Fishery Data Series No. 94-15

Catch and Effort Statistics for the Sockeye Salmon Sport Fishery During the Late Run to the Russian River With Estimates of Escapement, 1993

by

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[1] This investigation was partially financed by the Federal Aid in Sport Fish Restoration Act (16 U.S.C. 777-777K) under Project F-10-9, Job No. S-2-7.

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ABSTRACT

A direct expansion creel survey of the late-run Russian River recreational fishery was conducted in 1993 to determine angler effort for and harvest of sockeye salmon *Oncorhynchus nerka*. Anglers expended 94,905 angler-hours to harvest 26,536 sockeye salmon from the late run (18 July-20 August). The harvest rate for the late run was 0.280 sockeye salmon per hour of angler effort. Approximately 77% of the total fish harvested during the late run was taken from the confluence area of the fishery, where the Russian River flows into the Kenai River.

A total of 99,259 sockeye salmon bound for spawning areas were counted through a weir at the outlet of Lower Russian Lake during the late run. This total exceeds the escapement goal of 30,000 that has been established for the late run. The total late return (apportioned harvest plus escapement) was predominantly age 2.1, age 2.2 and age 1.2 (29.6%, 26.8%, and 24.2%, respectively).

A stream survey indicated that a minimum of 12,258 sockeye salmon spawned in the Russian River downstream from the Russian River falls. Scale samples taken from carcasses indicated that the most abundant age group (1.3) comprised 57.5% 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. Annual effort by anglers in this fishery exceeded 450,000 angler-hours and annual harvest exceeded 190,000 fish in 1987. 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), and Carlon et al. (1991).

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 are comprised of two segments based upon spawning location: (1) those spawning upstream of Russian River falls, and (2) those spawning downstream from the falls. While most fish migrating through the falls spawn in Upper Russian Lake, others spawn in tributaries to Upper Russian Lake and in the river section between the two lakes. These fish are primarily 2-ocean fish (have spent two winters at sea) and rear in the two lakes.[1] The other segment spawns in the Russian River downstream from the falls. These are primarily 3-ocean fish more closely associated with the age structure of sockeye salmon spawning in the mainstem Kenai River (Cross et al. 1983, 1985, 1986). Presmolt progeny of these fish are believed to spend their freshwater residency in Skilak Lake.

In addition to the sport harvest at the confluence of the Kenai and Russian rivers and in the Russian River, 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 harvest of sockeye salmon by sport fisheries in the mainstem of the Kenai River have been reported annually since 1977 (Mills 1979-1993). The personal use dip net harvest has been estimated in the Statewide Harvest Survey since 1983 (Mills 1984-1993). 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 number of spawning sockeye salmon migrate through a weir at the outlet of Lower Russian Lake during the late run (Figure 2). The escapement goal of the late run, established in 1979, is 30,000 fish. This goal is based upon evaluation of returns from past brood years. With the exception of 1977 when the escapement was 21,410 (Nelson 1978), the escapement goal has been achieved each year since 1975.

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

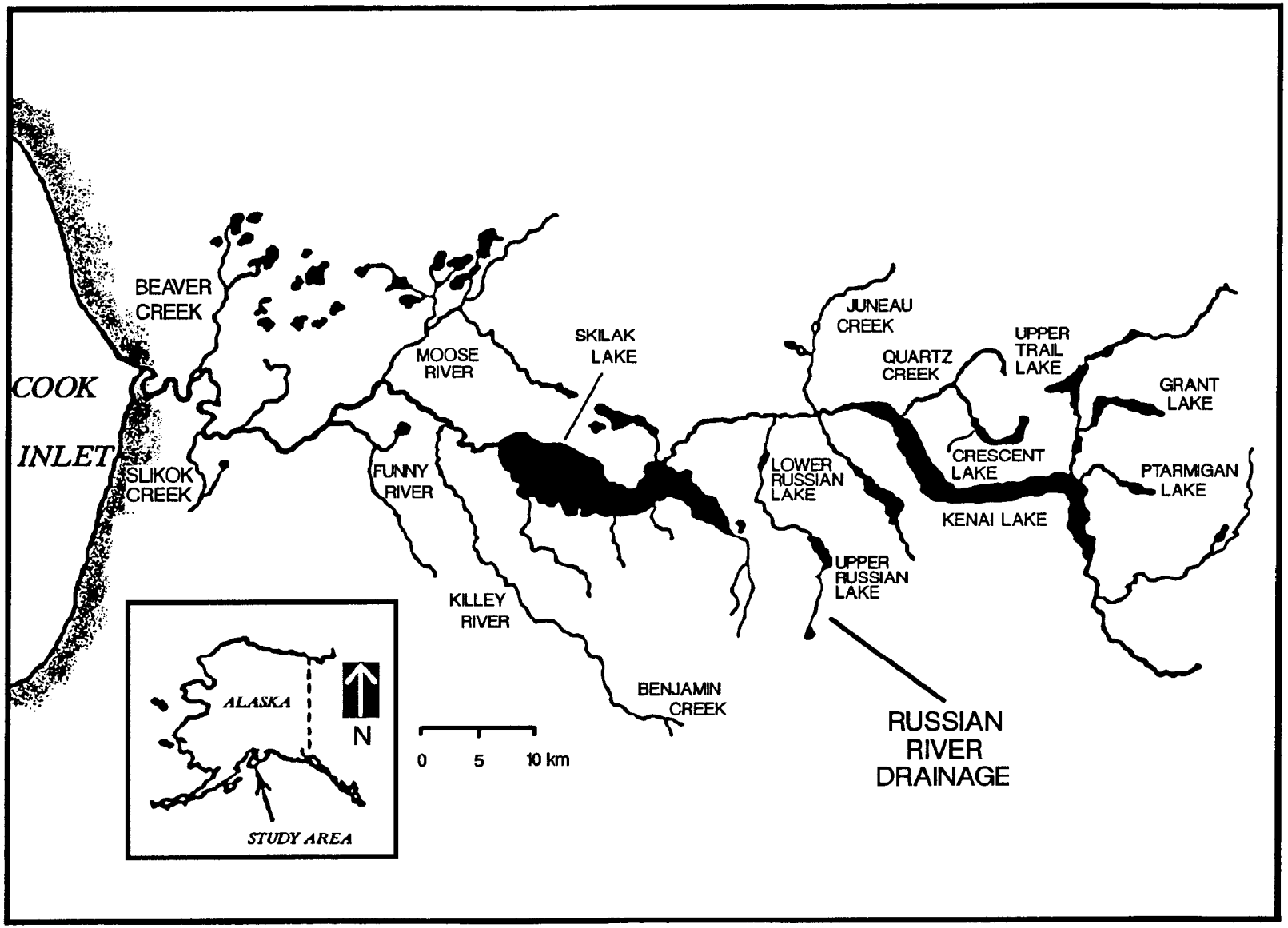

Figure 1. Map of the Kenai and Russian River drainages.

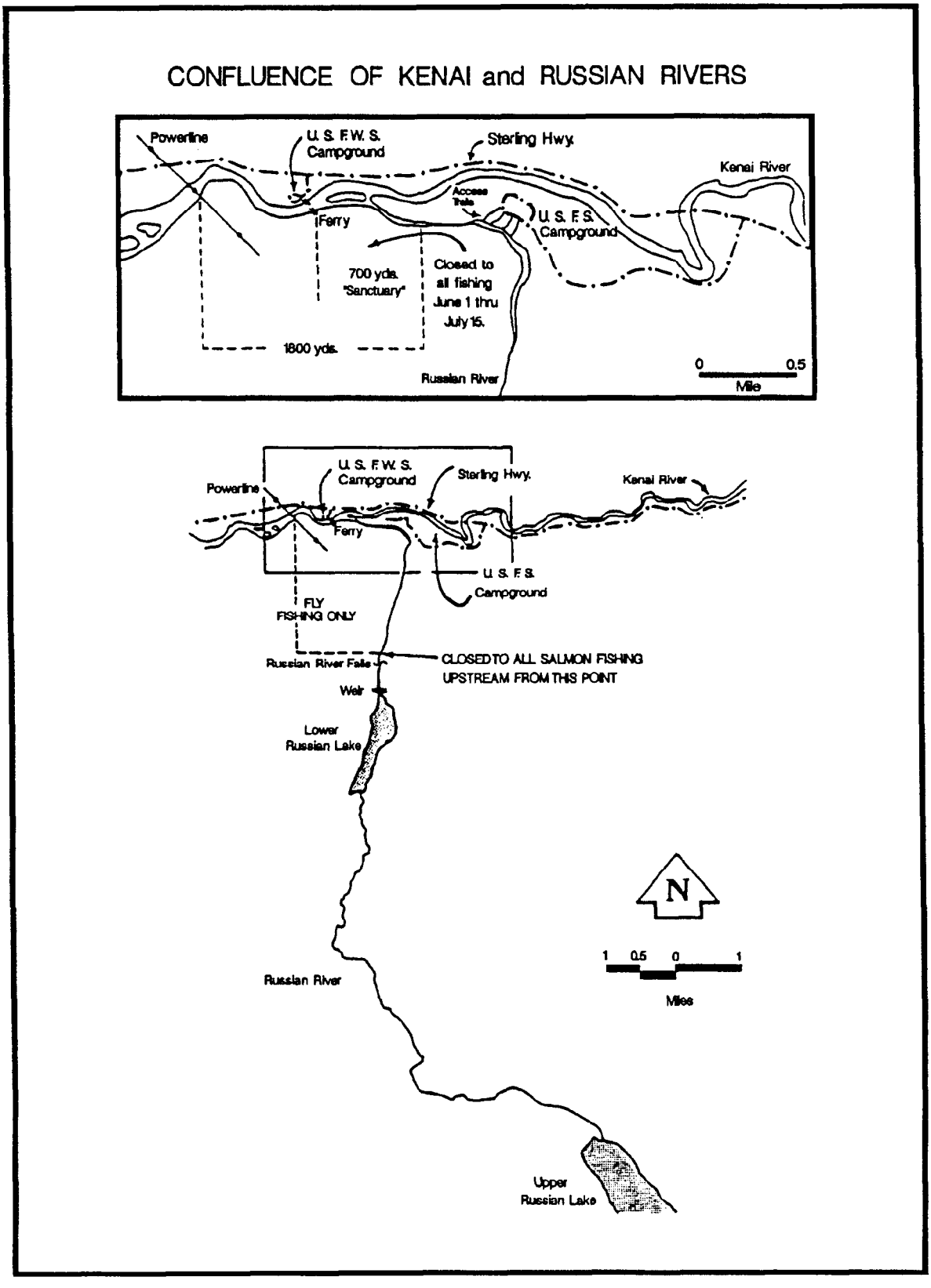

Figure 2. Detail map of the Kenai and Russian River study area.

Because the recreational fishery for sockeye salmon at the Russian River is one of the largest in the state, there is a potential for overharvest. Precise and timely management decisions are required to ensure that an adequate 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 by the recreational sockeye salmon 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 1 June through 20 August 1993, 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.

The objectives of this report are to present for 1993: (1) estimates of effort and harvest of late-run sockeye salmon for the recreational fishery; (2) estimates of the escapement of the late run of sockeye salmon; and (3) estimates of the age, sex, and length distributions of the harvest and escapement of the late run of sockeye salmon.

METHODS

Study Area

The recreational fishery occurs in two areas: (1) the confluence area, 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 area, 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 river area is provided primarily from a United States Forest Service (USFS) campground located on the east side of the Russian River. The main riverside trail affording access to the river area is intersected by four short trails serving 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 (Figure 3).

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[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 downriver of the ferry cable crossing.

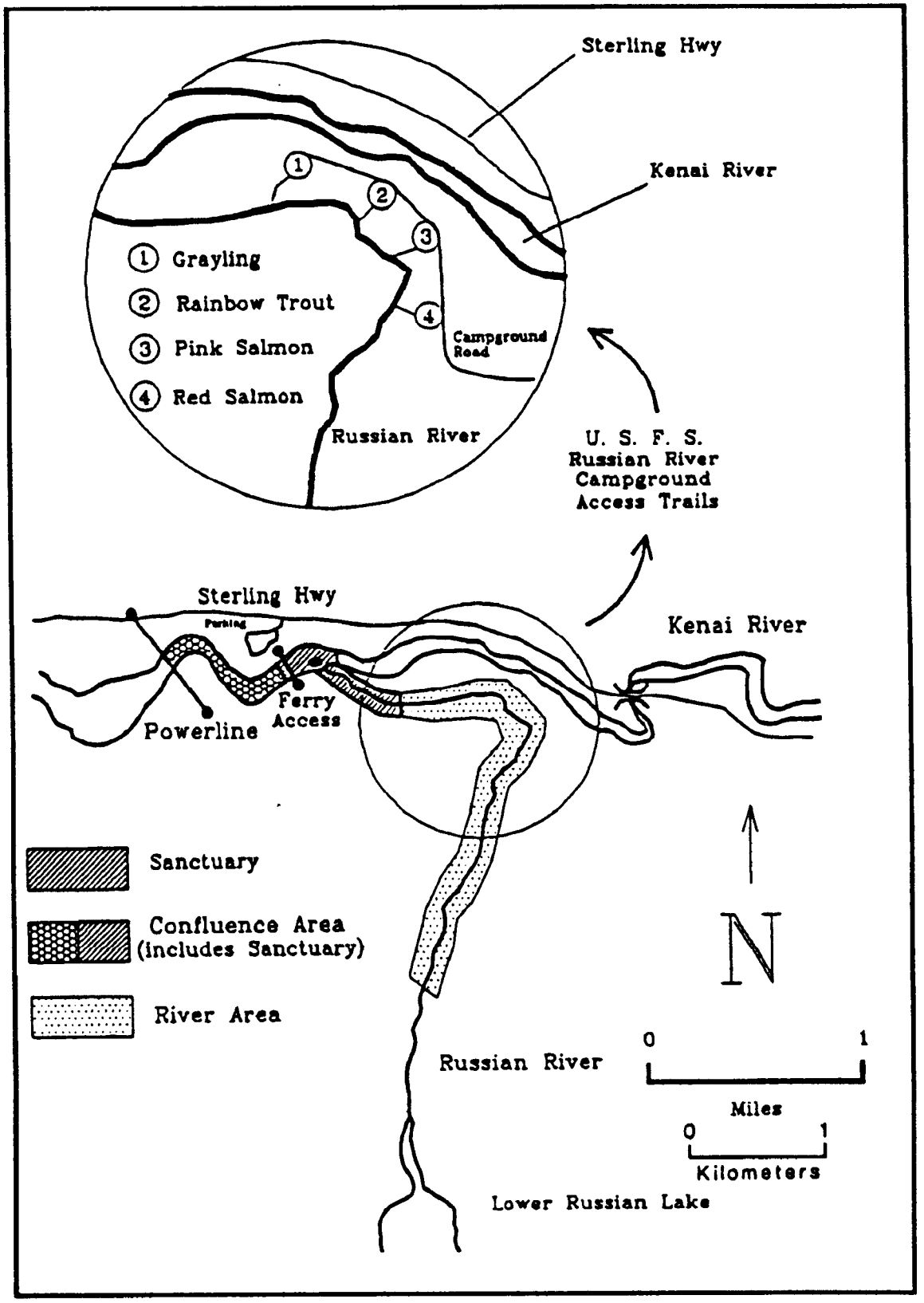

Figure 3. Map of the Russian River sockeye salmon recreational fishing areas and fishing access locations sampled during the 1993 creel survey.

Access to the confluence area 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 (Figure 3). Most anglers fishing the confluence area 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 the Russian River area. Anglers may also use the USFS campground trails to gain access to the confluence area.

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

Study Design

Creel Survey:

A direct expansion creel survey was utilized during the 1993 late run. Previous concerns with biased harvest and effort estimates (Carlon and Vincent-Lang 1990) obtained with a stratified roving creel design (Neuhold and Lu 1957) necessitated a change in creel design beginning with the 1990 season.

Sampling was stratified by access location to estimate harvest and effort. Area-specific (river or confluence area) 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 were sampled: the ferry, Grayling and Pink Salmon. Because the age distribution of sockeye salmon changed over time, the data were post-stratified into three temporal components (Table 1). The fishery was surveyed from 18 July to 19 August.

The creel survey 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 randomly selected from the six possible periods. During each sampled period, anglers were interviewed as they exited the fishery through a sampled location. Thus, all interviews were of completed-trip anglers. 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 area). 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.

During 1990, 1991 and 1992, approximately three-fourths of the harvest and effort occurred in the confluence area during the late run (Carlon et al. 1991; Marsh 1992, 1993). This is typical of the effort distribution in most years (Nelson et al. 1986). As a result of this concentration of harvest and

Table 1. Temporal components of the recreational harvest and escapement sampled for age composition during the late run of sockeye salmon to the Russian River, 1993.

Return Component	Temporal Delineation
Confluence area harvest	7/18 - 7/27 7/28 - 8/07 8/08 - 8/19
River area harvest	7/18 - 7/27 7/28 - 8/07 8/08 - 8/19
Escapement through weir	7/19 - 7/27 7/28 - 8/07 8/08 - 8/20 8/21 - 9/10
Escapement spawning between falls and confluence	8/18, 9/01[a]

[a] Escapement not stratified; dates listed are sampling dates.

effort and because harvest rate (harvest per hour) is considered a management tool to index sockeye salmon abundance at the confluence, the confluence access location (the ferry) was sampled every other day throughout the late run. This ensured that timely information regarding confluence harvest rates was available when formulating inseason management strategies.

In 1990 and 1991, there were significant differences in use among the five access locations (Carlon et al. 1991; Marsh 1992). Creel data indicated that angler use was consistently dominated by the three major sites (the ferry, Grayling and Pink Salmon). These access sites represented more than 90% of the total harvest and effort and also contributed approximately 90% of the total variance for both the harvest and effort estimates.

In an effort to reduce the overall variability of the estimates, a shift in the systematic sampling design was implemented in 1992. Estimates of effort, harvest, and their variances for the late run based upon data collected in 1990 and 1991 were used to optimally allocate available sampling days among the three major river access sites (Cochran 1977). This approach was continued during 1993 with the three major sites sampled and available sampling time optimally allocated between them based upon total effort, harvest and the variance surrounding those estimates. During the late run, the ferry was sampled approximately every 2 days, Grayling every 4 days and Pink Salmon every 5 days.

Harvest and effort were estimated for each temporal stratum of the fishery. On day i and sample period j, m_{kij} completed-trip anglers were interviewed as they exited location k and a_{kij} anglers were "missed" because they exited and were counted but were not interviewed. Interviewed anglers were assigned to one of three groups:

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

m_{2kij} = anglers that fished the confluence area 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 prorated based on information obtained from 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 (a_{rkij}) of missed anglers prorated as fishing the river was estimated as:

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

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

$$\hat{M}_{rkij} = m_{rkij} + \hat{a}_{rkij}. \tag{4}$$

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

$$\hat{M}_{ckij} = m_{ckij} + \hat{a}_{ckij}. \tag{5}$$

The mean river area harvest per interviewed angler was:

$$\bar{h}_{rkij} = \frac{\sum_{l=1}^{m_{rkij}} h_{rkijl}}{m_{rkij}} \tag{6}$$

where:

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

The variance of river area harvest among interviewed anglers was estimated as:

$$\hat{S}^2_{rkij} = \frac{\sum_{l=1}^{m_{rkij}} (h_{rkijl} - \bar{h}_{rkij})^2}{m_{rkij}-1}. \tag{7}$$

The total river area harvest of anglers exiting through access location k on day i during sample period j ($\hat{H}_{rkij}$) was estimated as:

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

The mean river area harvest per period ($\bar{H}_{rki}$) at location k on day i was estimated as:

$$\bar{H}_{rki} = \frac{\sum_{j=1}^{u} \hat{H}_{rkij}}{u} \tag{9}$$

where:

u = the number of periods sampled on day i ($u = 2$), and the variance among sample periods was estimated as:

$$\hat{S}^2_{rki} = \frac{\sum_{j=1}^{u} (\hat{H}_{rkij} - \bar{H}_{rki})^2}{u - 1}. \quad (10)$$

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

$$\hat{H}_{rki} = U \hat{\bar{H}}_{rki} \quad (11)$$

where:

U = the total number of periods in a day ($U = 6$).

The mean river area harvest per day ($\bar{H}_{rk}$) at location k was estimated as:

$$\hat{\bar{H}}_{rk} = \frac{\sum_{i=1}^{d} \hat{H}_{rki}}{d} \quad (12)$$

where:

d = the number of days sampled.

The variance of river area harvest among days ($\hat{S}^2_{rk}$) at location k was estimated using the variance for a systematic sample (Wolter 1985) as:

$$\hat{S}^2_{rk} = \frac{\sum_{i=2}^{d} (\hat{H}_{(i)} - \hat{H}_{(i-1)})^2}{2(d-1)}. \quad (13)$$

The total river area harvest at location k ($\hat{H}_{rk}$) was estimated by expanding the mean harvest per day by:

$$\hat{H}_{rk} = D \hat{\bar{H}}_{rk} \quad (14)$$

where:

D = the total number of days during a time stratum.

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

$$V(\hat{H}_{rk}) = (1-f_1)\, D^2_{rk}\, \frac{\hat{S}^2_{rk}}{d} + D_{rk}\, \frac{U^2}{u}\, (1-f_2)\, \frac{\sum_{i=1}^{d} \hat{S}^2_{rki}}{d}$$

$$+ D_{rk}\, U \sum_{i=1}^{d} \sum_{j=1}^{u} M^2_{rkij}\, (1-f_{3rkij})\, \frac{\hat{S}^2_{rkij}}{d\, u\, m_{rkij}} \qquad (15)$$

where:

D_{rk} = the total number of sampling days at location k during a time stratum;

f_1 = the finite population correction factor for days (d_{rk}/D_{rk});

f_2 = the finite population correction factor for periods (u_{rki}/U_{rki});

f_{3rkij} = the finite population correction factor for anglers (m_{rkij}/M_{rkij}).

There was a component of variance in the third stage (among anglers) due to the prorating of missed anglers that was not included. However, this component accounted for a small (0%-2%) percentage of variability for both total harvest and effort estimates of all strata in 1990, 1991 and 1992 (Carlon et al. 1991; Marsh 1992, 1993).

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

Total estimates of harvest and effort were determined for the late run by summing the individual stratum estimates. Stratum estimates were assumed to be independent and the variances of the total estimates were calculated as the sum of the variances of the individual stratum estimates.

Daily harvest rates were estimated for inseason management as an indicator of sockeye salmon abundance. Harvest rate in the confluence area was based solely on effort and harvest from the confluence area reported by interviewed anglers. The mean daily harvest rate of the confluence area was estimated as:

$$\overline{HPUE}_c = (1/n) \sum_{l=1}^{n} HPUE_l \qquad (16)$$

where:

n = number of interviewed anglers reporting confluence-area effort, and

$HPUE_l$ = confluence-area harvest per hour of effort for angler l.

The variance of this estimate was calculated as:

$$V(HPUE_c) = \frac{\sum_{l=1}^{n} (HPUE_l - \overline{HPUE_c})^2}{n(n-1)}. \quad (17)$$

The same procedure was used to estimate river-area harvest rates ($HPUE_r$).

Harvest rates for past years were 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.

Spawning Escapement:

Escapement of sockeye salmon to the Russian River drainage was enumerated at the stationary weir at the outlet of Lower Russian Lake. 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 (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 heads while the late-run fish have not yet developed these body characteristics. The period of overlap began on 17 July when late-run fish were intermixed with mature, early-run fish and continued through 26 July, after which early-run fish were no longer present.

Age, Sex, and Length Composition:

Ten time and area strata were sampled to estimate the age, sex, and length composition of the late run (Table 1). Differences in age composition over time among spatial components have been demonstrated in the past (Carlon and Vincent-Lang 1990; Carlon et al. 1991; Marsh 1992, 1993).

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 was also determined and recorded. Scale impressions were made in clear acetate and examined with a microfiche reader to determine age. 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 from brood is therefore the sum of the two numbers plus one.

The late-run harvest from the river area was not sampled for age composition prior to 1993. Age composition from the confluence area harvest was used to apportion the river area harvest (Nelson et al. 1986; Carlon and Vincent-Lang 1990). This procedure assumes that the age composition of the confluence harvest represents that of the river area; however, significant differences in age composition were found among the three sampled areas (Carlon et al. 1991; Marsh 1992, 1993). In 1993, each area was sampled individually. Chi-square tests were used to test the null hypotheses of equal age compositions among locations and time strata. Null hypotheses were rejected if calculated tail-area probabilities (P values) were less than 0.05.

Age and sex compositions of harvest and escapement were estimated for each spatial/temporal strata (i.e., confluence, river, and weir). The proportion of fish of age-sex group g in spatial/temporal strata f (e.g. confluence harvest 7/18-7/27) was estimated as:

$$\hat{P}_{gf} = n_{gf}/n_f \qquad (18)$$

where:

n_{gf} = number of legible scales taken from strata f and interpreted as age-sex g, and

n_f = total number of legible scales taken from strata f.

The variance of $\hat{P}_{gf}$ was estimated as (Scheaffer et al. 1978):

$$\hat{V}(P_{gf}) = \hat{P}_{gf}(1-\hat{P}_{gf})/(n_f-1). \qquad (19)$$

The spatial/temporal estimates of the late-run sport harvest (H_{Tf}) were also apportioned by age group for each sex:

$$\hat{N}_{gf} = \hat{H}_{Tf}\hat{P}_{gf}, \qquad (20)$$

where:

$\hat{H}_{Tf}$ = the estimated total harvest of sockeye salmon during spatial/temporal strata f.

The variance of $\hat{N}_{gf}$ was estimated as (Goodman 1960):

$$\hat{V}(N_{gf}) = \hat{H}^2_{Tf}\,\hat{V}(P_{gf}) + \hat{P}^2_{gf}\,\hat{V}(H_{Tf}) - \hat{V}(P_{gf})\,\hat{V}(H_{Tf}), \qquad (21)$$

where:

$\hat{V}(H_{Tf})$ = the variance of the harvest estimate during spatial/temporal stratum f.

Overall age composition by sex was estimated for the total late-run harvest by summing estimated number harvested by age over the spatial/temporal strata. The total number of fish harvested of sex and age g (N_g) was estimated as:

$$\hat{N}_g = \sum_{f=1}^{t} \hat{N}_{gf}, \tag{22}$$

where:

t = the number of spatial/temporal strata during the late run.

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

$$\hat{V}(N_g) = \sum_{f=1}^{t} \hat{V}(N_{gf}). \tag{23}$$

The proportion of adults of sex and age g in the total sport harvest from the late run (P_g) was estimated as:

$$\hat{P}_g = \hat{N}_g/\hat{H}, \tag{24}$$

where:

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

The variance of $\hat{P}_g$ was estimated as the variance of the quotient of two random variables as:

$$\hat{V}(P_g) = \hat{P}^2_g \left[\hat{V}(N_g)/\hat{N}^2_g + \hat{V}(H)/\hat{H}^2\right] - 2\hat{V}(N_g)/\hat{N}_g \hat{H}] \tag{25}$$

where:

$\hat{V}(H)$ = the variance of the estimated harvest of fish from the late run as defined previously.

The number of sockeye salmon of sex and age group g in the escapement was estimated for each spatial/temporal stratum f using the estimated proportions (P_{gf}) as defined previously:

$$\hat{N}_{gf} = \hat{N}_{Tf}\hat{P}_{gf}, \tag{26}$$

where:

N_{Tf} = the total number of sockeye salmon enumerated during stratum f at the weir or spawning downstream from the falls.

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

$$V(\hat{N}_{gf}) = N^2_{Tf}\, V(\hat{P}_{gf}). \quad (27)$$

Overall sex and age composition of the escapement was estimated for the late run by summing estimated numbers by sex and age over temporal strata. For the late run, the total number of spawning fish of age-sex g (N_g) was estimated as:

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

The variance of $\hat{N}_g$ was estimated as the sum of the variances of the individual estimates as:

$$V(\hat{N}_g) = \sum_{f=1}^{t} V(\hat{N}_{gf}). \quad (29)$$

The proportion of adults of sex and age g in the total escapement of the late run (P_g) was estimated as:

$$\hat{P}_g = \hat{N}_g/E, \quad (30)$$

where:

E = the total escapement of the late run enumerated at the weir or spawning downstream of the falls.

The variance of $\hat{P}_g$ was estimated by:

$$V(\hat{P}_g) = (1/E)^2\, V(\hat{N}_g). \quad (31)$$

Mean length-at-age was estimated by sex for each spatial/temporal stratum of the return: the confluence area harvest, the river harvest, and the weir escapement. To determine if individual spatial/temporal samples could be pooled to estimate overall mean length-at-age by 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 Survey

Survey Interviews:

Sampling at access locations began on 18 July. Sampling of two of the three major access locations continued until 19 August, just 1 day before the normal regulatory closure date. The third access location (ferry) discontinued operation on 15 August when ticket sales dropped below an acceptable level for the concessionaire.

The beginning of the late run was determined by the appearance of fresh ocean-bright sockeye salmon in the confluence area of the fishery. Prior to the arrival of these late-run fish, the sport fishery was characteristically slow with reddish colored, maturing fish dominating the small harvest. The few remaining early-run fish all showed signs of prespawning sexual maturity.

A total of 2,652 anglers were counted as they exited sampled access locations during the 1993 late-run survey (Table 2). Of these, 1,658 (62.5%) were interviewed and 994 (37.5%) were not interviewed. The total number of interviews collected in the late run represents a 19.5% decrease from 1992 (Marsh 1993). Most of the interviews (65%) were obtained from the ferry access location as this location was sampled most intensely and typically accounts for the most effort (Appendix A1).

Anglers exiting via the ferry location fished the confluence area almost exclusively (97%) 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 area (57%), while the majority of anglers who exited at Pink Salmon fished the river area (62%).

Harvest and Effort:

The ferry accounted for most of the harvest (49%) and corresponding effort (51%) during the late run (Table 3). Relative precisions of the total late-run harvest and effort estimates were 24% and 25%, respectively (Table 3). Estimates of harvest, effort, and variances are presented by stratum (temporal component/access location) in Appendix A3.

The 1993 late-run harvest estimate was 26,536 (SE = 3,227) sockeye salmon (Table 4). The effort estimate for the late run was 94,905 (SE = 10,344) angler-hours. During the late run, 77% of the harvest was taken from the confluence area and the remaining 23% was taken from the river area (Table 4, Figure 4). Correspondingly, the effort during the late-run sport fishery was directed primarily at the confluence area (79%) and less so at the river area (21%).

The estimated HPUE for the late run was 0.280 (Table 5), a 5.7% decline in angler catch efficiency from 1992 (Marsh 1993).

Table 2. Summary of the number of interviews collected during sampled periods for the Russian River creel survey during the late run, 1993.

Exit Location	Area Fished			Total Interviews	Anglers Exiting and not Interviewed	Total Anglers Exiting
	Confluence	River	Both			
Ferry	1,046	27	8	1,081	748	1,829
Grayling	208	155	21	384	181	565
Pink Salmon	69	113	11	193	65	258
Late-Run Total	1,323	295	40	1,658	994	2,652

Table 3. Estimates of harvest, effort, and associated variances by access location for the late-run Russian River sockeye salmon recreational fishery, 1993.

	Harvest	(%)	Variance of Harvest	(%)	Relative[a] Precision (%)	Effort	(%)	Variance of Effort	(%)	Relative[a] Precision (%)
Ferry	12,965	49%	2,555,443	25%	24%	48,437	51%	39,127,067	37%	25%
Grayling	9,885	37%	5,247,148	50%	45%	29,939	32%	30,980,251	29%	36%
Pink Salmon	3,686	14%	2,610,600	25%	86%	16,528	17%	36,892,812	34%	72%
Total	26,536	100%	10,413,191	100%	24%	94,905	100%	107,000,130	100%	21%

[a] alpha = 0.05

Table 4. Summary of estimated angler-effort and harvest of sockeye salmon during the late run, for each area of the Russian River recreational fishery, 1993.

Component	Confluence Area	River Area	Total	95% Confidence Interval
Effort	74,798	20,106	94,905	74,630 - 115,179
SE	9,538	4,004	10,344	
Harvest	20,532	6,004	26,536	20,211 - 32,861
SE	2,685	1,790	3,227	

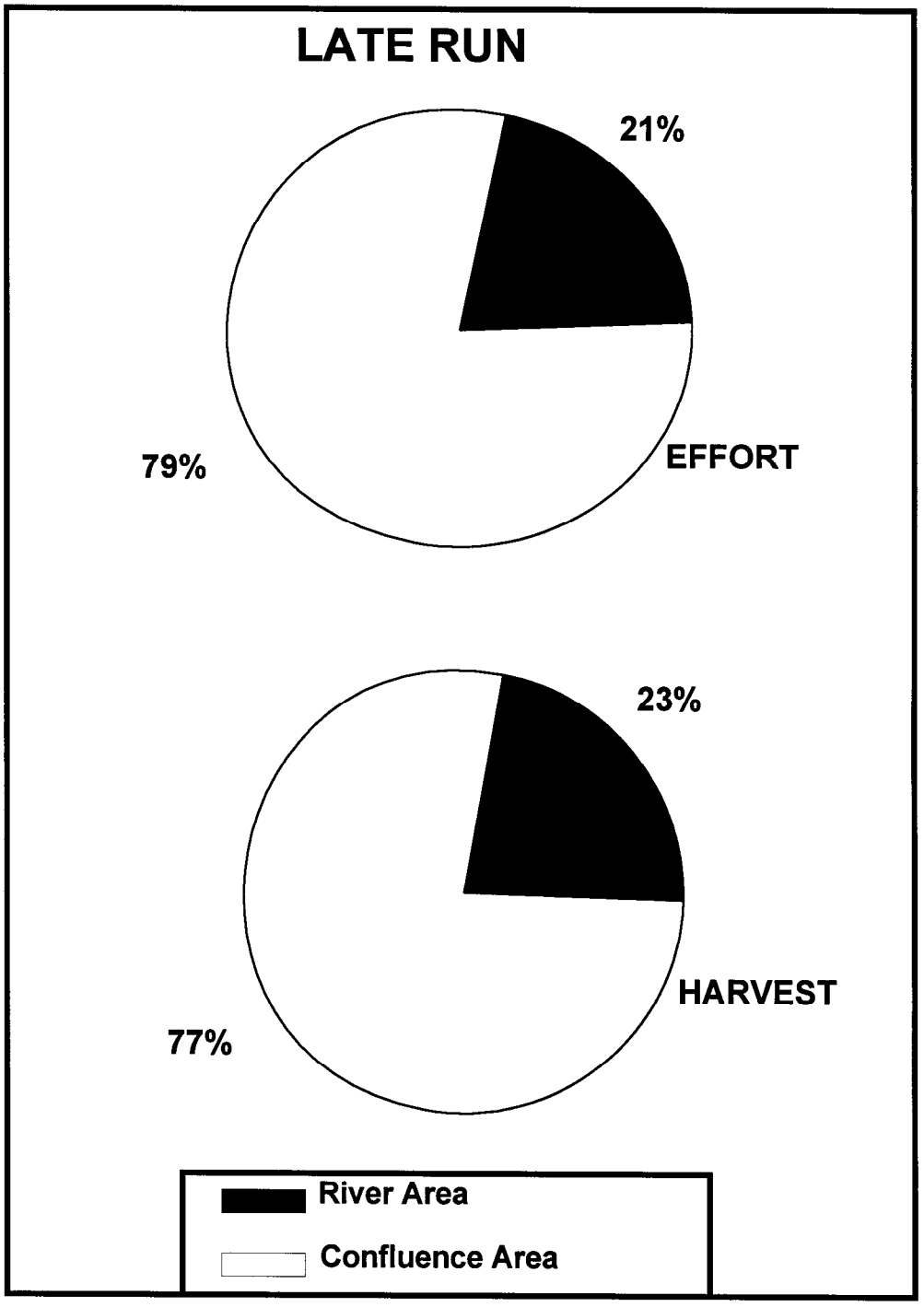

Figure 4. Harvest and angler effort by area for the Russian River late-run sockeye salmon recreational fishery, 1993.

Table 5. Estimated harvest per hour of angler effort (HPUE) by anglers interviewed during the late run, at each location, in the Russian River sockeye salmon recreational fishery, 1993.

Area	Days n[a]	Days N[b]	Number of Interviews[c]	HPUE	Variance of HPUE
Confluence	22	34	1,343	0.274	0.0013
River	15	34	315	0.299	0.0079
Both			1,658	0.280	0.0012

[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.

Spawning Escapement

A total of 99,259 late-run sockeye salmon passed through the weir (Table 6, Appendix A4). The greatest daily counts at the weir occurred near the middle of August (Figure 5). Transition between the two runs occurred from 19 July to 25 July. Weir enumeration ceased on 10 September. An estimated 95 sockeye salmon holding approximately 100 m downstream from the weir were included in the 10 September total.

An estimated 12,258 sockeye salmon were counted on 18 August during foot surveys of the Russian River downstream from the Russian River falls (Table 6).

A total of 1,094 coho salmon was enumerated through the weir during the late run (Table 6 and Appendix A4). This figure represents only a partial accounting of the total return as the weir was removed before the completion of the coho salmon migration.

Age, Sex, and Length Composition

The late-run escapement through the weir was comprised of five age groups: age 2.1 (36.1%), age 1.2 (28.1%), age 2.2 (22.1%), age 2.3 (8.9%), and age 1.3 (4.9%) (Table 7). There was a significant difference in the age composition among all the temporal strata ($\chi^2 = 232.02$, df = 12, $P < 0.005$). Age-2.2 and -2.3 fish dominated the first temporal stratum (44.8% and 30.4%, respectively). Age-2.2, -2.3, and -1.3 fish declined gradually throughout the duration of the migration to 6.7%, 0% and 0%, respectively, during the last time strata. Age-2.1 and age-1.2 fish increased from 2.2% and 13.3% during the first time strata to higher proportions of 83.3% and 41.4% later in the run.

The late-run harvest from the confluence area was comprised predominantly of age-2.2 (47.3%), age-2.3 (27.7%), and age-1.3 (12.3%) fish (Table 8). There were significant ($\chi^2 = 116.2$ df = 8, $P < 0.005$) temporal changes in the age composition. Similar to the weir escapement, age-2.2, age-2.3 and age-1.3 fish started strongly and were displaced proportionately by age-2.1 and age-1.2 fish later in the return. Age-2.2 adults ranged from 31.2% in the first time stratum to 54.1% in the third stratum and age-2.3 fish represented 43.5% in the first stratum and declined to 8.2% by the third time stratum. The proportion of age-1.3 adults declined from 20.8% during the first time stratum to 4.7% during the final stratum while age-2.1 and age-1.2 fish increased from 0% and 4.5% during the first stratum to 18.8% and 14.1% during the final stratum.

The late-run harvest from the river area was also primarily age-2.2 (34.3%) and age-2.3 (29.6%) fish with age 1.3 and 1.2 contributing 12.4% and 13.0%, respectively, to the harvest (Table 9). The sampled harvest from the river area was also dominated by age-2.2, -2.3 and -1.3 adults early in the return with age-2.1 adults and age-1.2 adults beginning to evidence a stronger contribution later in the run. There were significant ($\chi^2 = 143.2$, df = 8, $P < 0.005$) temporal changes in age distribution of the river harvest. The predominant age class in the first temporal stratum was age-2.3 fish (50.0%) with age-2.2 and -1.3 adults contributing 27.1% and 19.3%, respectively. These age classes subsequently contributed 7.6%, 38.9% and 3.5% during the

Table 6. Escapements of sockeye, coho, and chinook salmon during the late run to the Russian River drainage, 1993.

Component	Dates	Sockeye Salmon	Coho Salmon	Chinook Salmon
Late Run	07/18 - 09/10	99,259[a]	1,094[b]	76
Downstream[c]	08/18[d]	12,258[e]		46[f]

[a] From 7/19 through 7/25, early-run fish were differentiated from late-run fish based on the degree of external maturation (color).

[b] Only a partial count as the weir was removed prior to completion of migration.

[c] Fish that spawned downstream from the Russian River Falls.

[d] Two foot surveys (8/18 and 9/01) were made downstream from the Russian River falls. A greater number of fish were enumerated on 8/18 and the tabulated values are for that date only and represent a minimum estimate.

[e] 11,282 live fish and 976 dead fish that spawned downstream from the Russian River Falls.

[f] 31 live fish and 15 dead fish enumerated downstream from Russian River Falls.

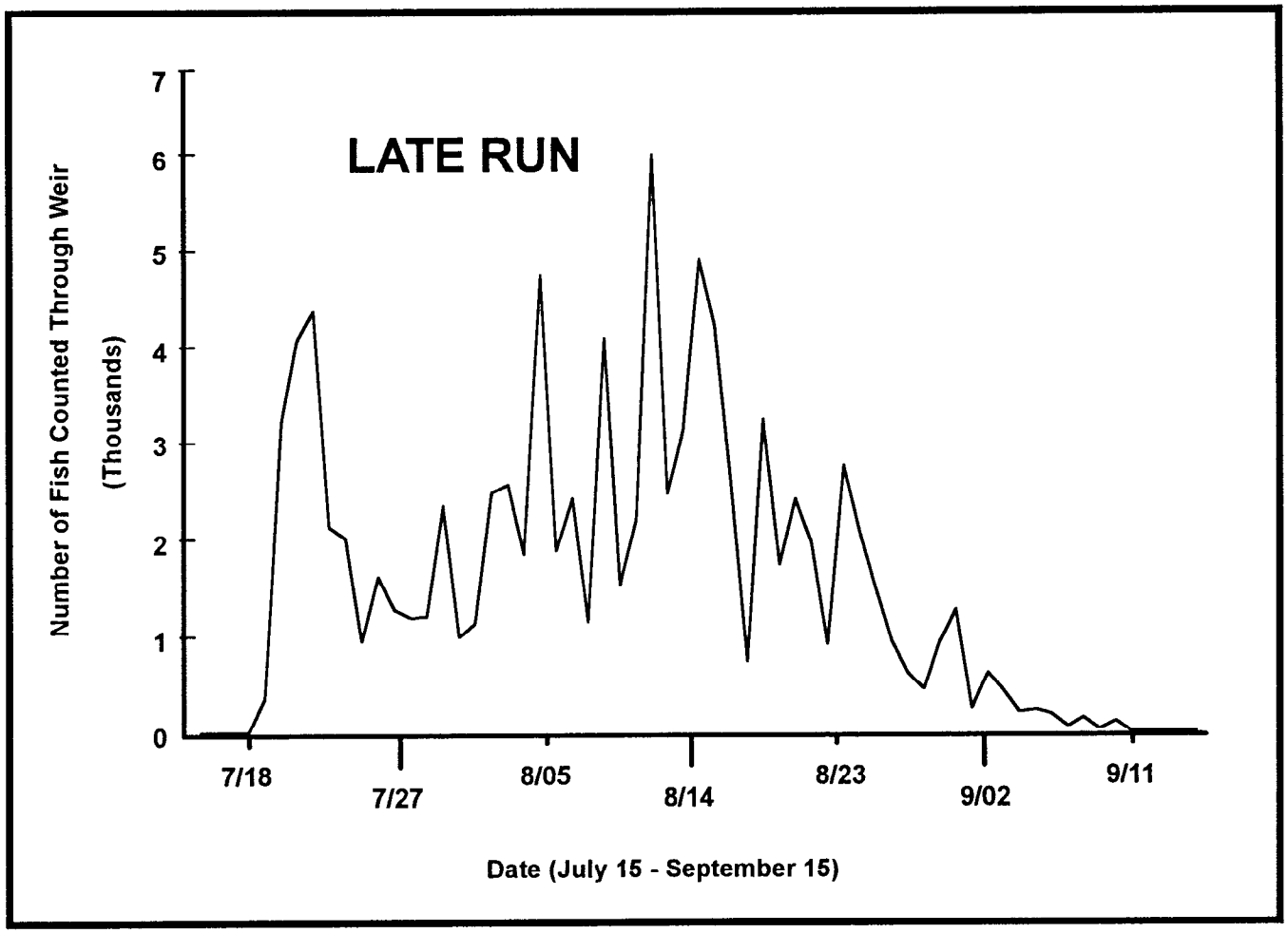

Figure 5. Daily escapement of sockeye salmon through the Russian River weir, 1993.

Table 7. Estimated age and sex composition of the late-run sockeye salmon escapement through the Russian River weir, 1993.

Dates	Age Group 2.3	1.3	2.2	2.1	1.2	Total
7/19 - 7/27						
n^a= 181						
Count= 20,047						
Females						
Sample Size	26	8	49	0	15	98
Percent	14.4	4.4	27.1	0.0	8.3	54.1
Variance of Percent	6.8	2.3	11.0	0.0	4.2	13.8
Number	2,880	886	5,427	0	1,661	10,854
Variance of Number	274,647	94,320	440,798	0	169,695	554,336
Males						
Sample Size	29	9	32	4	9	83
Percent	16.0	5.0	17.7	2.2	5.0	45.9
Variance of Percent	7.5	2.6	8.1	1.2	2.6	13.8
Number	3,212	997	3,544	443	997	9,193
Variance of Number	300,407	105,497	324,942	48,251	105,497	554,336
Sexes Combined						
Sample Size	55	17	81	4	24	181
Percent	30.4	9.4	44.8	2.2	13.3	100.0
Variance of Percent	11.8	4.7	13.7	1.2	6.4	
Number	6,092	1,883	8,971	443	2,658	20,047
Variance of Number	472,283	190,004	552,019	48,251	256,791	

-continued-

Table 7. (Page 2 of 5).

Dates	Age Group 2.3	1.3	2.2	2.1	1.2	Total
7/28 - 8/07						
n[a]= 99						
Count= 22,901						
Females						
Sample Size	2	3	20	0	28	53
Percent	2.0	3.0	20.2	0.0	28.3	53.5
Variance of Percent	2.0	3.0	16.4	0.0	20.7	25.4
Number	463	694	4,626	0	6,477	12,260
Variance of Number	105,929	157,255	862,719	0	1,085,497	1,331,209
Males						
Sample Size	7	7	7	12	13	46
Percent	7.1	7.1	7.1	12.1	13.1	46.5
Variance of Percent	6.7	6.7	6.7	10.9	11.6	25.4
Number	1,619	1,619	1,619	2,776	3,007	10,641
Variance of Number	351,640	351,640	351,640	570,050	610,456	1,331,209
Sexes Combined						
Sample Size	9	10	27	12	41	99
Percent	9.1	10.1	27.3	12.1	41.4	100.0
Variance of Percent	8.4	9.3	20.2	10.9	24.8	
Number	2,082	2,313	6,246	2,776	9,484	22,901
Variance of Number	442,280	485,962	1,061,472	570,050	1,298,447	

-continued-

Table 7. (Page 3 of 5).

Dates	Age Group 2.3	1.3	2.2	2.1	1.2	Total
8/08 - 8/20						
n^a= 118						
Count= 38,127						
Females						
Sample Size	0	1	8	1	27	37
Percent	0.0	0.8	6.8	0.8	22.9	31.4
Variance of Percent	0.0	0.7	5.4	0.7	15.1	18.4
Number	0	323	2,585	323	8,724	11,955
Variance of Number	0	104,400	785,232	104,400	2,192,404	2,674,251
Males						
Sample Size	2	1	9	53	16	81
Percent	1.7	0.8	7.6	44.9	13.6	68.6
Variance of Percent	1.4	0.7	6.0	21.1	10.0	18.4
Number	646	323	2,908	17,125	5,170	26,172
Variance of Number	207,016	104,400	875,355	3,074,005	1,456,249	2,674,251
Sexes Combined						
Sample Size	2	2	17	54	43	118
Percent	1.7	1.7	14.4	45.8	36.4	100.0
Variance of Percent	1.4	1.4	10.5	21.2	19.8	
Number	646	646	5,493	17,448	13,894	38,127
Variance of Number	207,016	207,016	1,532,095	3,083,821	2,877,697	

-continued-

Table 7. (Page 4 of 5).

Dates	Age Group 2.3	1.3	2.2	2.1	1.2	Total
8/21 - 9/10						
n^a= 30						
Count= 18,184						
Females						
Sample Size	0	0	1	0	3	4
Percent	0.0	0.0	3.3	0.0	10.0	13.3
Variance of Percent	0.0	0.0	11.1	0.0	31.0	39.8
Number	0	0	606	0	1,818	2,425
Variance of Number	0	0	367,398	0	1,026,180	1,317,564
Males						
Sample Size	0	0	1	25	0	26
Percent	0.0	0.0	3.3	83.3	0.0	86.7
Variance of Percent	0.0	0.0	11.1	47.9	0.0	39.8
Number	0	0	606	15,153	0	15,759
Variance of Number	0	0	367,398	1,583,610	0	1,317,564
Sexes Combined						
Sample Size	0	0	2	25	3	30
Percent	0.0	0.0	6.7	83.3	10.0	100.0
Variance of Percent	0.0	0.0	21.5	47.9	31.0	
Number	0	0	1,212	15,153	1,818	18,184
Variance of Number	0	0	709,457	1,583,610	1,026,180	

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Table 7. (Page 5 of 5).

Dates	Age Group 2.3	1.3	2.2	2.1	1.2	Total
Late Run Total 7/19 - 9/10						
n[a]= 428						
Count= 99,259						
Females						
Percent	3.4	1.9	13.3	0.3	18.8	37.8
Variance of Percent	0.4	0.4	2.5	0.1	4.5	6.0
Number	3,342	1,903	13,245	323	18,681	37,494
Variance of Number	380,575	355,976	2,456,147	104,400	4,473,776	5,877,360
Males						
Percent	5.5	3.0	8.7	35.8	9.2	62.2
Variance of Percent	0.9	0.6	1.9	5.4	2.2	6.0
Number	5,477	2,939	8,678	35,497	9,174	61,765
Variance of Number	859,063	561,537	1,919,335	5,275,916	2,172,201	5,877,360
Sexes Combined						
Percent	8.9	4.9	22.1	36.1	28.1	100.0
Variance of Percent	1.1	0.9	3.9	5.4	5.5	
Number	8,820	4,842	21,922	35,820	27,855	99,259
Variance of Number	1,121,579	882,982	3,855,044	5,285,732	5,459,115	

[a] n = sample size.

Table 8. Estimated age and sex composition of late-run sockeye salmon harvested in the confluence area of the Russian River recreational fishery, 1993.

Dates	Age Group 2.3	1.3	2.2	2.1	1.2	Total
7/18 - 7/27						
n^a= 154						
Harvest= 9,969						
Var(Harvest)= 5,903,235						
Females						
Sample Size	39	25	40	0	7	111
Percent	25.3	16.2	26.0	0.0	4.5	72.1
Variance of Percent	12.4	8.9	12.6	0.0	2.8	13.2
Number	2,525	1,618	2,589	0	453	7,185
Variance of Number	494,139	238,653	515,735	0	38,706	3,189,825
Males						
Sample Size	28	7	8	0	0	43
Percent	18.2	4.5	5.2	0.0	0.0	27.9
Variance of Percent	9.7	2.8	3.2	0.0	0.0	13.2
Number	1,813	453	518	0	0	2,784
Variance of Number	286,036	38,706	46,020	0	0	583,202
Sexes Combined						
Sample Size	67	32	48	0	7	154
Percent	43.5	20.8	31.2	0.0	4.5	100.0
Variance of Percent	16.1	10.8	14.0	0.0	2.8	
Number	4,337	2,071	3,107	0	453	9,969
Variance of Number	1,267,538	355,461	704,573	0	38,706	5,903,235

-continued-

Table 8. (Page 2 of 4).

Dates	Age Group 2.3	1.3	2.2	2.1	1.2	Total
7/28 - 8/07						
n[a]= 141						
Harvest= 9,189						
Var(Harvest)= 848,355						
Females						
Sample Size	11	6	76	8	12	113
Percent	7.8	4.3	53.9	5.7	8.5	80.1
Variance of Percent	5.1	2.9	17.7	3.8	5.6	11.4
Number	717	391	4,953	521	782	7,364
Variance of Number	48,109	25,862	394,830	34,685	52,634	639,896
Males						
Sample Size	8	0	14	0	6	28
Percent	5.7	0.0	9.9	0.0	4.3	19.9
Variance of Percent	3.8	0.0	6.4	0.0	2.9	11.4
Number	521	0	912	0	391	1,825
Variance of Number	34,685	0	61,761	0	25,862	128,476
Sexes Combined						
Sample Size	19	6	90	8	18	141
Percent	13.5	4.3	63.8	5.7	12.8	100.0
Variance of Percent	8.3	2.9	16.5	3.8	8.0	
Number	1,238	391	5,865	521	1,173	9,189
Variance of Number	85,019	25,862	483,487	34,685	80,317	848,355

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Table 8. (Page 3 of 4).

Dates	Age Group 2.3	1.3	2.2	2.1	1.2	Total
8/08 - 8/20						
n[a]= 85						
Harvest= 1,374						
Var(Harvest)= 456,604						
Females						
Sample Size	5	3	30	11	10	59
Percent	5.9	3.5	35.3	12.9	11.8	69.4
Variance of Percent	6.6	4.1	27.2	13.4	12.4	25.3
Number	81	48	485	178	162	954
Variance of Number	2,523	1,149	60,769	9,567	8,089	223,609
Males						
Sample Size	2	1	16	5	2	26
Percent	2.4	1.2	18.8	5.9	2.4	30.6
Variance of Percent	2.7	1.4	18.2	6.6	2.7	25.3
Number	32	16	259	81	32	420
Variance of Number	644	261	18,782	2,523	644	46,339
Sexes Combined						
Sample Size	7	4	46	16	12	85
Percent	8.2	4.7	54.1	18.8	14.1	100.0
Variance of Percent	9.0	5.3	29.6	18.2	14.4	
Number	113	65	744	259	194	1,374
Variance of Number	4,384	1,775	137,957	18,782	11,166	456,604

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Table 8. (Page 4 of 4).

Dates	Age Group 2.3	1.3	2.2	2.1	1.2	Total
Late Run Total						
n[a]= 380						
Harvest= 20,532						
Var(Harvest)= 7,208,194						
Females						
Percent	16.2	10.0	39.1	3.4	6.8	75.5
Variance of Percent	13.2	6.8	31.2	1.2	2.8	48.4
Number	3,322	2,058	8,027	699	1,397	15,503
Variance of Number	544,771	265,664	971,334	44,252	99,428	4,053,330
Males						
Percent	11.5	2.3	8.2	0.4	2.1	24.5
Variance of Percent	8.1	1.0	3.7	0.1	0.7	19.4
Number	2,366	469	1,689	81	423	5,029
Variance of Number	321,365	38,967	126,563	2,523	26,506	758,017
Sexes Combined						
Percent	27.7	12.3	47.3	3.8	8.9	100.0
Variance of Percent	27.5	9.4	40.0	1.4	3.9	
Number	5,689	2,527	9,716	780	1,820	20,532
Variance of Number	1,356,941	383,099	1,326,017	53,467	130,189	7,208,194

[a] n = sample size.

Table 9. Estimated age and sex composition of late-run sockeye salmon harvested in the river area of the Russian River recreational fishery, 1993.

Dates	Age Group 2.3	1.3	2.2	2.1	1.2	Total
7/18 - 7/27						
n[a]= 140						
Harvest= 3,157						
Var(Harvest)= 1,212,209						
Females						
Sample Size	43	19	24	0	4	90
Percent	30.7	13.6	17.1	0.0	2.9	64.3
Variance of Percent	15.3	8.4	10.2	0.0	2.0	16.5
Number	970	428	541	0	90	2,030
Variance of Number	127,759	29,714	44,570	0	2,738	515,424
Males						
Sample Size	27	8	14	0	1	50
Percent	19.3	5.7	10.0	0.0	0.7	35.7
Variance of Percent	11.2	3.9	6.5	0.0	0.5	16.5
Number	609	180	316	0	23	1,128
Variance of Number	54,891	7,352	17,790	0	509	169,079
Sexes Combined						
Sample Size	70	27	38	0	5	140
Percent	50.0	19.3	27.1	0.0	3.6	100.0
Variance of Percent	18.0	11.2	14.2	0.0	2.5	
Number	1,579	609	857	0	113	3,157
Variance of Number	318,798	54,891	101,763	0	3,715	1,212,209

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Table 9. (Page 2 of 4).

Dates	Age Group 2.3	1.3	2.2	2.1	1.2	Total
7/28 - 8/07						
n[a]= 44						
Harvest= 606						
Var(Harvest)= 153,318						
Females						
Sample Size	0	2	22	0	7	31
Percent	0.0	4.5	50.0	0.0	15.9	70.5
Variance of Percent	0.0	10.1	58.1	0.0	31.1	48.4
Number	0	28	303	0	96	427
Variance of Number	0	533	39,573	0	4,546	77,140
Males						
Sample Size	2	2	2	4	3	13
Percent	4.5	4.5	4.5	9.1	6.8	29.5
Variance of Percent	10.1	10.1	10.1	19.2	14.8	48.4
Number	28	28	28	55	41	179
Variance of Number	533	533	533	1,678	1,029	14,419
Sexes Combined						
Sample Size	2	4	24	4	10	44
Percent	4.5	9.1	54.5	9.1	22.7	100.0
Variance of Percent	10.1	19.2	57.7	19.2	40.8	
Number	28	55	331	55	138	606
Variance of Number	533	1,678	46,849	1,678	8,793	153,318

-continued-

Table 9. (Page 3 of 4).

Dates	Age Group 2.3	1.3	2.2	2.1	1.2	Total
8/08 - 8/20						
n[a]= 144						
Harvest= 2,241						
Var(Harvest)= 1,839,470						
Females						
Sample Size	6	2	28	14	16	66
Percent	4.2	1.4	19.4	9.7	11.1	45.8
Variance of Percent	2.8	1.0	11.0	6.1	6.9	17.4
Number	93	31	436	218	249	1,027
Variance of Number	4,082	660	73,034	19,340	24,908	391,942
Males						
Sample Size	5	3	28	24	18	78
Percent	3.5	2.1	19.4	16.7	12.5	54.2
Variance of Percent	2.3	1.4	11.0	9.7	7.6	17.4
Number	78	47	436	374	280	1,214
Variance of Number	2,964	1,252	73,034	54,188	31,176	545,231
Sexes Combined						
Sample Size	11	5	56	38	34	144
Percent	7.6	3.5	38.9	26.4	23.6	100.0
Variance of Percent	4.9	2.3	16.6	13.6	12.6	
Number	171	78	871	591	529	2,241
Variance of Number	12,304	2,964	283,481	132,419	106,562	1,839,470

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Table 9. (Page 4 of 4).

Dates	Age Group 2.3	1.3	2.2	2.1	1.2	Total
Late Run Total						
n[a]= 328						
Harvest= 6,004						
Var(Harvest)= 3,204,997						
Females						
Percent	17.7	8.1	21.3	3.6	7.3	58.0
Variance of Percent	51.5	13.0	65.4	6.1	12.3	255.5
Number	1,063	487	1,280	218	436	3,484
Variance of Number	131,841	30,907	157,177	19,340	32,191	984,506
Males						
Percent	11.9	4.2	13.0	7.1	5.7	42.0
Variance of Percent	24.9	3.9	33.7	17.8	11.0	189.1
Number	714	255	779	429	344	2,520
Variance of Number	58,387	9,137	91,357	55,866	32,713	728,729
Sexes Combined						
Percent	29.6	12.4	34.3	10.8	13.0	100.0
Variance of Percent	115.4	26.0	142.2	39.5	39.4	
Number	1,777	742	2,059	646	780	6,004
Variance of Number	331,634	59,533	432,092	134,097	119,070	3,204,997

[a] n = sample size.

third time stratum. The proportion of age-2.1 and -1.2 fish sampled in the river increased from 0% and 3.6% in the first time stratum to 26.4% and 23.6% in the third stratum.

Age composition of sockeye salmon that spawned in the Russian River downstream from the Russian River falls was predominantly age-1.3 fish (57.5%) (Table 10). Age-1.2 and -2.2 fish contributed 41.8% and 0.7%, respectively. Mean length by age and sex was also estimated for this spawning component of the late run (Table 11).

Differences in mean length by age and sex were tested among sample locations and time strata to determine if samples could be pooled together. Fish aged 1.2 were significantly larger ($F = 3.92$, $df = 2;180$, $P = 0.02$) at the weir than at either the river or the confluence. Additionally, there was a significant site by sex by time interaction with those sampled during the first time stratum significantly larger ($F = 3.65$, $df = 2;180$, $P = 0.01$) than those during the third stratum. Fish aged 1.3 were also shown to have significant length-at-age differences between sites over time ($F = 4.33$, $df = 4;90$, $P = 0.003$). Fish aged 2.1 and 2.3 were shown to have no significant differences in mean length-at-age. However, there were significant differences detected among age-2.2 adults sampled over time ($F = 4.88$, $df = 2;411$, $P = 0.008$) with larger fish sampled during the first time stratum than during the second time stratum. With differences detected in three of five age classes and significant differences in a predominant age class (age 2.2), samples were stratified by location and time to estimate mean length by age and sex (Table 12).

Total Return

An estimated 125,795 late-run sockeye salmon returned to the Russian River in 1993 (Table 13). Of these, 29.6% were age 2.1 and 26.8% were age 2.2. Ages 1.2 and 2.3 comprised 24.2% and 12.9% of the return, respectively. 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 (harvest plus escapement) of the 1993 late run was above the historical (1976-1992) average of 94,983 (Figure 6). The 1993 late run continued to follow a general trend, beginning in 1978, of greater numbers of sockeye salmon returning to the Russian River system, surpassing the previous historic (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,

Table 10. Estimated age and sex composition of sockeye salmon which spawn downstream from the Russian River Falls, 1993.

Dates	Age Group 2.3	1.3	2.2	1.2	Total
8/18 - 9/01[b]					
n[a]= 146					
Count= 12,258					
Females					
Sample Size	0	42	1	52	95
Percent	0.0	28.8	0.7	35.6	65.1
Variance of Percent	0.0	14.1	0.5	15.8	15.7
Number	0	3,526	84	4,366	7,976
Variance of Number	0	212,348	7,049	237,628	235,537
Males					
Sample Size	0	42	0	9	51
Percent	0.0	28.8	0.0	6.2	34.9
Variance of Percent	0.0	14.1	0.0	4.0	15.7
Number	0	3,526	0	756	4,282
Variance of Number	0	212,348	0	59,942	235,537
Sexes Combined					
Percent	0.0	57.5	0.7	41.8	100.0
Variance of Percent	0.0	28.3	0.5	19.8	
Number	0	7,053	84	5,121	12,258
Variance of Number	0	424,696	7,049	297,569	

[a] n = sample size.
[b] Indicates two distinct sampling dates.

Table 11. Mean length (millimeters) at age, by sex, for sampled sockeye salmon which spawn below the falls area during the late run of sockeye salmon to the Russian River, 1993.

Component		Age Class			
		2.3	1.3	2.2	1.2
Downstream Escapement[a]					
Female	Mean Length		564	522	534
	SE		2.2		2.7
	Sample Size		42	1	52
Male	Mean Length		588		530
	SE		3.2		16.2
	Sample Size		42		9

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

Table 12. Mean length (millimeters) at age, by sex, for the late run of sockeye salmon sampled from the Russian River, 1993.

			Time Strata										
			7/18 - 27			7/28 - 8/07			8/08 - 20			8/21 - 9/10	
Area	Age	Sex	n[a]	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE
Confluence													
	1.2												
		Female	7	505	5.8	12	505	5.6	10	486	8.6		
		Male				6	499	12.0	2	524	1.0		
	1.3												
		Female	25	580	3.6	6	548	8.2	3	533	10.9		
		Male	7	585	5.4				1	567			
	2.1												
		Female				8	401	7.8	11	383	7.3		
		Male							5	386	5.2		
	2.2												
		Female	40	542	2.9	76	530	2.1	30	530	2.9		
		Male	8	556	4.5	14	543	5.5	16	535	3.6		
	2.3												
		Female	39	585	2.6	11	583	3.2	5	590	10.9		
		Male	28	586	3.0	8	588	6.4	2	575	15.0		
River													
	1.2												
		Female	4	528	5.1	7	512	5.8	16	498	7.5		
		Male	1	500		3	487	26.8	18	509	2.9		
	1.3												
		Female	19	590	5.5	2	570	20.0	2	604	14.5		
		Male	8	581	9.6	2	551	9.0	3	595	7.6		
	2.1												
		Female							14	393	9.0		
		Male				4	395	5.0	24	393	6.8		
	2.2												
		Female	24	540	4.3	22	528	2.5	28	535	3.0		
		Male	14	535	9.0	2	520	5.0	28	540	3.1		
	2.3												
		Female	43	582	2.8				6	572	1.1		
		Male	27	589	4.6	2	590	10.0	5	580	8.3		

-continued-

Table 12. (Page 2 of 2).

Area	Age	Sex	Time Strata 7/18 - 27 n[a]	Mean	SE	7/28 - 8/07 n	Mean	SE	8/08 - 20 n	Mean	SE	8/21 - 9/10 n	Mean	SE
Weir[b]														
	1.2													
		Female	15	526	4.6	28	515	3.3	27	514	3.7	3	503	8.8
		Male	9	524	4.5	13	519	4.8	16	507	8.3			
	1.3													
		Female	8	586	8.4	3	582	8.3	1	565				
		Male	9	584	8.0	7	610	10.3	1	550				
	2.1													
		Female							1	415				
		Male	4	394	9.2	12	394	6.0	53	381	3.1	25	380	3.8
	2.2													
		Female	49	539	2.6	20	538	3.3	8	537	4.2	1	540	
		Male	32	535	4.4	7	537	5.4	9	536	5.2	1	510	
	2.3													
		Female	26	580	3.1	2	568	6.5						
		Male	29	586	2.9	7	591	8.0	2	572	0.5			

[a] n = sample size.

[b] Fish that migrated through the weir.

Table 13. Estimated age and sex composition of the late run of sockeye salmon to the Russian River, 1993.

Dates	Age Group 2.3	1.3	2.2	2.1	1.2	Total
7/19 - 9/10						
Late Run Total [a] n^b= 941						
Number= 125,795						
Var(Harvest)= 10,413,191						
Females						
Percent	6.1	3.5	17.9	1.0	16.3	44.9
Variance of Percent	0.6	0.4	1.7	0.1	2.1	2.0
Number	7,728	4,448	22,552	1,240	20,513	56,481
Variance of Number	1,057,188	652,546	3,584,658	167,992	4,605,395	10,915,196
Males						
Percent	6.8	2.9	8.9	28.6	7.9	55.1
Variance of Percent	0.7	0.4	1.2	2.0	1.2	1.5
Number	8,558	3,663	11,145	36,006	9,941	69,314
Variance of Number	1,238,815	609,641	2,137,255	5,334,305	2,231,421	7,364,106
Sexes Combined						
Percent	12.9	6.4	26.8	29.6	24.2	100.0
Variance of Percent	1.4	0.8	2.1	2.0	2.2	
Number	16,286	8,111	33,697	37,247	30,454	125,795
Variance of Number	2,810,155	1,325,613	5,613,153	5,473,296	5,708,374	

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

[b] n = Number sampled.

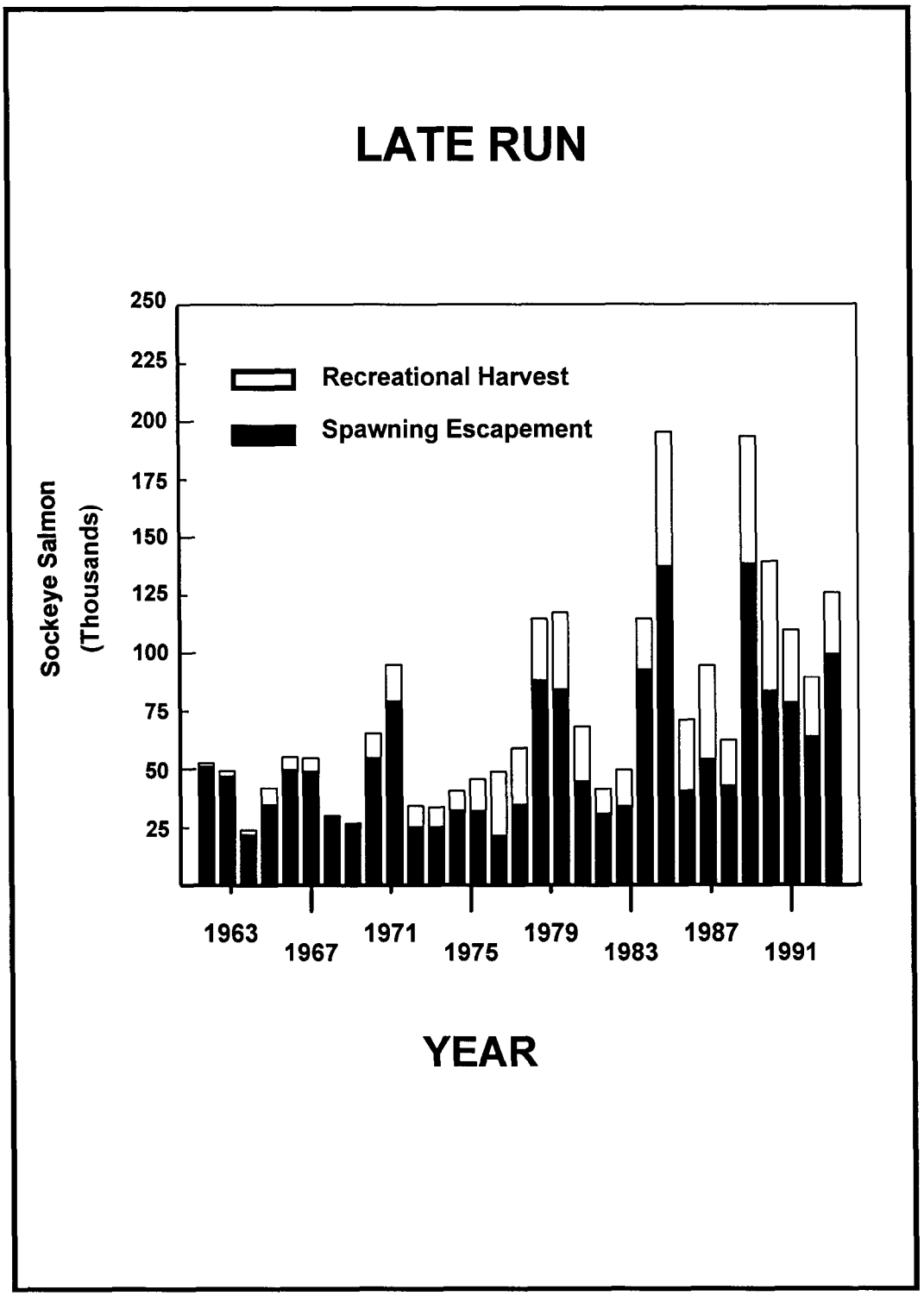

Figure 6. Historical returns of sockeye salmon to the Russian River.

these anglers comprised only a minor portion of the total fishery. Creel census personnel and the project leader informally monitored the other access sites at least twice a day 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 1993. An informal accounting of activity during these hours was accomplished through interviews 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 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:

Accurate assessment of 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 components adopted in 1990, 1991 and 1992 was continued during the 1993 season. Increased sampling intensity over previous years is an effort to achieve more accurate age composition estimates. Significant temporal changes in age composition were detected within spatial components as well as differences among spatial components within temporal strata since 1990 (Carlon et al. 1991; Marsh 1992, 1993).

Age composition of the confluence and river harvests and the weir escapement clearly differed during the late run in 1993. Because age compositions differed over time and among the spatial components of the fishery, samples could not be pooled. A harvest estimate or escapement number of each time stratum was calculated for each spatial stratum. This harvest or escapement was then apportioned based upon the sex and age proportions of each temporal/spatial strata. Estimated harvests or escapement from the different areas of the Russian River were thereby apportioned in an unbiased manner.

It is recommended that sampling of temporal and spatial strata be continued at the present sampling intensity. This will improve estimates of the numbers of sockeye salmon returning by age and sex and the 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

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 (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 be

continued in 1994 and subsequent years to further evaluate the value of these statistics in managing the Russian River sockeye salmon resource.

ACKNOWLEDGMENTS

Steve Hammarstrom provided consistent, critical review regarding all aspects of the project, from personnel matters to migratory timing influences to weir panels, which contributed greatly towards my understanding of the project and the fishery resource.

Paul Zallek collected creel survey data and age, sex, and length data from the fishery and monitored the fishery for regulation violations. Paul has been employed by the Department of Fish and Game at the Russian River for the last five seasons. His prior work experience with two different federal agencies assigned to the Russian River has also contributed to his detailed understanding of the sport fishery. His detailed observations of the fishery were vital to the conduct of the creel census and the management of the sockeye salmon resource.

Colleen O'Brien also collected creel survey data and age, sex, and length data from the fishery. Colleen has also been a long-term seasonal employee at the Russian River with four seasons' employment. This experience and her enthusiasm and conduct while performing her responsibilities proved to be an invaluable asset to the Russian River project.

Dave Athons provided vital aircraft logistical support and assisted with installing and removing the weir structure. His prior experience at the weir and his knowledge of the sport fishery were also valuable towards the day-to-day operations of the study.

Jim Hasbrouck provided detailed statistical support necessary to allocate the age compositions of the sport harvest and the escapement as well as much appreciated critical review. Sandy Sonnichsen wrote and streamlined the SAS statistical analysis code necessary to generate the harvest and effort estimates for the direct expansion creel model used for the Russian River project. Jay Carlon provided indispensable technical support and preliminary data analysis review. Dave Nelson provided valuable guidance and a long-term perspective towards achieving project objectives.

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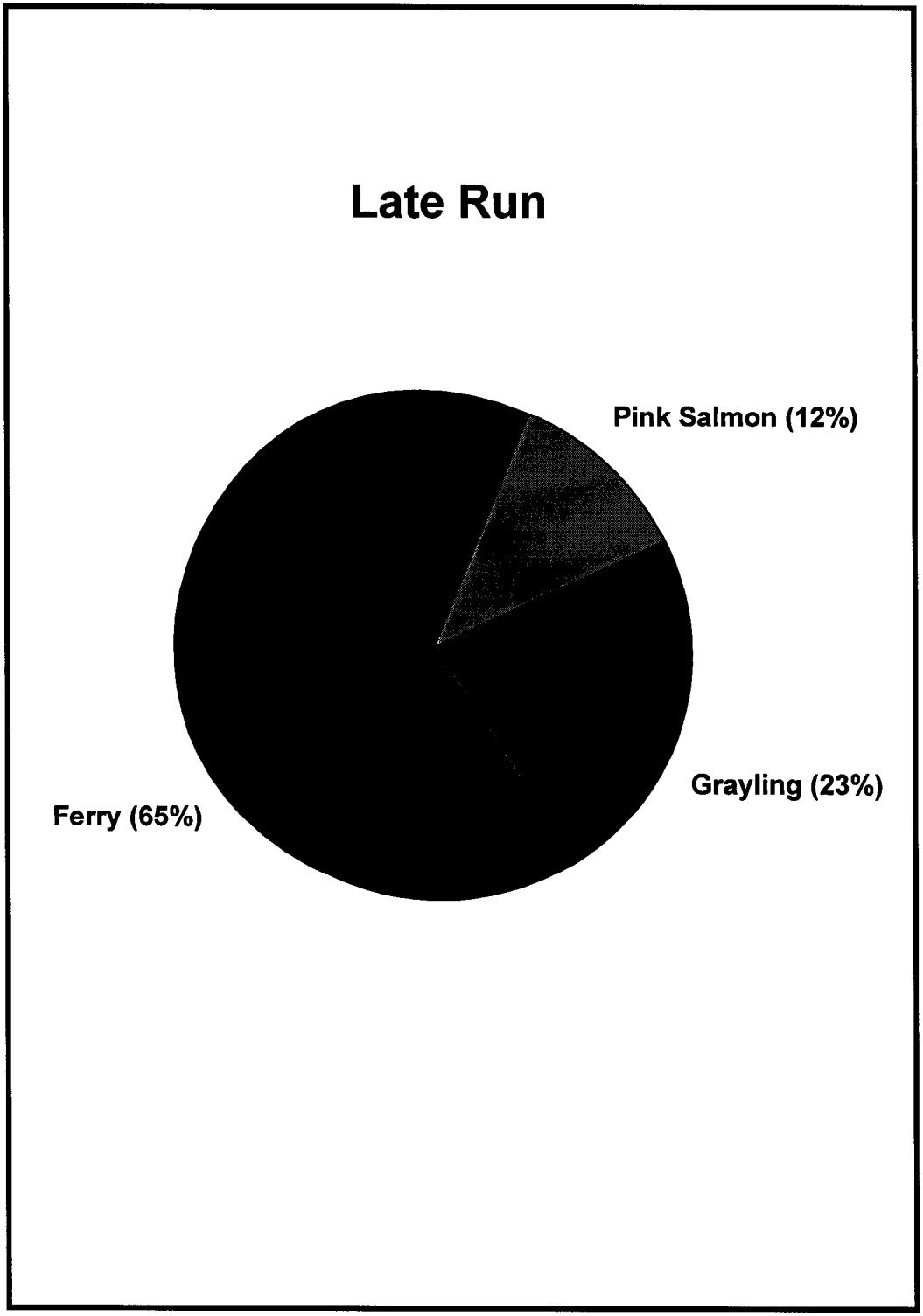
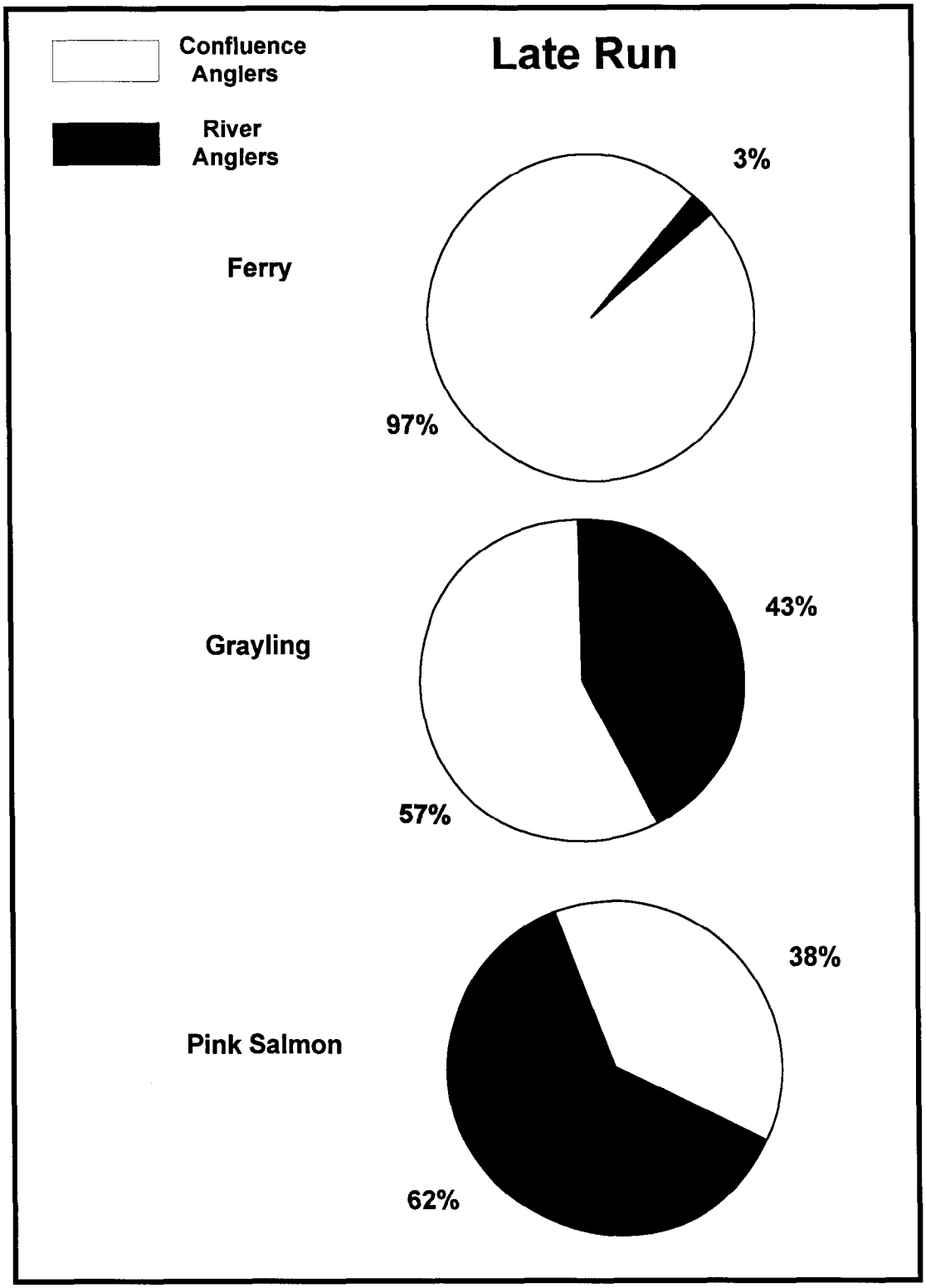
APPENDIX A

Selected Summaries of Fishery and Escapement Data from the Russian River, 1993



Appendix A1. Relative proportions of interviews collected at the three access locations to the Russian River late-run sockeye salmon recreational fishery, 1993.



Appendix A2. Relative proportions of confluence and river anglers interviewed during the creel survey by access location, and area fished, late run, 1993.

Appendix A3. Temporal harvest and effort estimates for the 1993 Russian River late-run 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	Variance Components: Days	%	Periods	%	Anglers	%
Late-run river effort:													
Ferry	7/18-7/27	10	5	29	3,704	286	59,417	37,040	62	22,280	37	97	0
Grayling	7/18-7/27	10	2	780	23,337	7,797	1,642,931	933,475	57	700,833	43	8,623	1
Pink salmon	7/18-7/27	10	2	398	137,687	3,982	5,561,404	5,507,468	99	52,496	1	1,440	0
	Total 7/18-7/27					12,065	7,263,752						
Ferry	7/28-8/07	11	6	23	996	256	10,393	9,126	88	1,267	12	0	0
Grayling	7/28-8/07	11	2	114	11,815	1,260	592,470	584,859	99	7,108	1	504	0
Pink salmon	7/28-8/07	11	2	142	40,664	1,568	2,213,174	2,012,859	91	200,086	9	229	0
	Total 7/28-8/07					3,085	2,816,037						
Ferry	8/08-8/20	8	4	103	56,465	823	693,331	451,722	65	225,861	33	15,749	2
Grayling	8/08-8/20	12	3	175	35,252	2,101	1,450,350	1,269,076	88	180,776	12	498	0
Pink salmon	8/08-8/20	12	2	169	57,359	2,032	3,808,937	3,441,531	90	363,975	10	3,431	0
	Total 8/08-8/20					4,957	5,952,618						
	Late-run river					20,106	16,032,407						
Late-run confluence effort:													
Ferry	7/18-7/27	10	5	1,975	367,296	19,751	22,598,394	3,672,958	16	18,906,197	84	19,239	0
Grayling	7/18-7/27	10	2	681	608,902	6,808	24,561,087	24,356,081	99	197,457	1	7,549	0
Pink salmon	7/18-7/27	10	2	674	608,323	6,738	24,402,056	24 332,915	100	62,719	0	6,422	0
	Total 7/18-7/27					33,298	71,561,537						
Ferry	7/28-8/07	11	6	2,317	1,541,239	25,488	15,135,902	14,128,022	93	987,000	7	20,879	0
Grayling	7/28-8/07	11	2	854	32,285	9,397	1,990,507	1,598,118	80	387,211	19	5,178	0
Pink salmon	7/28-8/07	11	2	189	17,511	2,081	890,483	866,779	97	23,526	3	177	0
	Total 7/28-8/07					36,967	18,016,892						
Ferry	8/08-8/20	8	4	229	64,544	1,832	629,630	516,349	82	113,213	18	68	0
Grayling	8/11-8/20	12	3	214	18,315	2,575	742,906	659,338	89	82,801	11	767	0
Pink salmon	8/11-8/20	12	2	11	221	126	16,758	13,230	79	3,528	21	0	0
	Total 8/08-8/20					4,534	1,389,294						
	Late-run confluence					74,798	90,967,723						
	Late-run total					94,905	107,000,130						

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Location Exited	Temporal Period	D[a]	d[b]	Mean	Variance	Estimated Total Harvest	Estimated Total Variance	Variance Components: Days	%	Periods	%	Anglers	%
Late-run river harvest:													
Ferry	7/18-7/27	10	5	8	298	83	4,900	2,975	61	1,827	37	97	2
Grayling	7/18-7/27	12	3	254	22,680	2,536	973,866	907,184	93	63,737	7	2,945	0
Pink salmon	7/18-7/27	12	3	54	5,779	538	233,443	231,173	99	2,035	1	235	0
	Total 7/18-7/27					3,157	1,212,209						
Ferry	7/28-8/07	11	6	1	15	16	267	134	50	107	40	27	10
Grayling	7/28-8/07	11	2	42	2,442	467	138,557	120,855	87	17,413	13	289	0
Pink salmon	7/28-8/07	11	2	11	252	123	14,494	12,463	86	1,982	14	49	0
	Total 7/28-8/07					606	153,318						
Ferry	8/08-8/20	8	4	20	2,150	161	28,499	17,198	60	8,599	30	2,702	9
Grayling	8/08-8/20	12	3	85	21,529	1,023	846,228	775,034	92	70,718	8	475	0
Pink salmon	8/08-8/20	12	2	88	15,506	1,057	964,743	930,336	96	32,666	3	1,741	0
	Total 8/08-8/20					2,241	1,839,470						
	Late-run river					6,004	3,204,997						
Late-run confluence harvest													
Ferry	7/18-7/27	10	5	605	26,804	6,050	1,696,165	268,038	16	1,423,571	84	4,556	0
Grayling	7/18-7/27	10	2	232	69,758	2,320	2,886,876	2,790,325	97	92,372	3	4,179	0
Pink salmon	7/18-7/27	10	2	160	32,749	1,599	1,320,194	1,309,969	99	9,201	1	1,024	0
	Total 7/18-7/27					9,969	5,903,235						
Ferry	7/28-8/07	11	6	562	69,729	6,185	754,342	639,180	85	109,598	15	5,564	1
Grayling	7/28-8/07	11	2	246	82	2,707	21,759	4,075	19	16,283	75	1,400	6
Pink salmon	7/28-8/07	11	2	27	1,458	297	72,254	72,171	100	0	0	83	0
	Total 7/28-8/07					9,189	848,355						
Ferry	8/08-8/20	8	4	59	7,721	470	71,270	61,767	87	9,457	13	46	0
Grayling	8/08-8/20	12	3	69	10,522	832	379,862	378,792	100	901	0	169	0
Pink salmon	8/08-8/20	12	2	6	72	72	5,472	4,320	79	1,152	21	0	0
	Total 8/08-8/20					1,374	456,604						
	Late-run confluence					20,532	7,208,194						
	Late-run total					26,536	10,413,191						

[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, 1993.

Date	Early-Run Sockeye[a]	Late-Run Sockeye	Coho	Chinook
7/19	107	356		
7/20	204	3,221		4
7/21	92	4,079		
7/22	90	4,375		
7/23	59	2,142		
7/24	19	2,022		
7/25	12	947		
7/26		1,621		2
7/27		1,284		1
7/28		1,201		
7/29		1,215		
7/30		2,352		
7/31		1,001		
8/01		1,140		2
8/02		2,490		3
8/03		2,579		3
8/04		1,855		
8/05		4,747		4
8/06		1,891		1
8/07		2,430		
8/08		1,154		1
8/09		4,093		2
8/10		1,535		4
8/11		2,210	2	5
8/12		5,996	5	13
8/13		2,483	5	5
8/14		3,130	14	9
8/15		4,905	20	5
8/16		4,233	28	1
8/17		2,654	10	1
8/18		735	3	
8/19		3,248	51	1
8/20		1,751	27	
8/21		2,421	35	3
8/22		1,976	48	4
8/23		920	11	
8/24		2,766	31	2

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Date	Early-Run Sockeye[a]	Late-Run Sockeye	Coho	Chinook
8/25		2,082	19	
8/26		1,505	51	
8/27		952	13	
8/28		614	29	
8/29		447	8	
8/30		946	44	
8/31		1,279	114	
9/01		246	13	
9/02		616	35	
9/03		427	12	
9/04		205	3	
9/05		233	2	
9/06		189	4	
9/07		57	36	
9/08		154	44	
9/09		34	18	
9/10		115[b]	359[c]	
9/11				
9/12				
9/13				
9/14				
Totals		99,259	1,094	76

[a] From 7/19 through 7/25, early-run fish were differentiated from late-run fish based on degree of external maturation, i.e., body coloration and kype development.

[b] An estimated 95 sockeye salmon remained downstream from the weir when it was dismantled on 9/10/93.

[c] An estimated 350 coho salmon remained downstream from the weir when it was dismantled on 9/10/93.