	23	575	3.1	13	527	8.1				8	556	6.9	6	513	5.5
	M	20	579	3.3	10	530	5.2				6	557	10.3	2	494	18.5
Escapement[a]	F	34	570	3.2	34	539	3.1				7	589	6.3	1	535	
	M	54	586	2.8	34	527	4.8	8	408	6.1	4	613	12.3	2	524	11.5
6 August - 11 September[b]																
Confluence	F	14	568	5.3	9	521	6.4	1	390		5	571	6.3	6	522	4.9
	M	15	576	5.3	10	521	9.1	3	410	8.7	3	570	16.1	4	478	23.0
River	F	12	567	4.0	19	505	6.5				2	568	12.5	6	493	12.2
	M	14	583	3.1	18	508	10.9	6	391	3.3	8	586	8.4	1	515	
Escapement	F	8	578	9.1	21	505	7.2				3	598	3.0	2	521	1.0
	M	18	582	5.6	18	475	9.7	63	401	2.4	7	557	8.1	4	502	13.7

[a] Fish sampled through the weir at the outlet of Lower Russian Lake.

[b] Sampling of the recreational harvest at the river and confluence areas concluded on 8/20.

Table 15.-Estimated age and sex composition of the late run of sockeye salmon to the Russian River, 11 July-11 September 1995.

Late Run Total[a]	Age Group 2.3	1.3	2.2	2.1	1.2	Total
n = 673						
Females						
Percent	13.5	3.5	16.3	0.1	2.3	35.6
Variance of Percent	2.2	0.7	3.3	0.0	0.4	5.0
Number	9,975	2,565	12,036	56	1,737	26,368
Variance of Number	1,253,533	370,773	1,806,649	3,158	200,920	3,044,264
Males						
Percent	20.0	3.7	15.4	22.8	2.3	64.4
Variance of Percent	3.5	0.9	3.0	4.3	0.6	5.0
Number	14,803	2,765	11,426	16,898	1,707	47,600
Variance of Number	1,934,804	511,299	1,682,941	2,329,639	303,033	2,935,971
Sexes Combined						
Percent	33.5	7.2	31.7	22.9	4.7	100.0
Variance of Percent	4.5	1.6	5.1	4.3	0.9	0.0
Number	24,778	5,330	23,462	16,954	3,444	73,968
Variance of Number	2,650,347	860,461	2,911,099	2,332,854	499,558	1,149,670

[a] Confluence area harvest + river area harvest + escapement through the weir.

in 1978, of greater numbers of sockeye salmon returning to the Russian River system which surpass the (1963-1977) average of 46,454 sockeye salmon.

SAMPLE DESIGN

Creel Survey

An underlying assumption necessary for accurate harvest estimates is that most, if not all, anglers exit the fishery through one of the three sampled access locations. Although anglers left the fishery from other locations, these anglers were only a minor portion of the total fishery. Creel survey personnel and the project leader informally monitored the other access sites during the process of shift and site changes and found that use was relatively minor.

Observations of angler activity during the unsampled hours of 0000 to 0600 hours indicated that, generally, only small numbers of anglers were fishing at those hours during 1995. Here again, an informal accounting of activity during these hours was accomplished through conversations with anglers and frequent queries of the campground and ferry employees. Additionally, the project staff was instructed to maintain field note records of numbers of anglers observed fishing during nonsurveyed hours. Generally, such observations occurred just prior to beginning the early morning shift (0600 hours) or after the completion of the sampling day (2400 hours). Further observations were made when project staff conducted personal fishing trips during

LATE RUN

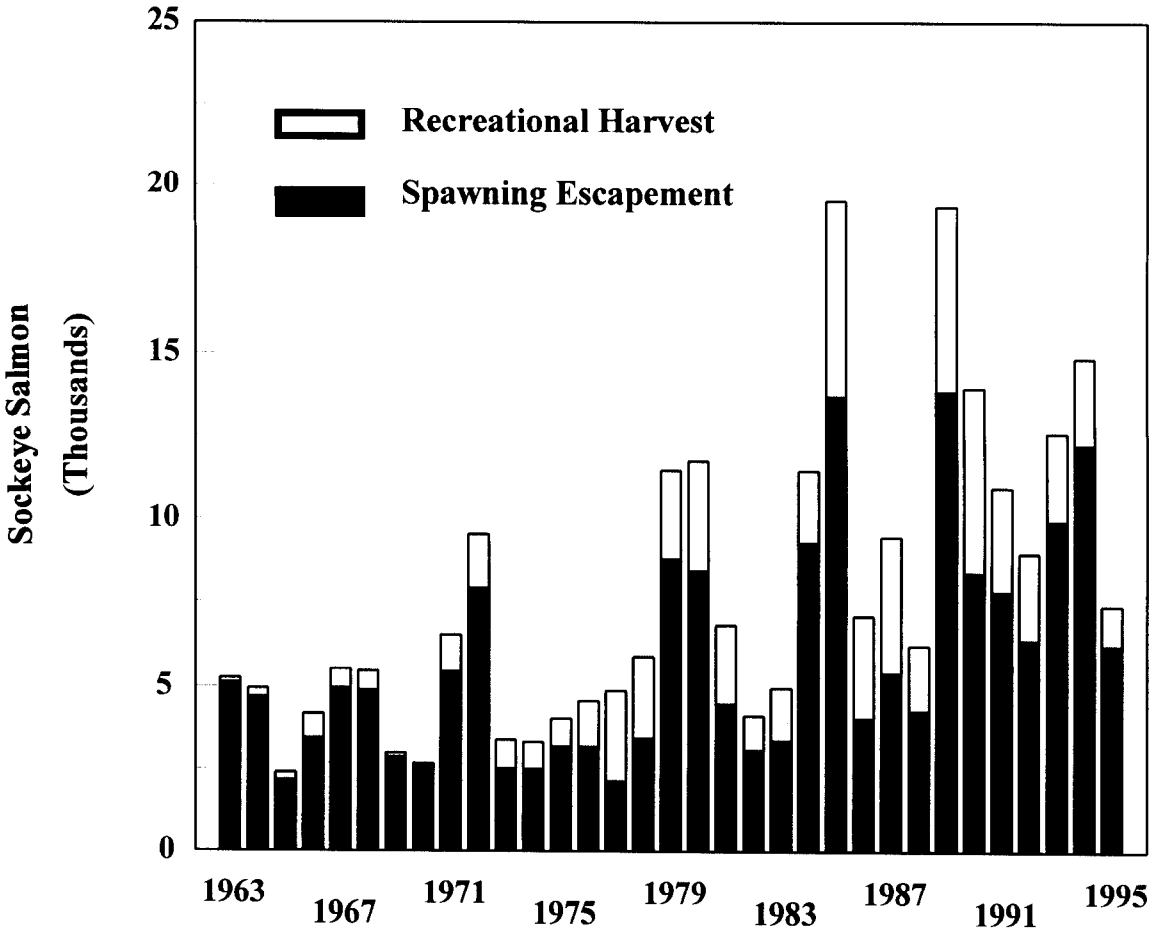

Figure 6.-Historical returns of sockeye salmon to the Russian River.

nonsurveyed hours. However, random observations of access locations during the nighttime period should be continued in the future. This will provide additional information regarding any possible changes in angler use patterns which might prove useful in further refining the survey.

Age Composition

An accurate estimate of the age composition of the sockeye salmon return is needed to establish accurate brood tables for the Russian River system. The sampling of time and area strata begun in 1990 was continued during the 1995 season. This increase in sampling intensity over previous years is an effort to achieve more accurate age composition estimates. Significant temporal changes in age composition have been detected within spatial strata as well as differences among temporal strata at the sampled locations since 1990 (Carlon et al. 1991, Marsh 1992-1995).

The age composition of the confluence and river harvests and the weir escapement clearly differed during the late run in 1995 (Table 7). Because age compositions either differed over time or among the spatial strata, biological data could not be pooled to allocate either the harvest or escapement. Therefore, a post-stratified harvest estimate or escapement estimate was calculated for each time stratum and for each spatial stratum. The exception to this finding was the confluence area harvest during 1995. Samples obtained during the two temporal strata were not significantly different, allowing biological data to be pooled to estimate the age composition of the confluence harvest. However, because of the significant differences in age composition within the other areas of the fishery over time, a poststratified harvest estimate was used for the confluence harvest as well. A z-test was used to determine if there were significant differences between the harvest estimate of the poststratified approach versus a "pooled" or nonstratified approach. This test indicated no significant difference ($P = 0.4562$). In addition, the poststratified estimates were less variable and therefore more precise.

Sampling the temporal and spatial strata should be continued at the present sampling intensity. This will improve the estimates of the numbers of sockeye salmon returning by age and sex and allow evaluation of differences over time. The end result will be improved accuracy of brood production information necessary for the long-term management of the Russian River system.

Management of the Fishery

The utilization of migratory timing statistics from weir counts and fishery harvest rates should be continued (Vincent-Lang and Carlon 1991). The technique of fitting a migratory timing distribution function to count and harvest rate data has been used successfully in the Kenai River to project escapements of chinook salmon *O. tshawytscha* (McBride et al. 1989) and was adapted from techniques used to quantify migratory timing of chinook salmon in the Yukon River drainage (Mundy 1982). It is recommended that this technique continue to be implemented in 1996 and subsequent years to further evaluate the value of these statistics in managing the Russian River sockeye salmon resource.

ACKNOWLEDGMENTS

Steve Hammarstrom has provided a consistent and reasoned voice of experience regarding all aspects of the project, from personnel matters to migratory timing influences, which has served to increase my understanding of the project and the fishery resources of the Russian River.

Colleen O'Brien collected creel survey interviews and age, sex, and length data from the sport fishery. Colleen has been a

long-term seasonal employee at the Russian River with six seasons of employment. Colleen's experience with the sport fishery and her observations of the fishery were a valued element towards the management of the sockeye salmon resources. In addition, Colleen's positive, "can do" enthusiasm while performing her responsibilities has proven to be an invaluable asset to the Russian River project.

Joe Richards collected creel survey interviews and age, sex, and length data from the sport fishery. While this was Joe's first season at the Russian River, he was instrumental in refining the necessary forms required for biological sampling. In addition, Joe's personal regard for job responsibilities was a much appreciated benefit to the conduct of the project.

Troy Tydingco operated the Russian River weir and field camp. Troy was responsible for collecting biological data and conducting inriver escapement counts and sampling surveys. Troy provided a new outlook and differing approaches towards constructing, refurbishing and making the field camp and weir facility a more efficient place to conduct the necessary research of the salmon resources of the Russian River drainage.

Dave Athons provided vital aircraft logistical support. Dave's prior work experience at the weir and knowledge of the sport fishery contributed towards the day-to-day operations of the study.

Jim Hasbrouck provided statistical review of the data analysis necessary to estimate the age compositions of the sport harvest and the escapement as well as much appreciated critical review.

Jay Carlon provided indispensable technical support.

Dave Nelson provided a long-term perspective towards achieving project objectives.

Sandy Sonnichsen streamlined the SAS statistical analysis code necessary to generate harvest and effort estimates for the direct expansion creel design used for the Russian River project.

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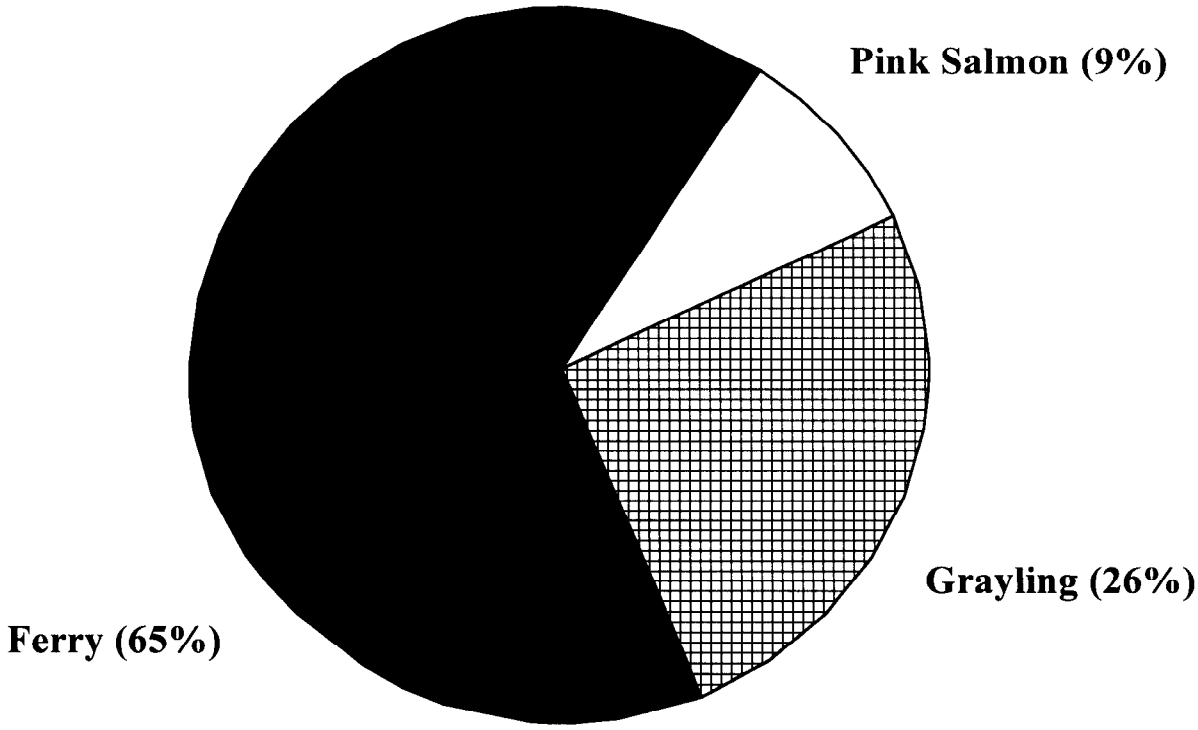
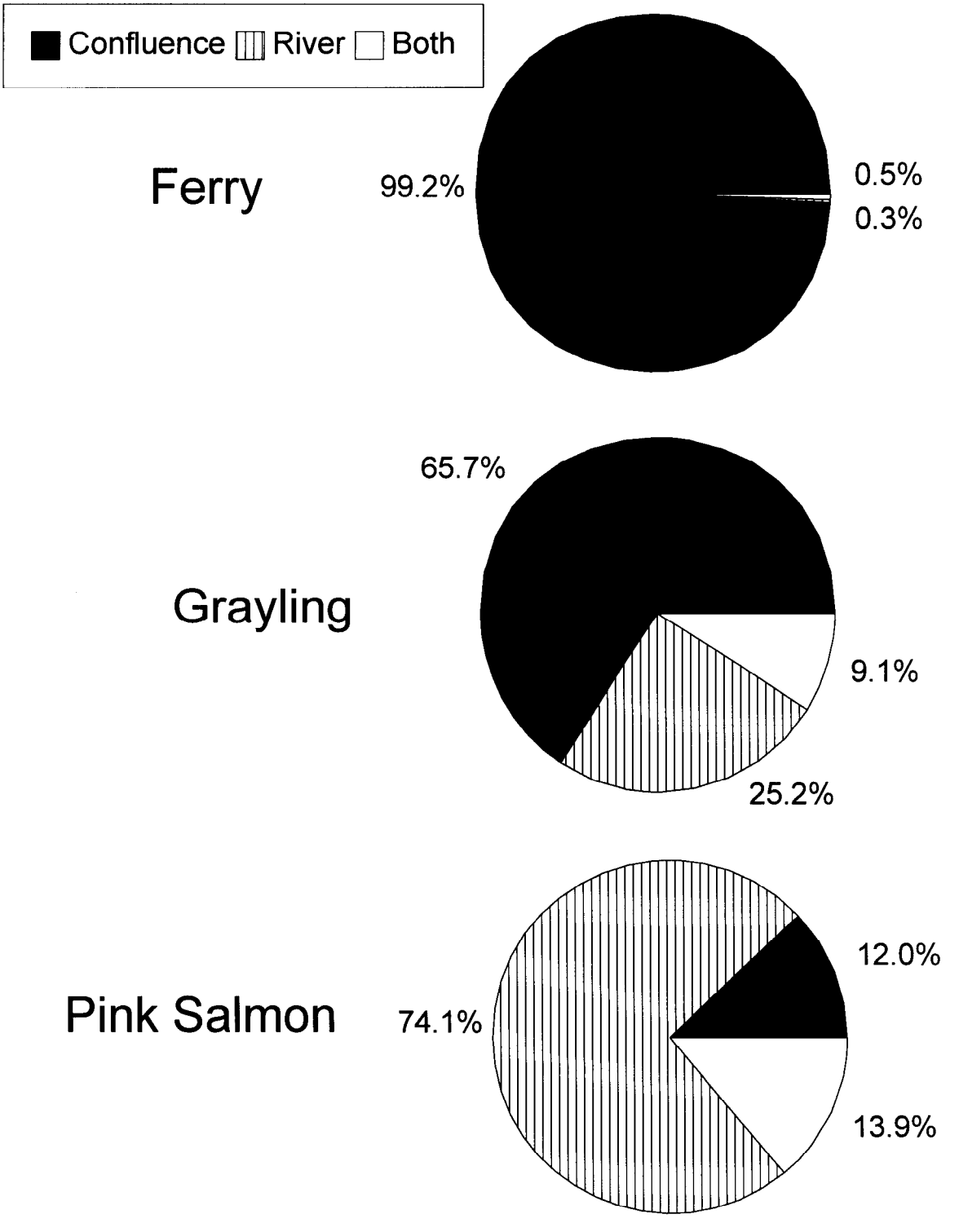
APPENDIX A.



Appendix A1.-Percentage of interviews collected at the three sampled exit locations to the Russian River late-run sockeye salmon recreational fishery, 1995.



Appendix A2.-Percent of anglers exiting three access locations that fished at the confluence area, river area, or both areas during the late-run fishery for sockeye salmon at the Russian River, 1995.

Appendix A3.-Temporal harvest and effort estimates for the 1995 late-run Russian River sockeye salmon recreational fishery by area and access location.

Location Exited	Temporal Period	D[a]	d[b]	Mean	Variance	Estimated Total Effort	Estimated Total Variance	Days	%	Periods	%	Anglers	%
River Effort:													
Ferry	7/12-8/05	25	12	4	28	88	1,625	765	47	859	53	0	0
Grayling	7/12-8/05	25	7	123	7,914	3,087	551,290	508,726	92	42,123	8	441	0
Pink Salmon	7/12-8/05	25	5	192	49,130	4,798	5,244,286	4,912,992	94	330,579	6	714	0
	Total 7/12-8/05					7,973	5,797,201						
Ferry	8/06-8/20	15	6	4	55	59	2,166	1,244	57	922	43	0	0
Grayling	8/06-8/20	15	2	167	7,414	2,498	810,250	722,819	89	87,119	11	312	0
Pink Salmon	8/06-8/20	15	2	221	14,243	3,313	1,453,426	1,388,707	96	64,514	4	204	0
	Total 8/06-8/20					5,870	2,265,842						
	Total River Effort					13,843	8,063,043						
Confluence Effort:													
Ferry	7/12-8/05	25	12	1,091	359,450	27,269	15,933,239	9,735,103	61	6,190,895	39	7,240	0
Grayling	7/12-8/05	15	7	794	214,316	11,915	6,717,965	4,822,118	72	1,892,139	28	3,708	0
Pink Salmon	7/12-8/05	25	5	440	37,682	10,995	3,199,977	2,422,431	76	775,985	24	1,561	0
	Total 7/12-8/05					50,179	25,851,181						
Ferry	8/06-8/20	15	6	339	4,485	5,089	997,619	437,295	44	559,241	56	1,082	0
Grayling	8/06-8/20	25	2	75	11,849	1,869	1,253,142	1,184,855	95	68,128	5	159	0
Pink Salmon	8/06-8/20	15	2	10	188	145	20,197	18,318	91	1,879	9	0	0
	Total 8/06-8/20					7,103	2,270,958						
	Total Confluence Effort					57,282	28,122,139						
	Total Effort					71,125	36,185,182						

-continued-

Appendix A3.-Page 2 of 2.

Location Exited	Temporal Period	D[a]	d[b]	Mean	Variance	Estimated Total Harvest	Estimated Total Variance	Days	%	Periods	%	Anglers	%
River Harvest:													
Ferry	7/12-8/05	25	12	0	0	0	0	0		0		0	
Grayling	7/12-8/05	25	7	12	207	293	15,935	13,301	83	2,615	16	19	0
Pink Salmon	7/12-8/05	25	5	23	890	570	94,099	89,014	95	4,964	5	121	0
		Total 7/12-8/05				863	110,034						
Ferry	8/06-8/20	15	6	0	0	0	0	0		0		0	
Grayling	8/06-8/20	15	2	40	1,331	602	141,227	129,795	92	11,266	8	167	0
Pink Salmon	8/06-8/20	15	2	38	436	574	46,270	42,480	92	3,667	8	123	0
		Total 8/06-8/20				1,176	187,497						
		Total River Harvest				2,039	297,531						
Confluence Harvest:													
Ferry	7/12-8/05	25	12	194	12,836	4,841	540,844	347,631	64	191,511	35	1,701	0
Grayling	7/12-8/05	25	7	68	1,576	1,705	113,696	101,290	89	12,164	11	243	0
Pink Salmon	7/12-8/05	25	5	14	371	356	40,046	37,091	93	2,830	7	126	0
		Total 7/12-8/05				6,902	694,586						
Ferry	8/06-8/20	15	6	111	3,492	1,669	114,060	78,570	69	34,916	31	574	1
Grayling	8/06-8/20	15	2	90	160	1,352	42,932	15,559	36	27,049	63	324	1
Pink Salmon	8/06-8/20	15	2	2	5	24	561	509	91	52	9	0	0
		Total 8/06-8/20				3,045	157,553						
		Total Confluence Harvest				9,947	852,139						
		Total Harvest				11,986	1,149,670						

[a] D = days possible in a stratum.

[b] d = days sampled in a stratum.

Appendix A4.-Daily escapement of sockeye, coho and chinook salmon through the Russian River weir during the late run, 1995.

Date	Early-Run Sockeye Salmon [a]	Late-Run Sockeye Salmon	Coho Salmon	Chinook Salmon
7/15	72			
7/16	74			
7/17	83			
7/18	42			
7/19	0			
7/20	20			
7/21	25			
7/22	39			
7/23	2			
7/24	35	47		
7/25	74	169		
7/26	176	3,343		
7/27	52	1,000		
7/28	4	104		
7/29	6	1,676		
7/30	3	42		
7/31	13	174		
8/1		6,924		1
8/2		4,840		1
8/3		5,461	1	3
8/4		2,008	0	0
8/5		883	0	2
8/6		1,529	1	3
8/7		1,470	0	3
8/8		3,473	6	5
8/9		1,220	6	1
8/10		606	3	6
8/11		1,271	6	4
8/12		832	0	0
8/13		1,324	17	1
8/14		2,037	24	1
8/15		370	0	0

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Appendix A4.-Page 2 of 2.

Date	Early-Run Sockeye Salmon [a]	Late-Run Sockeye Salmon	Coho Salmon	Chinook Salmon
8/16		2,126	38	3
8/17		1,530	20	0
8/18		1,543	27	3
8/19		106	1	0
8/20		1,407	8	2
8/21		1,211	13	0
8/22		1,341	21	0
8/23		782	5	0
8/24		1,331	41	2
8/25		314	2	0
8/26		1,435	17	0
8/27		1,452	48	0
8/28		714	1	0
8/29		1,217	43	0
8/30		143	11	0
8/31		579	4	0
9/1		137	1	0
9/2		633	13	0
9/3		169	1	0
9/4		122	4	0
9/5		254	10	0
9/6		51	0	0
9/7		1,180	307	0
9/8		829	358	0
9/9		116	56	0
9/10		257	259	0
9/11		200	300	0
Total		61,982	1,673	41

[a] From 7/15 through 7/31, early-run fish were differentiated from late-run fish based upon degree of external sexual maturation characteristics, i.e., body coloration and kype development. There was an 8-day overlap between early-run and late-run fish.