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

by

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ABSTRACT

A direct expansion creel survey of the early-run Russian River recreational fishery was conducted in 1993 to determine angler effort for and harvest of sockeye salmon *Oncorhynchus nerka*. Anglers expended 135,848 angler-hours (SE = 10,795) to harvest 37,881 sockeye salmon (SE = 4,569) from the early run (11 June-17 July). The weighted harvest rate for the early run was 0.279 sockeye salmon per hour of angler effort. Approximately 73% of the effort and 65% of the harvest during the early run was taken from the confluence area of the fishery, where the Russian River flows into the Kenai River.

A total of 39,857 sockeye salmon bound for spawning areas was counted through the weir at the outlet of Lower Russian Lake during the early run. This escapement exceeded the Board of Fisheries mandated escapement goal of 16,000 fish.

Estimates of the age composition of the total early run (apportioned harvest plus escapement) indicate that the return was primarily of age-2.3 and age-2.2 sockeye salmon (71.3% and 27.4%, respectively). Both the sport harvest and total return for the early run were larger than the mean historical values for 1976-1992.

KEY WORDS: Russian River, sockeye salmon, *Oncorhynchus nerka*, creel survey, direct expansion, harvest, effort, weir, escapement, age composition, recreational fishery, 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). One of the largest recreational fisheries 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 harvests exceeded 190,000 fish in 1987. Prior information pertaining to this fishery has been 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, 1993).

Sockeye salmon return to the Russian River in two temporal components, termed early and late runs. Historically, the total return during the early run has averaged approximately one-half that of the total return during the late run. The early run typically arrives at the confluence of the Russian and Kenai rivers in early June. Early-run fish typically remain in the confluence area for up to 2 weeks before continuing their migration. By mid July, these fish will have migrated through the Russian River and into Upper Russian Lake. The early run spawns almost exclusively in Upper Russian Creek (Nelson 1973, 1974) and is comprised primarily of 3-ocean fish (Nelson 1973-1985; Nelson et al. 1986; Athons and McBride 1987; Hammarstrom and Athons 1988 and 1989; Carlon and Vincent-Lang 1990; Carlon et al. 1991; Marsh 1992, 1993).

The early run of sockeye salmon bound for the Russian River is utilized predominantly by recreational anglers. The run migrates through the waters of Cook Inlet prior to the opening of the commercial fishery which would intercept the stock. Numerically, this stock is much smaller than later-arriving Kenai River mainstem stocks, which include the late-run Russian River sockeye. The early-run fish tend to migrate rapidly through the Kenai River, therefore, minimal harvest and effort occurs in the mainstem Kenai River. As such, all management decisions regarding harvest and stock conservation issues for the early run are focused upon the confluence area of the Kenai and Russian rivers and a short stretch of the mainstem Russian River.

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 from each run passes through a weir at the outlet of Lower Russian Lake (Figure 2). The current escapement goal for the early run is 16,000 fish. This goal is based upon evaluation of returns from past brood years. With the exception of 1989, the escapement goal has been achieved each year since the goals were formally adopted in 1979. Despite an emergency closure of the early-run fishery in 1989 (1 July through 15 July), the early-run escapement goal was not achieved (Carlon and Vincent-Lang 1990).

Because the recreational fishery for sockeye salmon at the Russian River is one of the largest in the state in terms of angler effort, there is a potential for overharvest. Precise and timely management decisions are required to ensure that adequate escapement is obtained. The data necessary for these decisions are provided by a creel survey and a counting weir. The creel survey provides data regarding angler effort and harvest from the recreational

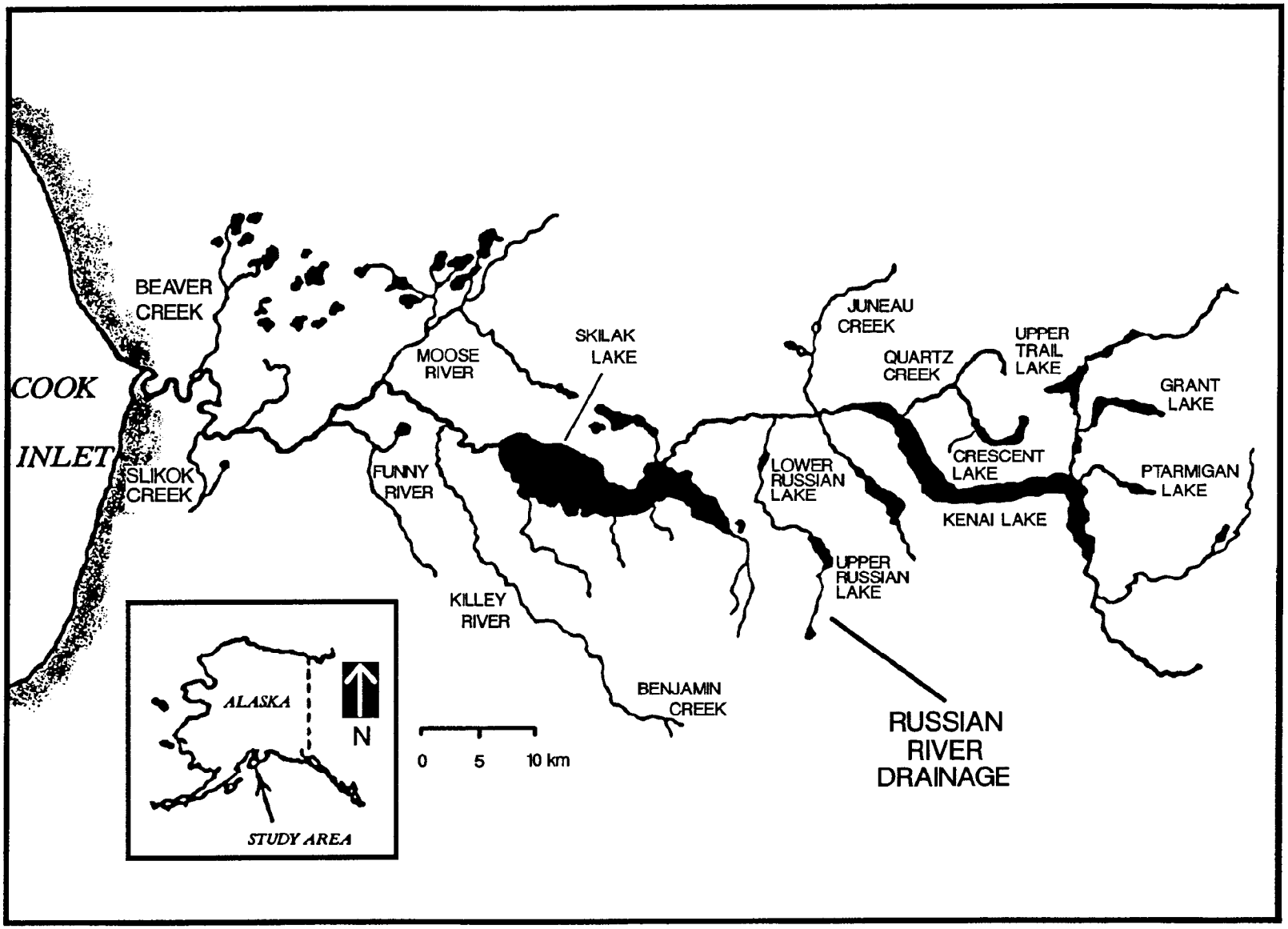

Figure 1. Map of the Kenai and Russian River drainages.

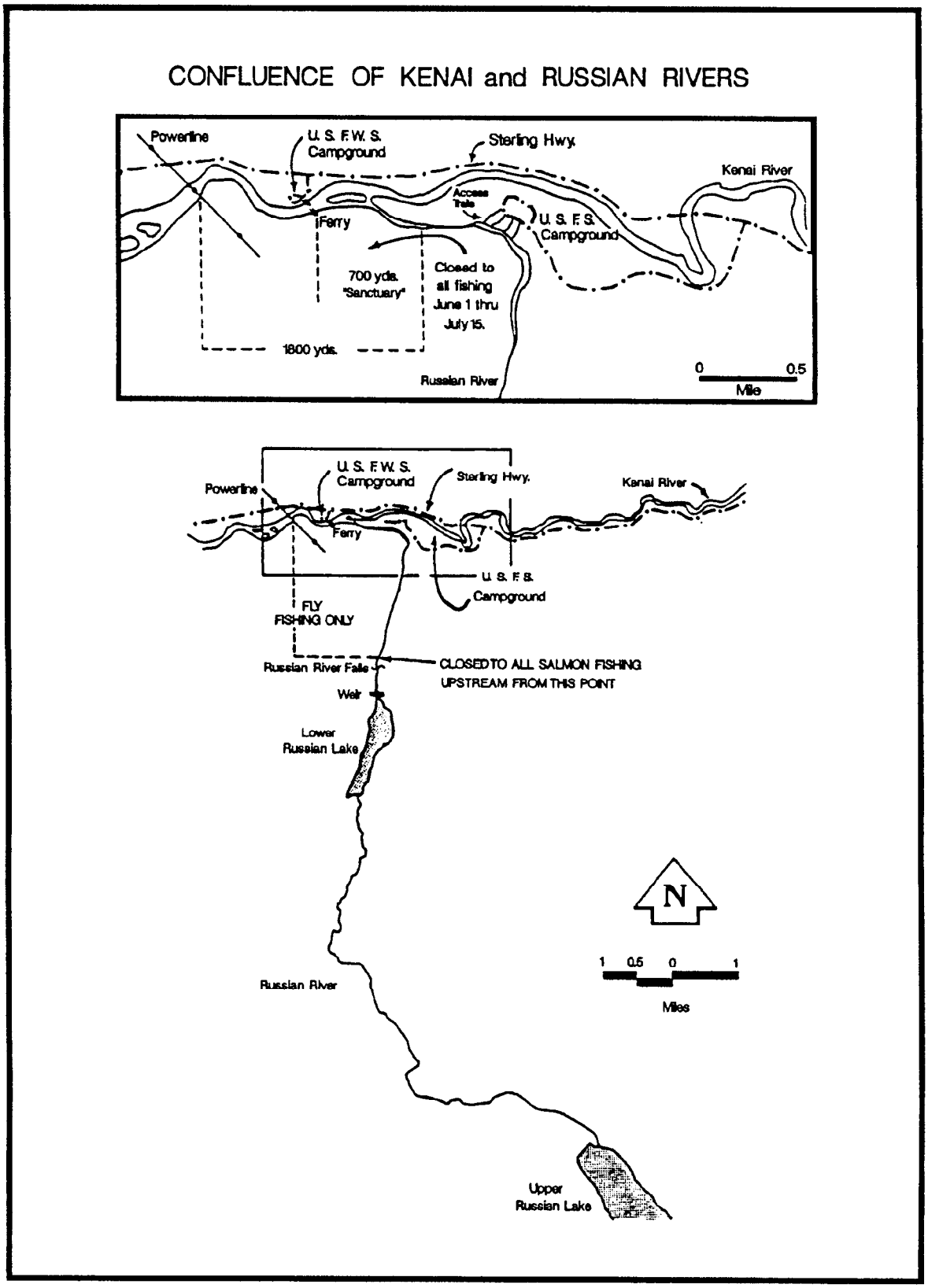

Figure 2. Detail map of the Kenai and Russian River study area.

fishery for sockeye salmon which occurs in the Kenai/Russian River "fly-fishing-only" area (Figure 2). Weir operations provide daily escapement information. Estimates of the total inriver return (harvest plus escapement) and the age, sex, and size compositions of the return provide necessary information required to evaluate 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. Within this "fly-fishing-only" area, there is a sanctuary area which 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) downstream of the ferry cable (approximately 640 m). This area is closed to all fishing from 1 June to 15 July by regulation.

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

METHODS

Study Area

The recreational fishery occurs in two areas (Figure 3): (1) the confluence area, which extends from the upper limit marker of the sanctuary area 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).

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. Most anglers fishing the confluence area use the ferry to reach the south bank of the Kenai River. Both the parking area and

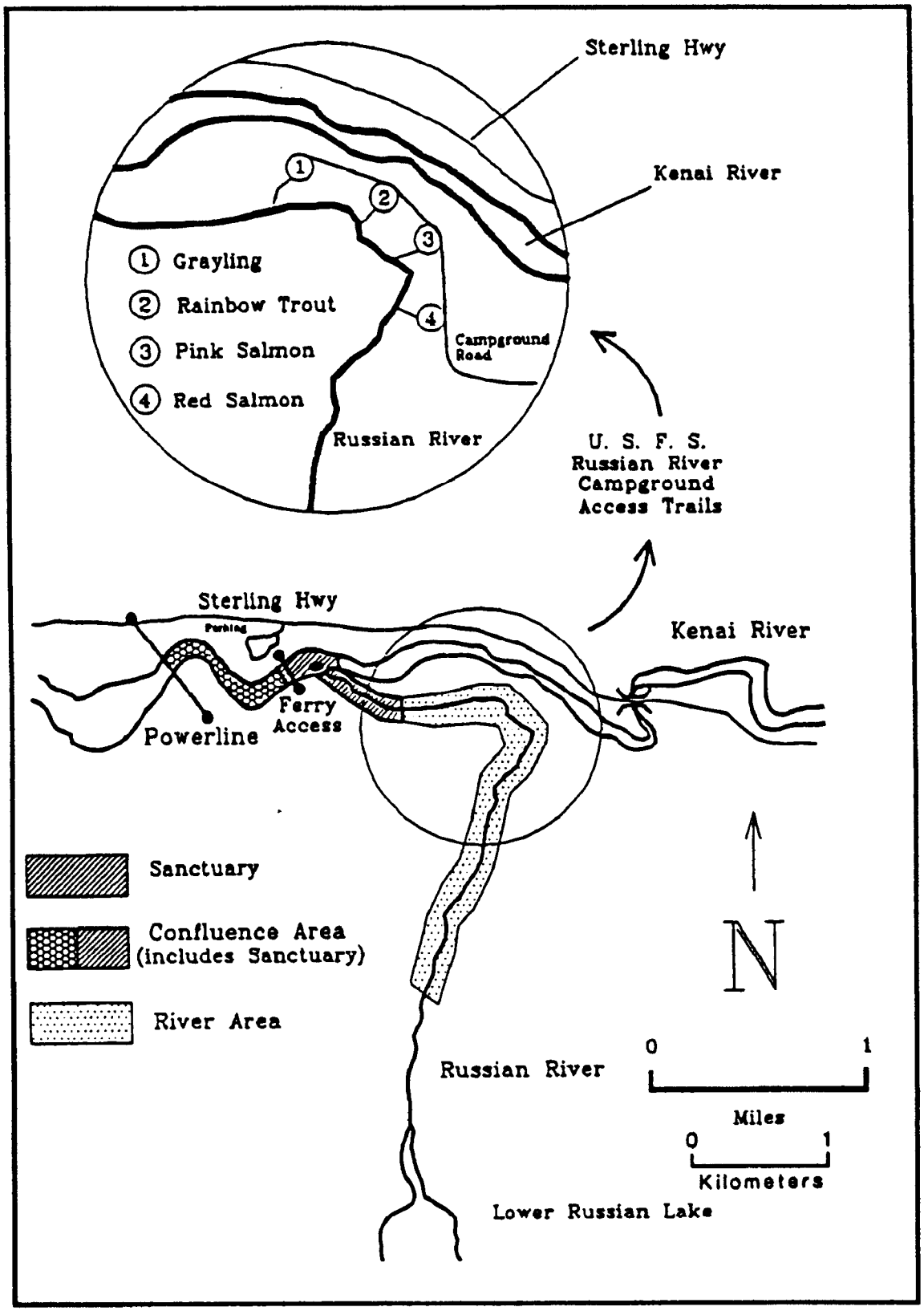

Figure 3. Map of the Russian River sockeye salmon recreational fishing areas and fishing access locations sampled during the 1993 creel survey.

the ferry are operated privately under a concession administered by the USFWS. Some anglers also use the ferry to traverse the Kenai River and then walk upstream to fish the Russian River area and others 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 by Nelson (1976) and provides a complete count of the early-run spawning escapement.

Study Design

Creel Survey:

A direct expansion creel survey was utilized during the 1993 season. This season was the fourth year that this creel survey design has been used during the Russian River sockeye salmon sport fishery. 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 for anglers exiting the fishery at each of the three sampled access locations. The stratification corresponded with the opening of the sanctuary area of the sport fishery which influenced catch rates and the subsequent harvest. This occurred on 23 June. Therefore, the data were poststratified by time. A survey stratum was thus defined as an access location/temporal component combination. The sampled locations included the ferry access to the confluence area and two river trails from the Grayling and Pink Salmon parking areas. These locations were sampled over two temporal components: from 11 June to 23 June, and from 24 June to 17 July. Area-specific (river or confluence area) harvest and effort were estimated for each stratum by recording the area fished for each interviewed angler.

The creel survey sampling day was 18 hours in length (0600 to 2400 hours) and was divided into six, 3-hour periods. 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 the years 1990 through 1992, approximately two-thirds of the harvest and effort occurred in the confluence area (Carlon et al. 1991, Marsh 1992, 1993). Historically, this has been typical of the early-run sport fishery in

most years (Nelson et al. 1986). As a result of this concentration of harvest and effort and because harvest rate (harvest per hour) is used as a management tool to index sockeye salmon abundance at the confluence, the confluence access location (the ferry) was sampled every other day throughout the early run. This ensured that timely information regarding confluence harvest rates was available when formulating inseason management strategies.

Creel survey results from the 1990 and 1991 seasons indicated that angler use patterns differed among the access locations to the sport fishery (Carlon et al. 1991; Marsh 1992, 1993). Three access locations, the ferry, Grayling and Pink Salmon, represented more than 90% of the total effort and more than 90% of the total harvest during the annual sport fishery. These locations also contributed approximately 90% of the total variance for both the harvest and effort estimates. Therefore, in order to better utilize creel census personnel and improve the precision of the estimates of harvest and effort from the remaining access locations, Rainbow and Red Salmon were dropped from the sampling schedule beginning with the 1992 season. This sampling regime was continued during the 1993 season.

Estimates of effort, harvest, and their variances for the early run in 1990, 1991 and 1992 were used to optimally allocate the number of sampling days among the river access locations (Cochran 1977). In 1993, the ferry was sampled every other day, while Grayling was sampled approximately every 3 days and Pink Salmon sampled approximately every 4 days.

The following formulae were applied to generate harvest and effort estimates for each temporal component of the fishery. At access location k on day i during sample period j, m_{kij} represents those completed-trip anglers interviewed as they exited through location k, and a_{kij} represents those anglers which 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 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 (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 ($\bar{H}_{rki}$) was estimated for location k on day i as:

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

where:

u = the number of sample periods on day i ($u = 2$) at location k, 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 through access location k on day i was estimated by expanding the mean river area harvest per period on day i by:

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

where:

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

The mean river area harvest per day ($\bar{H}_{rk}$) was estimated at location k 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 as (Wolter 1985):

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

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 the early run.

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

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

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

where:

D_{rk} = the total number of sampling days at location k during the early run;

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}).

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 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 early run by summing the individual stratum estimates. The stratum estimates were assumed to be independent, and therefore, 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. The daily confluence area harvest rate was based on interviews of anglers exiting the fishery that reported fishing the confluence area. The mean daily harvest rate for 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 ($HPUE_r$).

The overall harvest rate for the early run provides a relative basis for comparing seasonal fishing success among years (Nelson 1985; Hammarstrom and Athons 1988). A harvest rate for the early run was estimated by dividing the total run-specific harvest estimate by the total run-specific 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. 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, adults have not yet developed the reddish body coloration and large green head with hooked jaws characteristic of more sexually mature fish which pass 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 physical characteristics. The period of overlap began on 19 July when late-run fish were intermixed with mature, early-run fish and continued through 25 July, after which early-run fish were no longer present.

Biological Data:

Six time and area strata within the Russian River sockeye salmon return were sampled for biological data (Table 1). The sampling strata corresponded to those for which harvest was estimated by the creel survey. Schedules of each creel census clerk allowed for biological sampling of the harvest at least part of each day that angler interviews were conducted. In addition, a full day of sampling was scheduled for one or both creel clerks when fishing effort and harvest were the greatest.

Scales were collected from the preferred area of each sampled fish and placed on adhesive-coated cards (Clutter and Whitesel 1956). The 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 for age determination. The European method of age description was used to record ages: the numeral preceding the decimal represents the number of freshwater annuli and

Table 1. Temporal components of the recreational harvest and escapement sampled for age composition during the 1993 early-run Russian River sockeye salmon return.

Return Component	Temporal Delineation
Confluence area harvest	6/11 - 6/23 6/24 - 7/17
River area harvest	6/17 - 6/23 6/24 - 7/17
Escapement through weir	6/11 - 6/23 6/24 - 7/25

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.

Age composition was estimated for each temporal stratum of all spatial return components. The proportion of fish of age group h in stratum i of a component was estimated for each sex as:

$$\hat{P}_{gf} = n_{gf}/n_{Tf}, \tag{18}$$

where:

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

n_{Tf} = the total number of legible scales read from sockeye salmon sampled during stratum f.

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

$$V(\hat{P}_{gf}) = \hat{P}_{gf}(1-\hat{P}_{gf})/(n_{Tf}-1). \tag{19}$$

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

$$\hat{N}_{gf} = \hat{H}_{Tf}\hat{P}_{gf}, \tag{20}$$

where:

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

The variance of $\hat{N}_{gf}$ was estimated as the product of two independent random variables (Goodman 1960):

$$V(\hat{N}_{gf}) = \hat{H}^2_{Tf}\, V(\hat{P}_{gf}) + \hat{P}^2_{gf}\, V(\hat{H}_{Tf}) - V(\hat{P}_{gf})\, V(\hat{H}_{Tf}), \tag{21}$$

where:

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

Age composition estimates of each sex were generated for the total harvest during the early run by summing estimated number harvested by age over the spatial/temporal strata. For the early run, the total number of fish of age g harvested (N_g) was estimated as:

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

where:

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

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

$$V(\hat{N}_g) = \sum_{f=1}^{t} V(\hat{N}_{gf}). \quad (23)$$

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

$$\hat{P}_g = \hat{N}_g/\hat{H}, \quad (24)$$

where:

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

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

$$V(\hat{P}_g) = \hat{P}^2_g \, [V(\hat{N}_g)/\hat{N}^2_g + V(\hat{H})/\hat{H}^2 - 2V(\hat{N}_g)/\hat{N}_g\hat{H}], \quad (25)$$

where:

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

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

$$\hat{N}_{gf} = N_{Tf}\hat{P}_{gf}, \quad (26)$$

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:

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

Age composition estimates of weir escapements were generated for the early run by summing estimated numbers by age over temporal strata. For the early run, the total number of fish of age g (N_g) migrating through the weir was estimated as:

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

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

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

The proportion of age g adults in the total escapement of the early run (P_g) migrating through the weir was estimated as:

$$\hat{P}_g = \hat{N}_g/E, \tag{30}$$

where:

E = the total escapement of the early run enumerated at the weir.

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

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

In prior years, the age composition of the early-run escapement was used to estimate the return by age for both the escapement and early-run harvest at both the confluence and river areas (Nelson et al. 1986, Carlon and Vincent-Lang 1990). This assumed that the age composition of the escapement through the weir represented that of the river and confluence-area sport harvests. This assumption was tested in both 1990 and 1991. Significant differences in age compositions were found among the three sampled areas during some of the temporal strata (Carlon et al. 1991, Marsh 1992, 1993). Chi-square tests were applied and the null hypotheses of equality of age distributions among the three areas and between the two time frames was rejected if calculated tail-area probabilities were less than 0.05. Failure to reject the null hypothesis would allow the age samples to be pooled to achieve a more precise estimate of the number of sockeye by age in the harvest and escapement.

Mean length-at-age was estimated for each temporal component within each of three spatial components of the return: the confluence area harvest, the river harvest, and the weir escapement. Associated variances were estimated using standard normal procedures. An analysis of variance (ANOVA) was used to determine if mean length-at-age differed by area, by temporal component, by sex and all interactions of these components. This analysis was conducted for

the predominant age groups (age-2.2 and -2.3 fish) due to insufficient samples in the remaining age groups.

RESULTS

Creel Statistics

Survey Interviews:

Sampling began on 11 June at the ferry access location and continued every other day through the end of the early run on 17 July; sampling of the two Russian River Campground access locations began on 17 June. Harvest and effort are considered negligible until nearly the third week of June because early-run sockeye salmon typically hold in the confluence area before entering the Russian River. During the 1993 early run, effort and harvest began earlier with significant catches occurring on 14 June.

A total of 4,772 anglers were enumerated as they exited sampled access locations during the 1993 early-run survey (Table 2). Of these, 2,848 (59.7%) were interviewed and 1,924 (40.3%) were not interviewed. The total number of interviews collected in the early run represents a 20.4% decrease from 1992. However, this level of creel sampling remains more than 180% above the number collected in 1989 (Carlon and Vincent-Lang 1990) and 1988 (Hammarstrom and Athons 1989). Most of the interviews (61%) were made at the ferry access as this location was sampled the most intensely and typically accounts for the most effort (Appendix A1). Anglers exiting via the ferry location tended to fish the confluence area (97%) (Appendix A2).

Harvest and Effort:

Estimates of harvest, effort, and variances are presented by stratum (temporal component/access location) in Appendix A3. By examining stratum estimates and associated variance components by access location, it is possible to determine which access locations most affected the relative precision of early-run estimates of both harvest and effort (Table 3). Of the three access locations, (the ferry, Grayling, and Pink Salmon), the ferry accounted for most of the effort (61%) and harvest (55%) during the early run. The relative precisions of the total early-run harvest and effort estimates were 24% and 16%, respectively (Table 3). The 1993 early-run harvest estimate was 37,881 (SE = 4,569) sockeye salmon (Table 4). The effort estimate for the early run was 135,848 (SE = 10,795) angler-hours. During the early run, 65% of the harvest was taken from the confluence area and the remaining 35% was taken from the river area (Table 4 and Figure 4).

The weighted harvests per hour of angler effort for both the confluence and river areas in 1993 are presented in Table 5.

Spawning Escapement

A total of 39,857 early-run sockeye salmon passed through the weir (Appendix A4) with the peak daily escapement occurring 28 June (Figure 5). Late-run sockeye salmon began arriving on 19 July and the last early-run fish was passed on 25 July.

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

Exit Location	Area Fished			Total Interviews	Anglers Exiting and not interviewed	Total Anglers Exiting
	Confluence	River	Both			
Ferry	1,673	48	13	1,734	1,491	3,225
Grayling	301	437	17	755	291	1,046
Pink Salmon	54	290	15	359	142	501
Total	2,028	775	45	2,848	1,924	4,772

Table 3. Estimates of recreational harvest, effort, and associated variances by access location during the early run of Russian River sockeye salmon, 1993.

Access Location	Harvest	(%)	Variance of Harvest	(%)	Relative Precision[a]	Effort[b]	(%)	Variance of Effort	(%)	Relative Precision[a]
Ferry	20,791	55	4,901,663	23	21%	83,702	61	72,578,022	62	20%
Grayling	11,087	29	6,872,765	33	46%	32,273	24	28,302,392	24	32%
Pink Salmon	6,003	16	9,098,606	44	98%	19,873	15	15,654,642	14	39%
Total	37,881	100	20,873,034	100	24%	135,848	100	116,535,056	100	16%

[a] $\alpha = 0.05$

[b] Angler-hours.

Table 4. Summary of estimated angler effort and harvest by component during the early run of Russian River sockeye salmon, 1993.

Component	Confluence Area	River Area	Total	95% Confidence Interval
Effort[a]	99,557	36,292	135,848	114,690 - 157,007
SE	9,894	4,317	10,795	
Harvest	24,790	13,091	37,881	28,926 - 46,836
SE	2,801	3,610	4,569	

[a] Angler-hours.

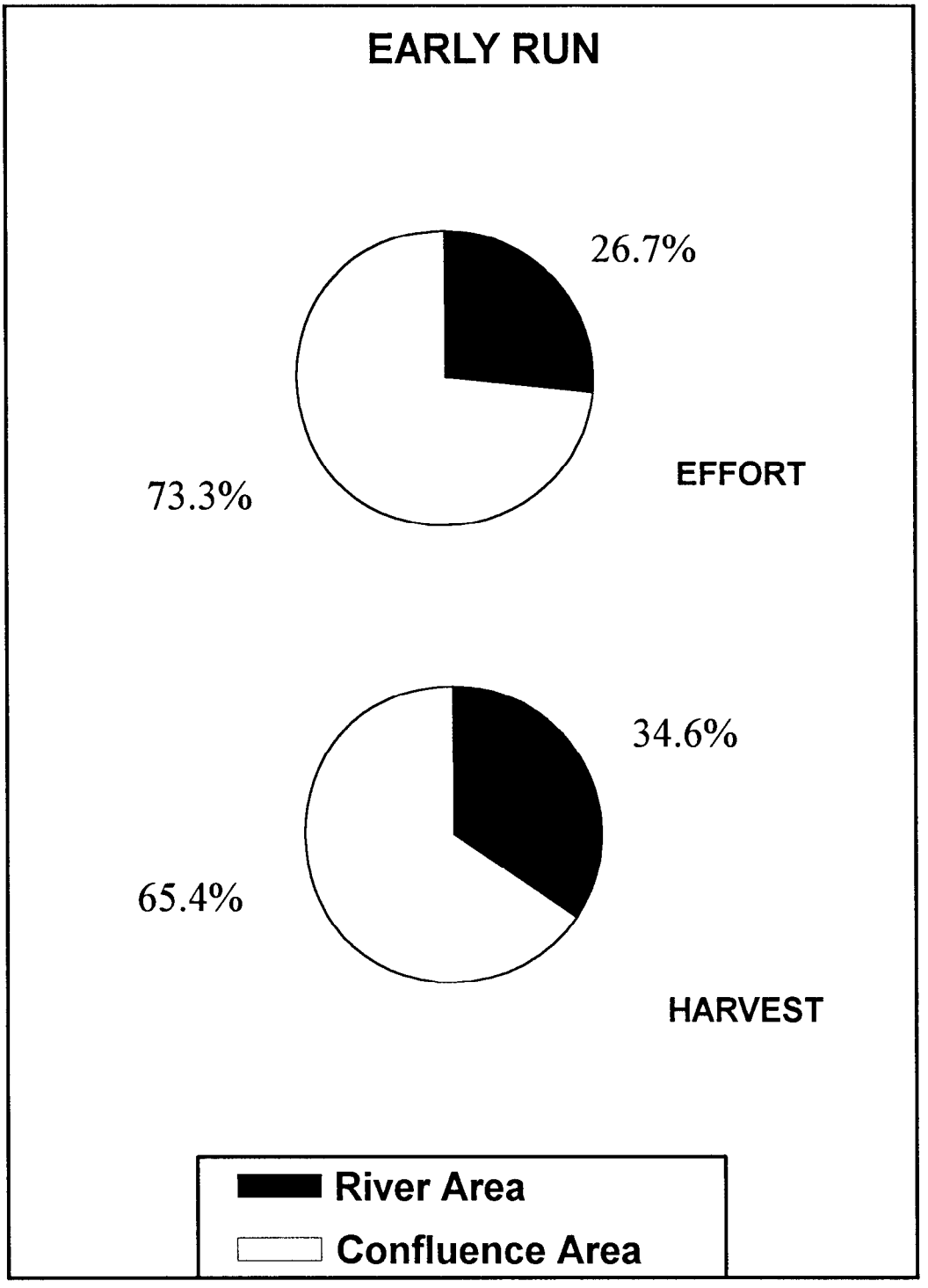

Figure 4. Harvest and angler effort by area for the Russian River early-run sockeye salmon recreational fishery, 1993.

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

Area	Days n[a]	Days N[b]	Number of Interviews[c]	HPUE	Variance of HPUE
Confluence	26	36	2,049	0.249	0.0008
River	21	31	799	0.361	0.0099
Both			2,848	0.279	0.0011

[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.

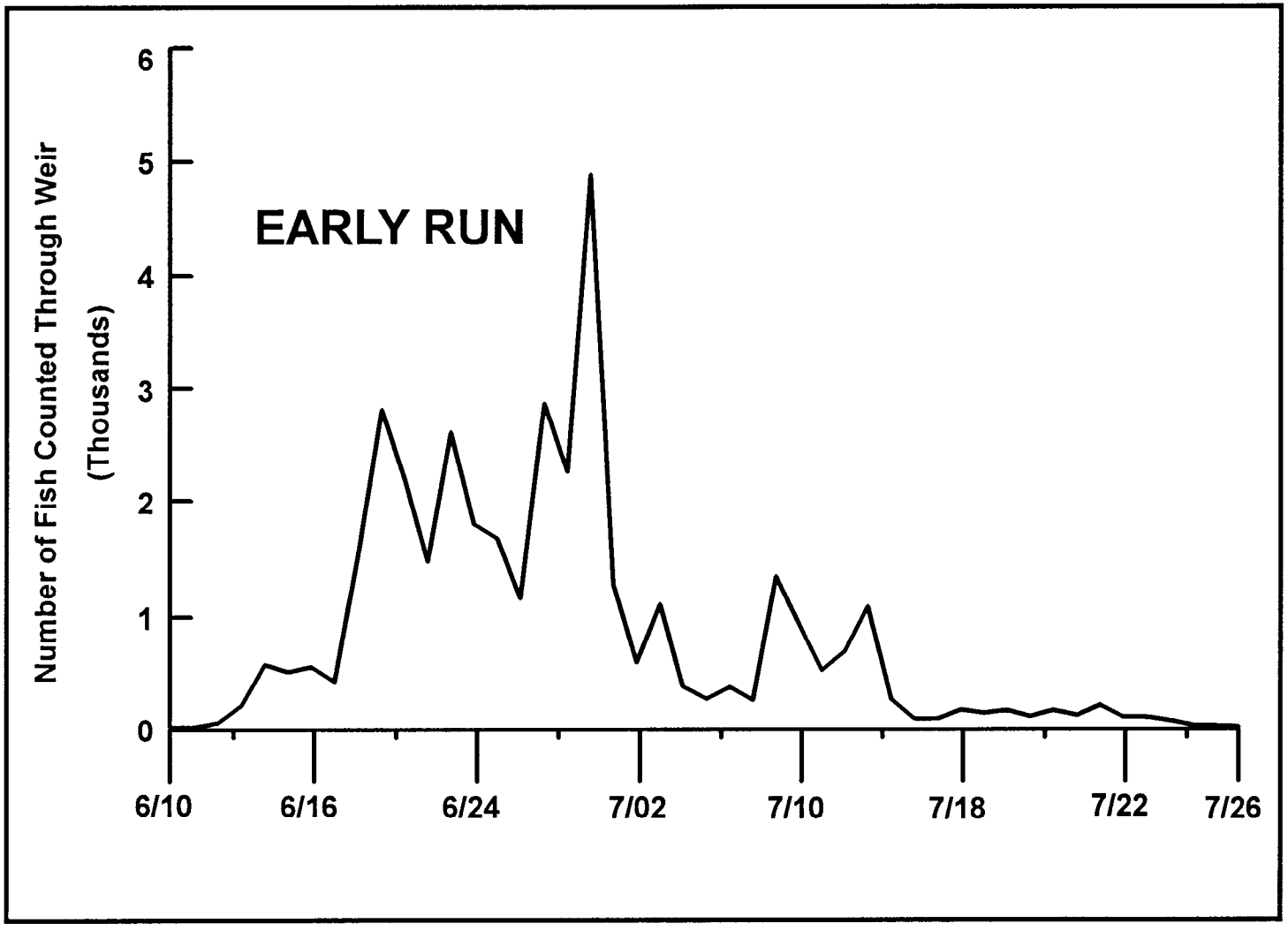

Figure 5. Daily escapement of sockeye salmon through the Russian River weir, 1993.

Biological Data

During both temporal strata, age composition differed significantly between the three spatial components (confluence area harvest, river area harvest, and weir escapement) (Table 6). During the second temporal stratum, the age composition of the confluence area harvest differed from the weir escapement (Table 6; $\chi^2 = 4.06$, df = 1, $P < 0.050$) and the river area harvest ($\chi^2 = 6.32$, df = 1, $P < 0.025$). However, the age composition of the river area harvest did not significantly differ from the weir escapement during temporal stratum 1 ($\chi^2 = 0.04$, df = 1, $P > 0.10$), nor during temporal stratum 2 ($\chi^2 = 1.60$, df = 1, $P > 0.10$).

Chi-square tests performed upon the temporal strata for each individual location indicated that age composition changed significantly over time within all individual spatial components.

Because the confluence area harvest differed from both the river area harvest and the weir escapement over time and all sites indicated significant age composition changes over time, the sample data for the confluence and river area harvest and weir escapement were stratified by location and temporal strata. Estimates were generated for each spatial/temporal stratum and then these estimates were summed to estimate the age composition of the total harvest (Tables 7-9).

The early-run escapement through the weir was comprised predominantly of two age groups, ages 2.3 and 2.2 (Table 7). A third age group, age 1.3, comprised less than 1% of the escapement with the predominant age group (73.3%) being age 2.3. There was a significant difference in the relative proportions of age-2.3 and -2.2 adults detected over the two temporal sampling strata ($\chi^2 = 11.95$, df = 1, $P < 0.005$).

The early-run recreational harvest from the confluence area was also comprised of predominantly age-2.3 and -2.2 adults with age-2.3 adults contributing 64.4% to the harvest (Table 8). There were significant temporal changes detected in the contribution by age ($\chi^2 = 50.22$, df = 1, $P < 0.025$); age-2.3 adults contributed proportionately more during the first stratum (89.5%) than during the second stratum (51.4%), and age-2.2 fish contributed proportionately more during the second stratum (45.3%) than during the first stratum (9.8%).

The early-run recreational harvest from the river area was also comprised of predominantly age-2.3 and -2.2 adults with age-2.3 adults contributing 78.6% to the harvest (Table 9). There were significant temporal changes detected in the contribution by age ($\chi^2 = 11.02$, df = 1, $P < 0.025$); age-2.3 adults contributed proportionately more during the first stratum (89.8%) than during the second stratum (71.2%), and age-2.2 fish contributed proportionately more during the second stratum (27.1%) than during the first stratum (9.6%).

Mean length-at-age was examined to determine if samples could be pooled among areas or between temporal components. There were no significant differences in length-at-age due to area for age-2.2 fish ($F = 0.99$, df = 2;193, $P = 0.37$), nor for age-2.3 fish ($F = 2.65$, df = 2;573, $P = 0.07$). There were significant differences in length-at-age over time for age-2.2 fish ($F = 7.10$, df = 1;193, $P = 0.008$) and age-2.3 fish ($F = 11.94$, df = 1;573, $P = 0.0006$).

Table 6. Results of contingency tests comparing age compositions between spatial fishery components for the early-run Russian River sockeye salmon recreational fishery, 1993.

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	P>0.10	P>0.10	P>0.10
2	P<0.025	P<0.050	P>0.10

[a] 1 = 6/11-6/23.
2 = 6/24-7/17 (6/24-7/25 for weir escapement).

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

Dates	Age Group 2.3	1.3	2.2	2.1	1.2	Total
6/11 - 6/23						
n[a]= 47						
Count= 15,478						
Females						
Sample Size	16	0	1	0	0	17
Percent	34.0	0.0	2.1	0.0	0.0	36.2
Variance of Percent	48.8	0.0	4.5	0.0	0.0	50.2
Number	5,269	0	329	0	0	5,598
Variance of Number	1,169,386	0	108,451	0	0	1,202,393
Males						
Sample Size	26	0	4	0	0	30
Percent	55.3	0.0	8.5	0.0	0.0	63.8
Variance of Percent	53.7	0.0	16.9	0.0	0.0	50.2
Number	8,562	0	1,317	0	0	9,880
Variance of Number	1,287,267	0	405,513	0	0	1,202,393
Sexes Combined						
Sample Size	42	0	5	0	0	47
Percent	89.4	0.0	10.6	0.0	0.0	100.0
Variance of Percent	20.7	0.0	20.7	0.0	0.0	
Number	13,831	0	1,647	0	0	15,478
Variance of Number	495,103	0	495,103	0	0	

-continued-

Table 7. (Page 2 of 3).

Dates	Age Group 2.3	1.3	2.2	2.1	1.2	Total
6/24 - 7/25						
n[a]= 241						
Count= 24,379						
Females						
Sample Size	81	0	49	0	0	130
Percent	33.6	0.0	20.3	0.0	0.0	53.9
Variance of Percent	9.3	0.0	6.7	0.0	0.0	10.4
Number	8,194	0	4,957	0	0	13,150
Variance of Number	552,575	0	401,129	0	0	615,252
Males						
Sample Size	71	2	38	0	0	111
Percent	29.5	0.8	15.8	0.0	0.0	46.1
Variance of Percent	8.7	0.3	5.5	0.0	0.0	10.4
Number	7,182	202	3,844	0	0	11,229
Variance of Number	514,628	20,380	328,902	0	0	615,252
Sexes Combined						
Sample Size	152	2	87	0	0	241
Percent	63.1	0.8	36.1	0.0	0.0	100.0
Variance of Percent	9.7	0.3	9.6	0.0	0.0	
Number	15,376	202	8,801	0	0	24,379
Variance of Number	576,793	20,380	571,250	0	0	

-continued-

Table 7. (Page 3 of 3).

Dates	Age Group 2.3	1.3	2.2	2.1	1.2	Total
Early Run Total						
n[a]= 288						
Count= 39,857						
Females						
Percent	33.8	0.0	13.3	0.0	0.0	47.0
Variance of Percent	10.8	0.0	3.2	0.0	0.0	11.4
Number	13,463	0	5,286	0	0	18,749
Variance of Number	1,721,961	0	509,580	0	0	1,817,644
Males						
Percent	39.5	0.5	12.9	0.0	0.0	53.0
Variance of Percent	11.3	0.1	4.6	0.0	0.0	11.4
Number	15,744	202	5,161	0	0	21,108
Variance of Number	1,801,896	20,380	734,414	0	0	1,817,644
Sexes Combined						
Percent	73.3	0.5	26.2	0.0	0.0	100.0
Variance of Percent	6.7	0.1	6.7	0.0	0.0	
Number	29,207	202	10,447	0	0	39,857
Variance of Number	1,071,896	20,380	1,066,353	0	0	

[a] n = sample size.

Table 8. Estimated age and sex composition of early-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
6/11 - 6/23						
n[a]= 153						
Harvest= 8,458						
Var(Harvest)= 1,527,486						
Females						
Sample Size	52	1	4	0	0	57
Percent	34.0	0.7	2.6	0.0	0.0	37.3
Variance of Percent	14.8	0.4	1.7	0.0	0.0	15.4
Number	2,875	55	221	0	0	3,151
Variance of Number	279,780	3,056	12,771	0	0	319,671
Males						
Sample Size	85	0	11	0	0	96
Percent	55.6	0.0	7.2	0.0	0.0	62.7
Variance of Percent	16.2	0.0	4.4	0.0	0.0	15.4
Number	4,699	0	608	0	0	5,307
Variance of Number	585,173	0	38,629	0	0	709,030
Sexes Combined						
Sample Size	137	1	15	0	0	153
Percent	89.5	0.7	9.8	0.0	0.0	100.0
Variance of Percent	6.2	0.4	5.8	0.0	0.0	
Number	7,574	55	829	0	0	8,458
Variance of Number	1,267,846	3,056	55,411	0	0	1,527,486

-continued-

Table 8. (Page 2 of 3).

Dates	Age Group 2.3	1.3	2.2	2.1	1.2	Total
6/24 - 7/17						
n[a]= 148						
Harvest= 16,332						
Var(Harvest)= 6,315,550						
Females						
Sample Size	46	2	50	0	2	100
Percent	31.1	1.4	33.8	0.0	1.4	67.6
Variance of Percent	14.6	0.9	15.2	0.0	0.9	14.9
Number	5,076	221	5,518	0	221	11,035
Variance of Number	989,584	24,770	1,117,125	0	24,770	3,271,501
Males						
Sample Size	30	0	17	0	1	48
Percent	20.3	0.0	11.5	0.0	0.7	32.4
Variance of Percent	11.0	0.0	6.9	0.0	0.5	14.9
Number	3,311	0	1,876	0	110	5,297
Variance of Number	545,805	0	263,443	0	12,177	1,052,524
Sexes Combined						
Sample Size	76	2	67	0	3	148
Percent	51.4	1.4	45.3	0.0	2.0	100.0
Variance of Percent	17.0	0.9	16.9	0.0	1.4	
Number	8,387	221	7,394	0	331	16,332
Variance of Number	2,107,951	24,770	1,733,233	0	37,777	6,315,550

-continued-

Table 8. (Page 3 of 3).

Dates	Age Group 2.3	1.3	2.2	2.1	1.2	Total
Early Run Total						
n[a]= 301						
Harvest= 24,790						
Var(Harvest)= 7,843,036						
Females						
Percent	32.1	1.1	23.1	0.0	0.9	57.2
Variance of Percent	20.5	0.5	16.7		0.4	33.3
Number	7,951	276	5,739	0	221	14,186
Variance of Number	1,269,363	27,826	1,129,896	0	24,770	3,591,172
Males						
Percent	32.3	0.0	10.0	0.0	0.4	42.8
Variance of Percent	19.8		5.2		0.2	27.5
Number	8,009	0	2,484	0	110	10,604
Variance of Number	1,130,978	0	302,072	0	12,177	1,761,554
Sexes Combined						
Percent	64.4	1.1	33.2	0.0	1.3	100.0
Variance of Percent	37.1	0.5	23.8		0.6	
Number	15,960	276	8,223	0	331	24,790
Variance of Number	3,375,797	27,826	1,788,644	0	37,777	7,843,036

[a] n = sample size.

Table 9. Estimated age and sex composition of early-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
6/11 - 6/23						
n[a]= 157						
Harvest= 5,211						
Var(Harvest)= 481,045						
Females						
Sample Size	57	0	6	0	0	63
Percent	36.3	0.0	3.8	0.0	0.0	0.0
Variance of Percent	14.8	0.0	2.4	0.0	0.0	0.0
Number	1,892	0	199	0	0	0
Variance of Number	102,946	0	6,987	0	0	0
Males						
Sample Size	84	1	9	0	0	94
Percent	53.5	0.6	5.7	0.0	0.0	0.0
Variance of Percent	15.9	0.4	3.5	0.0	0.0	0.0
Number	2,788	33	299	0	0	0
Variance of Number	180,240	1,102	10,821	0	0	0
Sexes Combined						
Sample Size	141	1	15	0	0	157
Percent	89.8	0.6	9.6	0.0	0.0	100.0
Variance of Percent	5.9	0.4	5.5	0.0	0.0	
Number	4,680	33	498	0	0	5,211
Variance of Number	403,643	1,102	19,166	0	0	481,045

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Table 9. (Page 2 of 3).

Dates	Age Group 2.3	1.3	2.2	2.1	1.2	Total
6/24 - 7/17						
n[a]= 59						
Harvest= 7,880						
Var(Harvest)= 12,548,953						
Females						
Sample Size	25	0	10	0	1	36
Percent	42.4	0.0	16.9	0.0	1.7	61.0
Variance of Percent	42.1	0.0	24.3	0.0	2.9	41.0
Number	3,339	0	1,336	0	134	4,808
Variance of Number	2,461,704	0	480,744	0	17,838	4,875,251
Males						
Sample Size	17	0	6	0	0	23
Percent	28.8	0.0	10.2	0.0	0.0	39.0
Variance of Percent	35.4	0.0	15.8	0.0	0.0	41.0
Number	2,271	0	801	0	0	3,072
Variance of Number	1,217,055	0	207,816	0	0	2,110,227
Sexes Combined						
Sample Size	42	0	16	0	1	59
Percent	71.2	0.0	27.1	0.0	1.7	100.0
Variance of Percent	35.4	0.0	34.1	0.0	2.9	
Number	5,609	0	2,137	0	134	7,880
Variance of Number	6,534,408	0	1,091,710	0	17,838	12,548,953

-continued-

Table 9. (Page 3 of 3).

Dates	Age Group 2.3	1.3	2.2	2.1	1.2	Total
Early Run Total						
n[a]= 216						
Harvest= 13,091						
Var(Harvest)= 13,029,998						
Females						
Percent	40.0	0.0	11.7	0.0	1.0	36.7
Variance of Percent	151.5		32.2		1.1	178.1
Number	5,231	0	1,535	0	134	4,808
Variance of Number	2,564,651	0	487,731	0	17,838	4,875,251
Males						
Percent	38.6	0.3	8.4	0.0	0.0	23.5
Variance of Percent	132.1	0.1	16.0			107.2
Number	5,059	33	1,100	0	0	3,072
Variance of Number	1,397,295	1,102	218,637	0	0	2,110,227
Sexes Combined						
Percent	78.6	0.3	20.1	0.0	1.0	100.0
Variance of Percent	238.1	0.1	69.5		1.1	
Number	10,289	33	2,635	0	134	13,091
Variance of Number	6,938,051	1,102	1,110,877	0	17,838	13,029,998

[a] n = sample size.

Sockeye salmon sampled during the first temporal component were significantly larger than those sampled during the second temporal component. Therefore, samples collected from the harvest and escapement were stratified by spatial/temporal components (Table 10).

Total Return Statistics

Overall, an estimated 77,738 (SE = 4,569) early-run sockeye salmon returned to the Russian River in 1993 (Table 11). Brood years 1987 (age 2.3) and 1988 (age 1.3 and 2.2) were both significant contributors to the early-run return. However, age-2.3 fish returning from the 1987 brood year comprised the majority of the return (71.3%). The brood year 1988 contributed 28.1% to the early-run return with the 1989 (age 1.2) brood year comprising just 0.6% of the return. The 1987 escapement of approximately 61,000 spawners produced approximately 109,000 returning adults (Table 12).

APPLICATION OF THE DATA FOR FISHERY MANAGEMENT

Both the early and late sockeye salmon runs are managed for escapement. Based upon analyses of brood production data (Carlon and Vincent-Lang 1990), a sockeye salmon escapement goal of 16,000 was established by the Board of Fisheries during their 1989 forum. On Monday, 14 June 1993, a total of 834 sockeye salmon had migrated through the weir and an estimated 500 fish were holding immediately downstream from the weir in the falls area with an additional 5,000-6,000 fish concentrated in the sanctuary area near the confluence of the Kenai and Russian rivers. Stream survey observations in conjunction with harvest data from the sport fishery documented an HPUE of 0.371, indicating that the sport fishery was jumping to a strong and early start. However, close monitoring was necessary to ensure that the run was in fact early and strong and not simply early. On Friday, 18 June, 1,629 fish passed through the weir with an additional 1,000-1,500 holding downstream from the weir and 7,000-8,000 fish in the sanctuary area near the confluence of the Kenai and Russian rivers. The sport fishery continued to maintain high catch rates with evidence of strong numbers of sockeye salmon downstream in the mainstem Kenai River. By 22 June, the cumulative weir escapement had reached 13,579 with approximately 3,100 fish holding in the falls area and approximately 7,000-8,000 staging in the confluence sanctuary area.

Since the escapement goal was assured, the decision to open the sanctuary area at the confluence of the Kenai and Russian rivers was deemed appropriate. Therefore, the fishery was liberalized by removing the no fishing restriction on the sanctuary area on Wednesday, 23 June, at 12:00 p.m. Anglers were therefore afforded increased fishing opportunity in 1993.

DISCUSSION

Relative Run Strength

The strength of the 1993 early run, as determined from total return estimates (harvest plus escapement), exceeded the historical average (1976-1992) (Figure 6). This return maintains the trend, beginning in 1978, of greater numbers of early-run sockeye salmon returning to the Russian River system.

Table 10. Mean length[a] at age, by sex, for the early run of sockeye salmon sampled from the Russian River, 1993.

			Age											
			2.3			2.2			1.3			1.2		
Date	Component	Sex	n	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE
6/11-6/23	Confluence	F	52	594	3.0	4	553	2.6	1	591				
		M	85	593	2.1	11	547	6.7						
	River	F	57	595	2.8	6	546	6.8						
		M	84	598	2.1	9	548	4.1	1	580				
	Escapement[b]	F	16	588	3.8	1	580							
		M	26	596	2.4	4	544	10.7						
6/24-7/25	Confluence	F	46	581	3.2	50	536	2.4	2	570	10.0	2	532	7.5
		M	30	587	3.6	17	536	3.6				1	540	
	River	F	25	592	3.5	10	541	4.5				1	525	
		M	17	589	6.2	6	552	12.0						
	Escapement	F	81	589	2.0	49	542	2.6						
		M	71	585	2.0	38	538	3.4	2	603	11.5			

[a] Millimeters; mid-eye to fork of tail.

[b] Fish that migrated through the weir.

Table 11. Estimated age and sex composition of the early run of sockeye salmon to the Russian River, 1993.

Dates	Age Group 2.3	1.3	2.2	2.1	1.2	Total
6/11 - 7/17						
Early Run Total[a]						
n[b]= 800						
Females						
Percent	34.3	0.4	16.2	0.0	0.5	51.2
Variance of Percent	5.3	0.0	2.9			5.8
Number	26,645	276	12,559	0	354	37,743
Variance of Number	5,555,975	27,826	2,127,206	0	42,608	10,284,067
Males						
Percent	37.1	0.3	11.2	0.0	0.1	48.8
Variance of Percent	4.6		1.9			6.0
Number	28,812	236	8,745	0	110	34,784
Variance of Number	4,330,168	21,482	1,255,123	0	12,177	5,689,426
Sexes Combined						
Percent	71.3	0.7	27.4	0.0	0.6	100.0
Variance of Percent	2.2	0.1	4.5			
Number	55,457	511	21,305	0	465	77,738
Variance of Number	11,385,744	49,308	3,965,874	0	55,615	20,873,034

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

[b] n = sample size.

Table 12. Summary of returns from each brood year, early-run Russian River sockeye salmon, 1974-1993.

Year	Spawning Escapement	Return Age 1.2	Age 2.1	Age 1.3	Age 2.2	Age 2.3	(1.1,1.4) Misc	Measured Return To Date	Return Per Spawner
1974	13,164	(1978) 216	(1978) 0	(1979) 1,264	(1979) 5,873	(1980) 45,271	0	52,624	4.00
1975	5,644	(1979) 0	(1979) 0	(1980) 4,528	(1980) 2,403	(1981) 9,016	0	15,947	2.83
1976	14,735	(1980) 3,465	(1980) 0	(1981) 14,783	(1981) 6,021	(1982) 89,040	0	113,309	7.69
1977	16,061	(1981) 2,008	(1981) 0	(1982) 1,087	(1982) 362	(1983) 14,218	0	17,675	1.10
1978	34,240	(1982) 0	(1982) 0	(1983) 11,055	(1983) 828	(1984) 5,053	0	16,936	0.49
1979	19,742	(1983) 3,310	(1983) 0	(1984) 56,173	(1984) 389	(1985) 34,971	0	94,843	4.80
1980	28,616	(1984) 3,109	(1984) 0	(1985) 3,090	(1985) 3,990	(1986) 32,798	0	42,987	1.50
1981	21,142	(1985) 430	(1985) 0	(1986) 9,697	(1986) 21,462	(1987) 43,722	0	75,311	3.56
1982	56,106	(1986) 7,273	(1986) 0	(1987) 162,612	(1987) 9,046	(1988) 95,055	0	273,986	4.88
1983	21,268	(1987) 0	(1987) 0	(1988) 3,847	(1988) 1,519	(1989) 17,914	0	23,280	1.09

-continued-

Table 12. (Page 2 of 2).

Year	Spawning Escapement	Return Age 1.2	Age 2.1	Age 1.3	Age 2.2	Age 2.3	(1.4,2.4) Misc	Measured Return To Date	Return Per Spawner
		(1988)	(1988)	(1989)	(1989)	(1990)			
1984	28,899	810	0	4,149	4,324	33,543	0	42,826	1.48
		(1989)	(1989)	(1990)	(1990)	(1991)			
1985	30,601	236	0	264	22,584	20,555	137	43,776	1.43
		(1990)	(1990)	(1991)	(1991)	(1992)			
1986	36,336	540	0	43,166	3,334	43,596	0	90,636	2.49
		(1991)	(1991)	(1992)	(1992)	(1993)			
1987	61,513	30,346	0	266	23,145	55,457	0	109,214	1.78
		(1992)	(1992)	(1993)	(1993)	(1994)			
1988	50,406	0	622	511	21,305		238	22,676	0.45
		(1993)	(1993)	(1994)	(1994)	(1995)			
1989	15,338	465	0					465	0.03
		(1994)	(1994)	(1995)	(1995)	(1996)			
1990	25,144							0	0.00
		(1995)	(1995)	(1996)	(1996)	(1997)			
1991	32,389							0	0.00
		(1996)	(1996)	(1997)	(1997)	(1998)			
1992	37,117							0	0.00
		(1997)	(1997)	(1998)	(1998)	(1999)			
1993	39,857							0	0.00

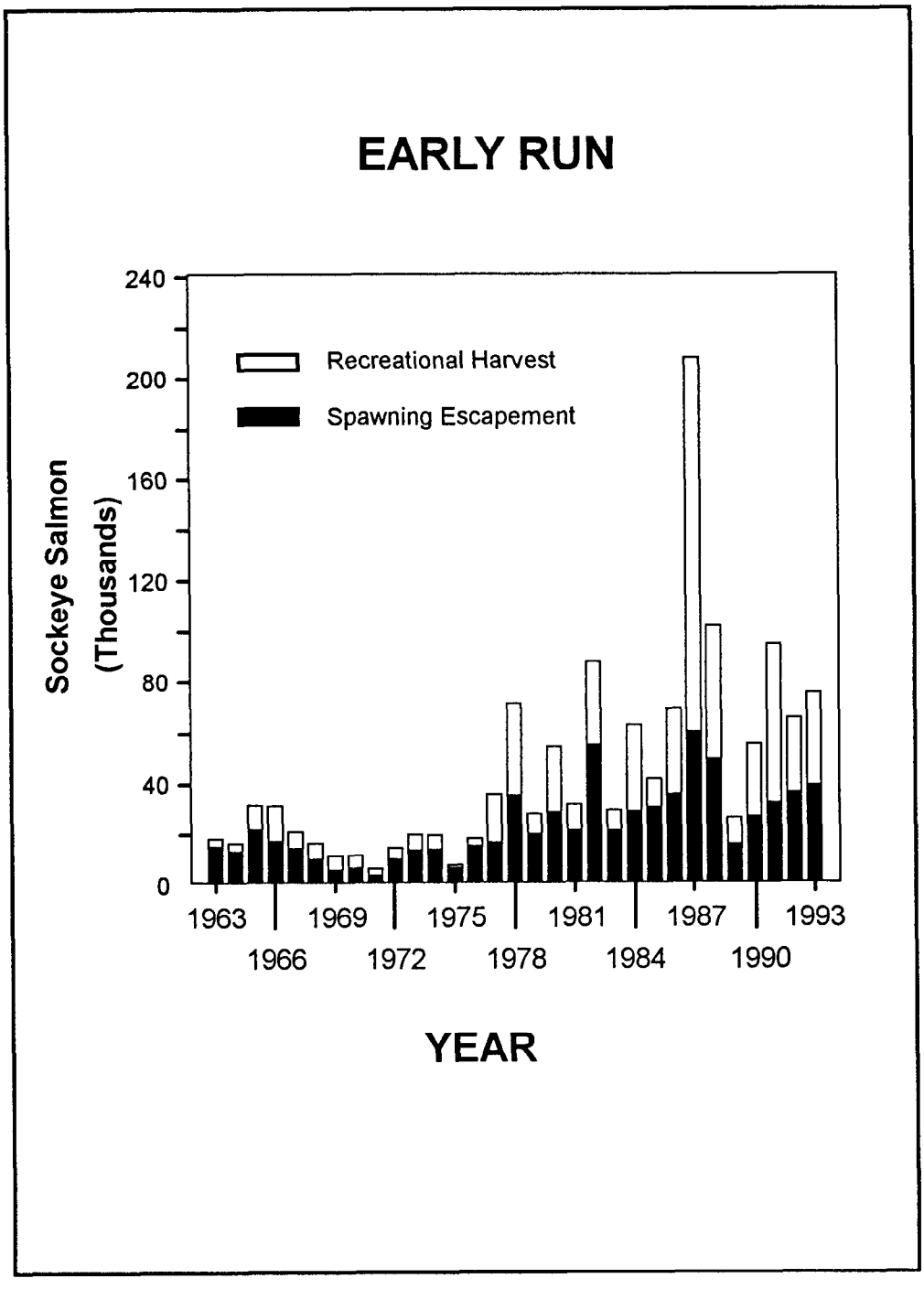

Figure 6. Historical returns of early-run sockeye salmon to the Russian River.

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. Creel survey personnel and the project leader documented use of other access sites at least twice a day during transit between sampled sites and during shift changes. Anglers were observed exiting at other locations, but the level at which this occurred during 1993 appeared to be insignificant. However, the number of anglers fishing the mainstem Kenai River on the unsurveyed north side of the river, near the Sterling Highway, was significant during the 1993 early run. During the early run, all fish caught in the mainstem Kenai are believed to be of Russian River origin, as no other stock is believed to be present at that time. The addition of a formal monitoring schedule might be appropriate if the numbers of anglers utilizing the north side of the Kenai River continues to expand.

Observations of angler activity during the unsampled hours of 0000 to 0600 hours indicated that small numbers of anglers were engaged in fishing at those hours during 1993. Informal monitoring of the activity during these hours was accomplished through interviews with anglers and frequent queries of 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:

The accurate assessment 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 components adopted in 1990 was continued in 1993. This increase in sampling intensity over prior years is an effort to achieve more accurate age composition estimates. Significant temporal changes in age composition have been detected within spatial components as well as changes between spatial components within temporal strata since 1990 and 1991 (Carlon et al. 1991; Marsh 1992, 1993).

Statistical comparisons of the early-run age composition of the harvests and the weir escapement revealed that differences continued to occur in 1993. Therefore, it was not appropriate to use the age composition from one area to apportion the harvest estimates or escapements. The harvest and escapement were each allocated independently and each temporal component was allocated independently as well.

Because changes in the age composition of the early run were detected over time and between areas in 1993, sampling of the individual spatial components should be continued at the present sampling intensity. This will improve both

estimating the number of sockeye salmon returning by age and sex and evaluating those 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 derived 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 should be again utilized in 1994 and subsequent years to further evaluate its value in managing the Russian River sockeye salmon resource.

ACKNOWLEDGEMENTS

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 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 while performing her responsibilities have proved to be invaluable assets to the Russian River project.

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

Jim Hasbrouck provided detailed statistical support required to allocate the age compositions of the sport harvest and the escapement as well as much appreciated critical review.

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.

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

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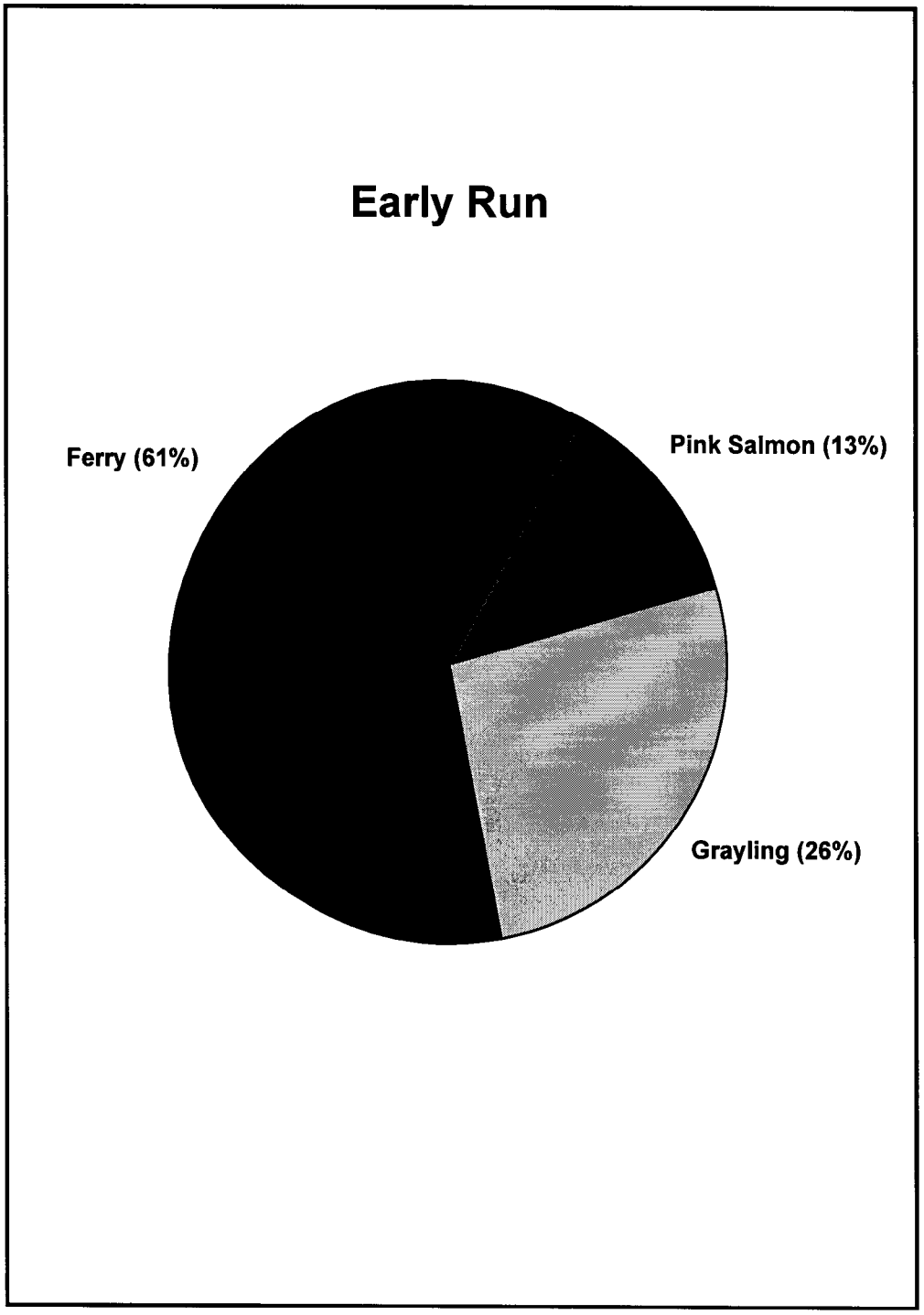
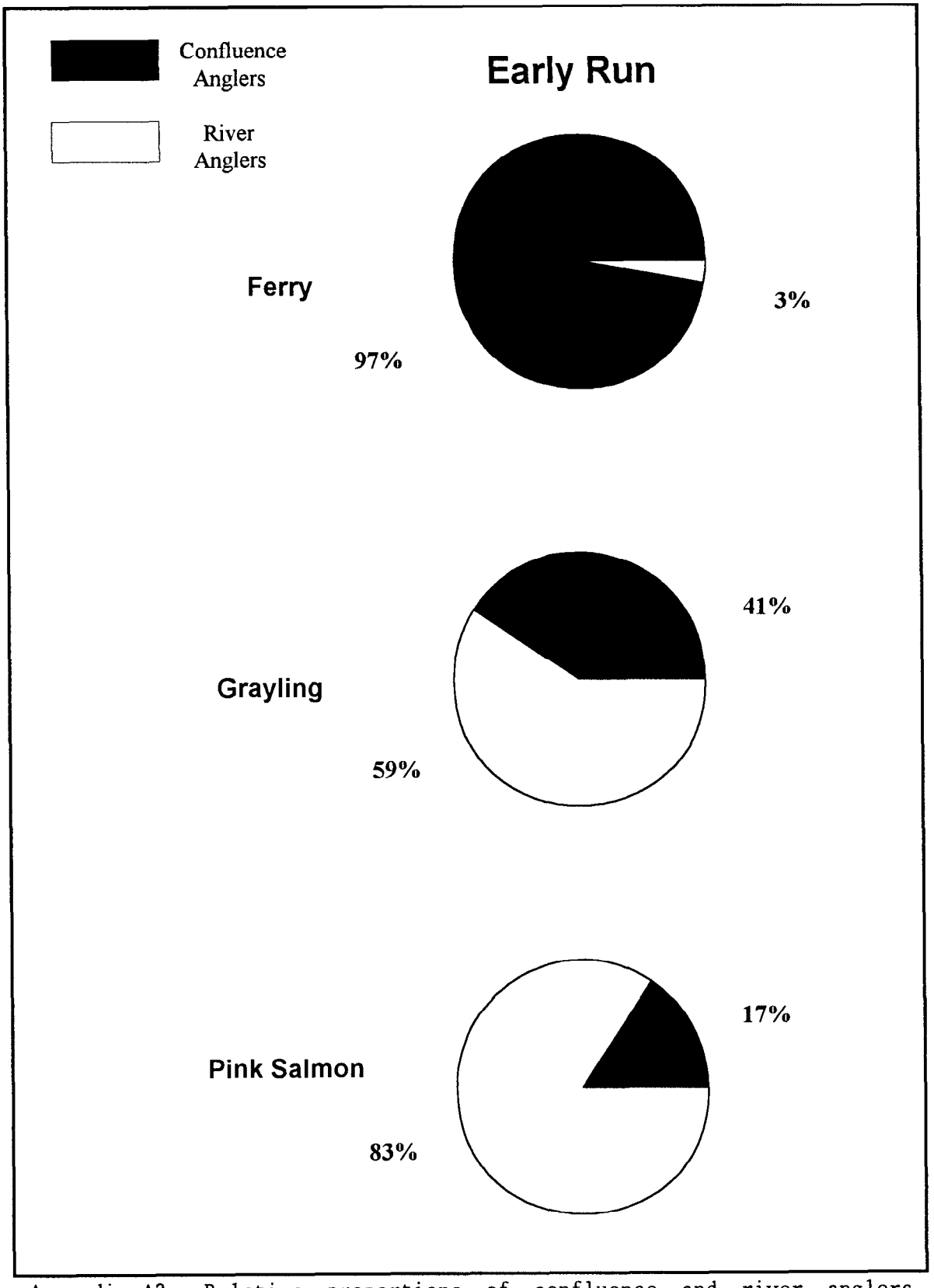
APPENDIX A

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



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



Appendix A2. Relative proportions of confluence and river anglers interviewed during the Russian River creel survey by access location, early run, 1993.

Appendix A3. Temporal harvest and effort estimates for the 1993 early-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	Variance components: Days	%	Periods	%	Anglers	%
River effort:													
Ferry	6/12-6/23	12	6	150	6,970	1,799	482,694	83,634	17	396,026	82	3,034	1
Grayling	6/17-6/23	7	2	1,307	99,136	9,147	2,280,194	1,734,885	76	541,413	24	3,896	0
Pink salmon	6/17-6/23	7	2	836	537	5,849	333,122	9,401	3	322,086	97	1,634	0
	Total 6/12-6/23					16,795	3,096,010						
Ferry	6/24-7/17	24	13	17	3,188	414	83,989	64,737	77	18,050	21	1,202	1
Grayling	6/24-7/17	24	9	339	85,726	8,135	3,548,573	3,429,057	97	117,462	3	2,054	0
Pink salmon	6/24-7/17	24	6	456	156,979	10,947	11,911,916	11,302,497	95	603,103	5	6,315	0
	Total 6/24-7/17/17					19,496	15,544,478						
	Total river effort					36,292	18,640,488						
Confluence effort:													
Ferry	6/12-6/23	12	6	2,720	1,004,554	32,639	26,691,961	12,054,647	45	14,600,542	55	36,772	0
Grayling	6/17-6/23	7	2	87	2,669	610	52,710	46,699	89	6,010	11	0	0
Pink salmon	6/17-6/23	7	2	52	5,392	363	119,523	94,360	79	25,163	21	0	0
	Total 6/12-6/23					33,613	26,864,194						
Ferry	6/24-7/17	24	13	2,035	1,913,188	48,849	45,319,378	38,852,436	86	6,375,679	14	91,262	0
Grayling	6/24-7/17	24	9	599	520,352	14,380	22,420,915	20,814,062	93	1,594,126	7	12,727	0
Pink salmon	6/24-7/17	24	9	113	45,084	2,714	3,290,081	3,246,037	99	41,775	1	2,269	0
	Total 6/24-7/17					65,944	71,030,374						
	Total confluence effort					99,557	97,894,568						
	Total effort					135,848	116,535,056						

-continued-

Appendix A3. (Page 2 of 2).

Location Exited	Temporal Period	D[a]	d[b]	Mean	Variance	Estimated Total Harvest	Estimated Total Variance	Variance components: Days	%	Periods	%	Anglers	%
River harvest:													
Ferry	6/12-6/23	12	6	35	536	417	30,934	6,436	21	23,726	77	772	2
Grayling	6/17-6/23	7	2	573	3,810	4,014	348,194	66,679	19	279,658	80	1,857	1
Pink salmon	6/17-6/23	7	2	111	5,785	780	101,917	101,245	99	344	0	327	0
	Total 6/12-6/23					5,211	481,045						
Ferry	6/24-7/17	24	13	.04	2	9	121	44	36	34	28	42	35
Grayling	6/24-7/17	24	9	127	89,647	3,051	3,608,782	3,585,890	99	22,050	1	842	0
Pink salmon	6/24-7/17	24	9	201	116,695	4,820	8,940,050	8,402,060	94	536,488	6	1,502	0
	Total 6/24-7/17					7,880	12,548,953						
	Total river harvest					13,091	13,029,998						
Confluence harvest:													
Ferry	6/12-6/23	12	10	685	83,099	8,217	1,502,864	997,190	66	496,456	33	9,218	1
Grayling	6/17-6/23	7	2	22	998	156	18,029	17,465	97	494	3	70	0
Pink salmon	6/17-6/23	7	2	12	294	85	6,593	5,137	78	1,370	21	86	1
	Total 6/12-6/23					8,458	1,527,486						
Ferry	6/24-7/17	24	13	506	142,908	12,148	3,367,744	2,902,135	86	443,371	13	22,238	1
Grayling	6/24-7/17	24	9	161	60,042	3,866	2,897,760	2,401,695	83	494,086	17	1,979	0
Pink salmon	6/24-7/17	24	6	13	678	318	50,046	48,800	98	923	2	322	1
	Total 6/24-7/17					16,332	6,315,550						
	Total confluence harvest					24,790	7,843,036						
	Total harvest					37,881	20,873,034						

[a] D = days possible in a stratum.

[b] d = days sampled in a stratum.

Appendix A4. Daily escapement of early- and late-run sockeye and chinook salmon through the Russian River weir, 11 June to 25 July 1993.

Date	Early Run Sockeye[a]	Late Run Sockeye	Chinook
6/11	0		
6/12	43		
6/13	206		
6/14	585		
6/15	516		
6/16	564		
6/17	429		
6/18	1,629		
6/19	2,979		
6/20	2,316		
6/21	1,553		
6/22	2,759		
6/23	1,899		
6/24	1,770		
6/25	1,206		
6/26	3,039		
6/27	2,392		
6/28	5,181		
6/29	1,343		
6/30	604		
7/01	1,147		
7/02	376		
7/03	266		
7/04	371		
7/05	251		
7/06	1,412		
7/07	962		
7/08	534		
7/09	710		
7/10	1,124		
7/11	256		
7/12	73		
7/13	79		
7/14	161		
7/15	128		
7/16	158		
7/17	98		
7/18	155		
7/19	107		
7/20	204		4[b]
7/21	92		
7/22	90	356	
7/23	59	3,221	
7/24	19	4,079	
7/25	12	4,375	
Total	39,857		

[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. There was a 7-day temporal overlap between early-run and late-run fish. The total late-run sockeye salmon escapement is tabulated in the Fishery Data Series report for the 1993 late run to the Russian River (Marsh *In prep*).

[b] Total estimated chinook escapement is tabulated in the Fishery Data Series report for the 1993 late run to the Russian River (Marsh *In prep*).