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INTENSIVE EVALUATION AND MONITORING OF CHINOOK SALMON AND STEELHEAD TROUT PRODUCTION, CROOKED RIVER AND UPPER SALMON RIVER SITES

ANNUAL PROGRESS REPORT
Period Covered: January 1, 1994 - December 3 1, 1994

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ABSTRACT

The purpose of this intensive monitoring project is to determine the number of returning chinook and steelhead adults necessary to achieve optimal smolt production, and develop mitigation accounting based on increases in smolt production. Two locations in Idaho are being intensively studied to meet these objectives. Information from this research will be applied to parr monitoring streams statewide to develop escapement objectives and determine success of habitat enhancement projects.

This project to date has developed good information on the relationship between adult chinook salmon escapement and smolt production at low to medium seeding levels. Adult chinook salmon escapements have been too low to test carrying capacity. For steelhead trout, we have developed a fairly good relationship between parr populations and smolt production at low to high seeding levels. This information for steelhead includes a fair estimate of carrying capacity. To date, we have been unable to accurately estimate egg-to-parr survival for steelhead.

Future efforts will include determining the relationship between adult steelhead trout escapement and age 1 + parr production, determining environmental and habitat factors that affect smolt production, and developing project results to help the region make good management decisions for anadromous fish.

Major findings of the project to date:

1. Estimates of chinook salmon egg-to-parr survival for brood years 1987-1993 in the headwaters of the Salmon River averaged 25.2% (90% confidence interval (C.I.) = 10.0% to 44.4%), and for brood year 1989-1993 in Crooked River averaged 14.5% (90% C.I. = 10.6% to 16.9%).

2. Estimates of chinook salmon parr-to-smolt survival for migratory years 1988-l 994 in the upper Salmon River averaged 19.4% (90% C.I. = 17.3% to 21.3%), and for migratory years 1989-1994 in Crooked River averaged 23.8% (90% C.I. = 13.8% to 35.6%).

3. Estimates of age 2+ and older steelhead trout parr-to-smolt survival for migratory years 1988-1994 in the upper Salmon River averaged 24.9% (90% C.I. = 13.4% to 38.4%), and for migratory years 1989-l 994 in Crooked River averaged 39.1% (90% C.I. = 26.1% to 53.0%). However, estimates of age 2 + and older steelhead trout parr-to-smolt survival has declined dramatically in the upper Salmon River, from an average of 51.4% for migratory years 1988 and 1989 to an average of 16.2% for migratory years 1990-l 994.

4. In all migratory years studied (1988-1994), the wild/natural spring chinook salmon smolts from both study areas arrived at Lower Granite Dam significantly later than the majority of chinook salmon smolts (which are comprised predominately of hatchery fish). Migration improvement decisions should consider that wild/natural spring chinook salmon smolts arrive later at Lower Granite Dam than the more numerous hatchery spring chinook salmon smolts (Kiefer and Lockhart 1993).

5. Our research indicates that in streams degraded by dredge mining, connecting off-channel ponds to the stream can increase the carrying capacity for chinook salmon parr (Kiefer and Forster 1991) and complex instream structures can increase the carrying capacity for steelhead trout parr (Kiefer and Lockhart 1994).

6. Passive Integrated Transponder (PIT) tag detection data from the Snake and Columbia river smolt collection facilities indicate that after a chinook salmon or steelhead trout parr has been successfully tagged during August, there is no significant difference in survival to an outmigrating smolt whether it was collected with a seine or a backpack electrofisher (Kiefer and Lockhart 1995).

7. Our data indicate that anglers can have a major impact on wild/natural steelhead trout parr populations in streams with high angler use and general fishing regulations. In 1992, with an estimated angler effort of 206 hours per hectare, we estimated that 10.9% of the age 1 + and 45.5% of the age 2+ wild/natural steelhead trout pre-fishing season populations in Crooked River were fishing mortalities (Kiefer and Lockhart 1994).

8. Mortality of wild/natural chinook salmon parr PIT-tagged in August and returned to their natural rearing habitat was not significantly different than for un-handled wild/natural chinook salmon parr in the same habitat over a two-month period (Kiefer and Lockhart 1994).

9. PIT tag detections indicate the smolt guidance system at Lower Granite Dam is not efficient at guiding sockeye salmon smolts away from the turbines and into the collection facility (Kiefer and Forster 1992).

INTRODUCTION

Project 83-7 was established under the Northwest Power Planning Council's 1982 Fish and Wildlife Program, measure 704 (d)(l) to monitor natural production of anadromous fish, evaluate Bonneville Power Administration (BPA) habitat improvement projects, and develop a credit record for off-site mitigation projects in Idaho. Project 83-7 is divided into two subprojects: general and intensive monitoring. Results of the intensive monitoring subproject are reported here. Results from the general monitoring subproject will be reported in a separate document (Petrosky et al. 1995). Field work for the intensive monitoring subproject began in 1987 in the upper Salmon River and Crooked River (South Fork Clearwater River tributary) study areas.

The goals of the intensive monitoring subproject are to quantify escapement objectives for wild/natural anadromous stocks that optimize smolt production, and provide mitigation accounting based on increases in smolt production. Our approach to determine escapement needs for wild/natural anadromous stocks is: (1) to estimate egg deposition using weir counts of returning adults, redd counts, and carcass surveys; (2) to use snorkel counts and stratified random sampling to estimate parr abundance and egg-to-parr survival; (3) to Passive Integrated Transponder (PIT) tag representative groups of parr and use PIT tag detections at the lower Snake and Columbia river smolt collecting dams to estimate parr-to-smolt survival; and (4) to use adult outplants into tributary streams to estimate egg-to-parr survival and carrying capacity. Our approach to mitigation accounting based on increases in smolt production is: (1) to estimate parr production attributable to habitat projects; (2) to quantify relationships between spawning escapement, parr production, and smolt production; and (3) to use smolt production as a basis for assessing habitat improvement benefits.

OBJECTIVES

The objectives of this project are to determine:

1. The mathematical relationship between spawning escapement, parr production, and smolt production;

2. Carrying capacity and optimal smolt production; and

3. Habitat factors relating to substrate, riparian, and channel quality that limit natural smolt production.

Project efforts in 1994 focused on objective 1.

STUDY AREAS

Upper Salmon River

The Salmon River originates at elevations above 2,800 m in the Smoky Mountains in south central Idaho. The upper Salmon River study area is the entire Salmon River drainage upstream of the Sawtooth Fish Hatchery weir at 1,980 m elevation (Figure 1). Tributary streams in the Upper Salmon River drain watersheds of the Sawtooth Range and Smoky Mountains on the west and the Boulder Mountains and White Cloud Peaks on the east. The Salmon River and tributaries upstream from and including Pole Creek are considered as headwaters upper Salmon River.

The river above Sawtooth Fish Hatchery is a major production area for spring chinook salmon *Oncorhynchus tshawytscha* and A-run summer steelhead trout 0. *mykiss*. Other resident salmonids in the Upper Salmon River drainage are native rainbow trout 0. *mykiss*, cutthroat trout *0. clarki*, bull trout *Salvelinus confluentus*, mountain whitefish *Prosopium williamsoni*, and non-native brook trout *S. fontinalis* (Mallet 1974).

Historically, sockeye salmon *0. nerka* existed in all moraine lakes in the Stanley Basin (Everman 1895). An extremely depressed remnant run of sockeye salmon returns to Redfish Lake. The outlet of Redfish Lake enters the Salmon River approximately 2.7 km downstream from Sawtooth Fish Hatchery. Occasionally, adult sockeye salmon have been seen in Alturas Lake Creek (Kent Ball, Idaho Department of Fish and Game [IDFG], personal communication), but an irrigation diversion that completely dewatered the stream every summer made adult passage to the lake unlikely (Bowles and Cochnauer 1984). In 1992, most of the Alturas Lake Creek water rights were purchased and the irrigation diversion was rebuilt with BPA mitigation funding. Adult sockeye salmon passage is now possible. No other sockeye salmon runs are known to exist in the Salmon River drainage.

Nearly pristine water quality and an abundance of high quality spawning gravel and rearing habitat is present throughout much of the upper basin. Water flows at the Sawtooth Fish Hatchery range from lows of 1.73 to 3.46 m^3/s from July through April to highs of 11.2 to 23.3 m^3/s during May and June. Conductivity in the upper Salmon River drainage ranges from 37 to 218 mhos/cm (Emmett 1975).

Livestock grazing and hay production are the predominant uses of private land throughout the upper Salmon River basin. In localized areas, grazing within riparian zones has degraded aquatic habitat. Additionally, diversion of water from the river and its tributaries has impaired the production potential for chinook salmon and steelhead trout. Flow diversion from tributary streams varies from partial to complete dewatering. Five major tributary creeks in the Upper Salmon River (Fourth of July Creek, Champion Creek, Fisher Creek, Williams Creek, and Beaver Creek) are completely dewatered on their lower ends during the summer and early fall in low to average flow years. In 1992, most of the water rights to Busterback Ranch on the Salmon River between Alturas Lake Creek and Pole Creek were purchased with BPA mitigation funds. Until this time, the Busterback Ranch diversion at river km 639 dewatered a section of the Salmon River during the summer and early fall in low to average water flow years.

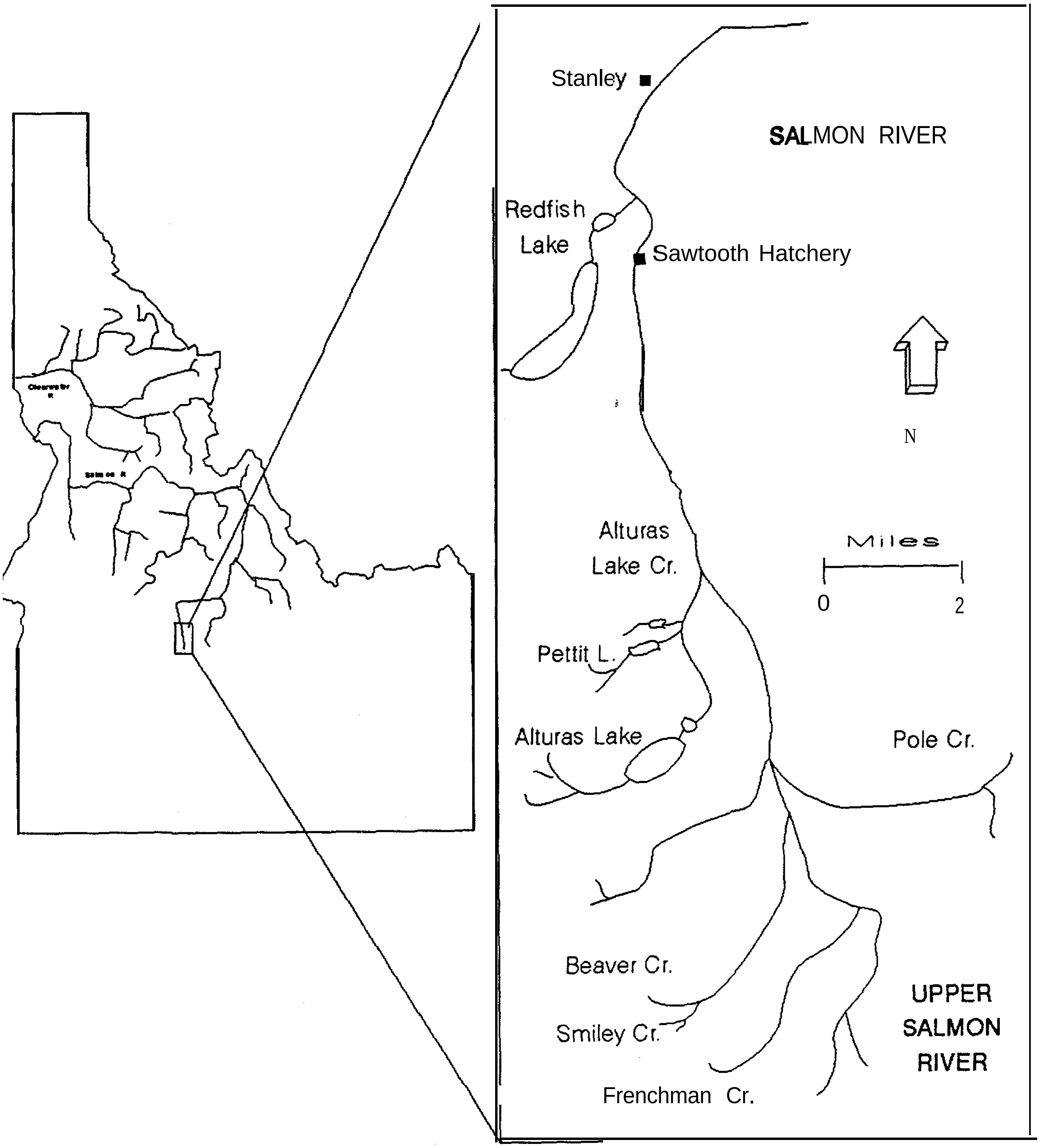

Figure 1. Location of upper Salmon River study area.

In 1982, a water user along Pole Creek converted from flood irrigation to overhead sprinkler irrigation. This has decreased the withdrawal of water from Pole Creek. In 1983, BPA funded the construction of a fish screen for the Pole Creek irrigation diversion. From 1985 to 1989 steelhead trout fry were outplanted into upper Pole Creek (IDFG, unpublished data). Additionally, as part of this project's research, adult chinook salmon were outplanted into Pole Creek in 1988-l 990 and adult steelhead trout were outplanted in 1991.

The Sawtooth Fish Hatchery was constructed in cooperation with the U.S. Fish and Wildlife Service and the U.S. Army Corps of Engineers through the Lower Snake River Compensation Plan. The hatchery program involves trapping adult chinook salmon and steelhead trout and releasing smolts and other life stages. The hatchery is designed to produce 2.4 million chinook salmon smolts per year. Eyed steelhead trout eggs are sent to other facilities for rearing. The steelhead trout smolts are transported back to Sawtooth Fish Hatchery for release. The objective is to release 4.5 million steelhead trout smolts at Sawtooth Fish Hatchery.

Crooked River

Crooked River originates at an elevation of 2,070 m in the Clearwater Mountains within the Nez Perce National Forest and enters the South Fork Clearwater River at river km 94 at an elevation of 1,140 m (Figure 2). The study area includes the entire Crooked River drainage. Historical chinook salmon and steelhead trout runs were eliminated in 1927 by the construction of Harpster Dam on the South Fork Clearwater River. Following removal of the dam in 1962, spring chinook salmon and B-run summer steelhead trout were reestablished in Crooked River. Other resident salmonids in the Crooked River drainage are native rainbow trout 0. *mykiss,* cutthroat trout 0. *clarki,* bull trout S. *confluentus,* mountain whitefish *P. williamsoni,* and non-native brook trout S. *fontinalis* (Petrosky and Holubetz 1986). Measured flows on Crooked River from 1991 through 1994 ranged from 0.285 to 6.88 m^3/s. Conductivity ranges from 29 to 39 μmhos/cm in flowing sections and 38 to 51 μmhos/cm in off-channel ponds (Mann and Von Lindern 1987).

During the 1950s, dredge mining activities severely degraded habitat within the two meadow reaches of the stream. In the upstream meadow reach, the stream was forced to the outside of the floodplain. This resulted in a mostly straight, high gradient channel. In the lower meadow reach, dredge tailings have forced the stream into long meanders with many ponds and sloughs. During runoff, juvenile trout and chinook salmon use some of these ponds, but are trapped as flows recede.

Fish density and habitat surveys were initiated in 1984 by IDFG and the Intermountain Forest and Range Experiment Station, U.S. Forest Service (USFS), Boise, Idaho. In 1984, in an effort to compensate for stream gradient and to increase the pool to riffle ratio, the USFS, with BPA funds, placed a series of log structures, rock and boulder deflectors, organic debris structures, and loose rock weirs in the upper meadow stream section. In addition, stream sides were stabilized and revegetated, an off-channel pond was connected with a side channel, and a culvert blocking adult passage was removed (Hair and Stowell 1986). Recent efforts have concentrated on connecting additional ponds in the dredge tailings to the main channel and developing side channels to provide continuous water supply during low flow periods.

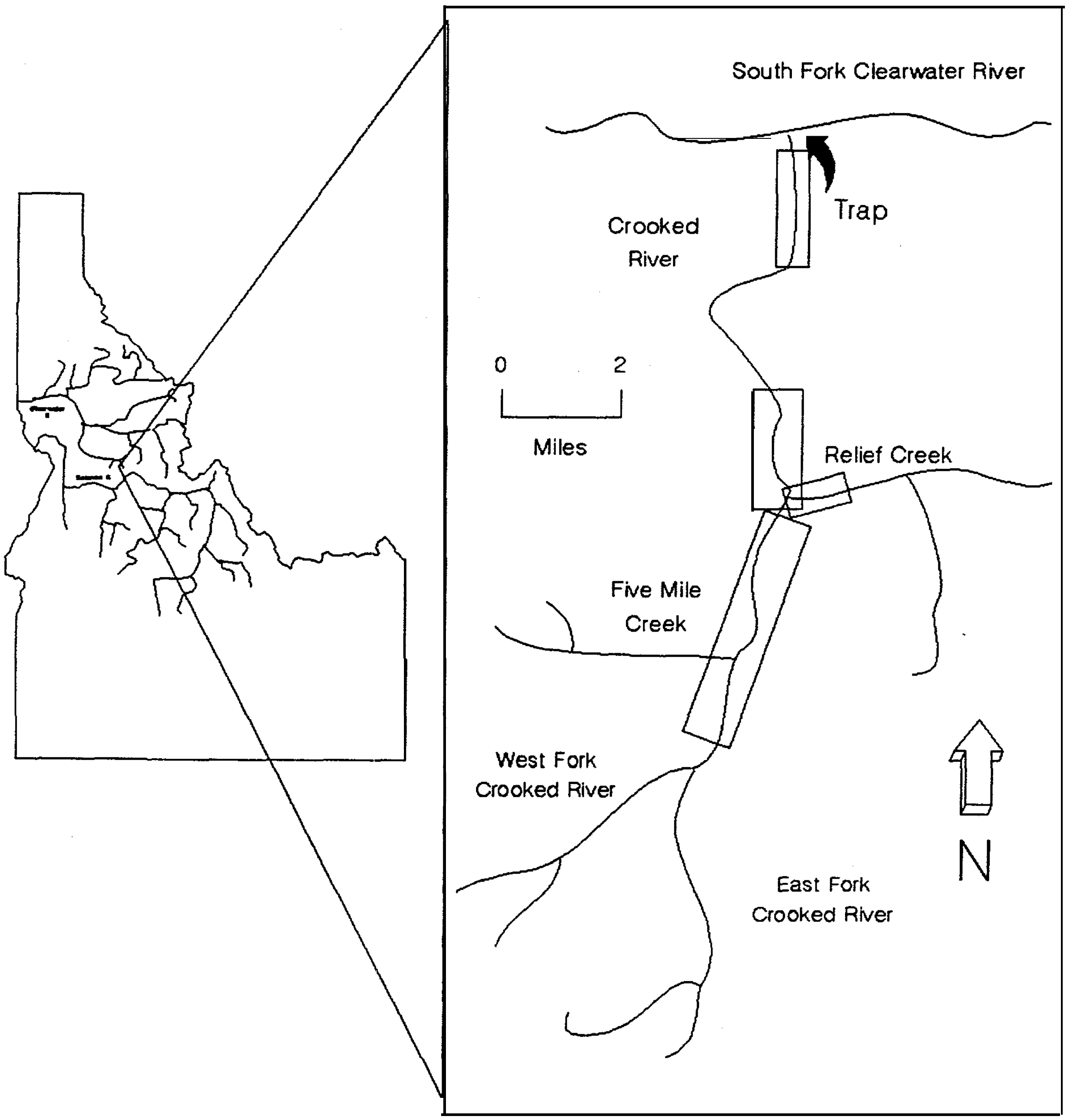

Figure 2. Location of Crooked River study area. Dredged areas are boxed.

METHODS

Study Area Structure

The upper Salmon River study area (Figure 1) was divided into strata that were established during Idaho habitat enhancement studies (Petrosky and Holubetz 1986). Each stratum contained at least two study sites of approximately 100 m length. The study area began at river km 617 and ended at river km 656. Tributary streams within the study area were divided into strata and each stratum had at least two study sites.

The Crooked River study area (Figure 2) also was divided into strata that were established during Idaho habitat enhancement studies (Petrosky and Holubetz 1986). In general, the strata were separated by habitat type. Off-channel ponds were included as two separate strata. B-ponds were off-channel ponds downstream of the Canyon stratum and A-ponds were above the Canyon stratum (Figure 2). Relief Creek had two strata and Five Mile Creek had one stratum.

Adult Escapements

Adult escapements for chinook salmon and steelhead trout in the upper Salmon River and Crooked River were obtained from Sawtooth and Clearwater Fish Hatchery records, respectively. Except for the possibility of a small number of early adults which may have passed before weir placement or when weir panels were pulled because of high water flow, the escapement into the study areas consisted of fish that were trapped at the weirs and released upstream to spawn naturally.

Adult Outplants

Upper Salmon River

The source of all adult chinook salmon and steelhead trout used for outplants in the upper Salmon River was adults trapped at the Sawtooth Fish Hatchery weir. Adult steelhead trout were outplanted for carrying capacity research into the headwaters of the upper Salmon River.

In August, pairs of adult chinook salmon were outplanted into Frenchman Creek (strata 2). A major factor in the selection of this outplant site was the absence of natural reproduction as determined by our ground redd counts the previous year. Picket weirs were constructed to prevent the fish from moving above or below the release site. Spawning activity was monitored every day. Redds were counted, mortalities were measured for length, and female mortalities were examined for egg retention. Carcasses were measured (fork length) and cut open to confirm sex and determine completeness of spawning.

Crooked River

Adult steelhead trout for outplants into Crooked River came from the Crooked River adult trap. Adults were released above the weir. Crooked River was walked twice weekly to count redds and mortalities. Mid-eye to hypural plate length (MEH length) was measured on female mortalities and egg retention was estimated. Beginning in 1993, radio tags were placed in female adult steelhead and their movements were tracked. The radio tags were stomach implants with activity and mortality signals. Fish were tracked daily to monitor movements and spawning activities.

Adult chinook salmon captured at the Crooked River trap were transported to the Red River facility and placed in a holding pond. When the adult chinook salmon from Crooked River became ripe, they were transported to Crooked River and released. Spawning activity in Crooked River was monitored on alternate days. Records were kept of observed spawning activity and redds and female mortalities were checked for egg retention.

Redd Counts and Estimated Egg Deposition

Aerial redd counts were conducted by IDFG fisheries personnel on Crooked River. These were one-day peak counts via helicopter. The steelhead trout redd count for Crooked River was conducted via helicopter from the townsite of Orogrande downstream to the weir excluding the Canyon stratum.

In addition to aerial counts, project personnel conducted ground redd counts of the entire probable steelhead trout and chinook salmon spawning areas and adult outplant areas in the upper Salmon River and Crooked River. The counts were done in early May for steelhead trout and late August to early September for chinook salmon. The number of redds counted were reported by Elms-Cockrum et al. (1995). All salmon carcasses found were measured (fork length and MEH) and cut open to confirm sex and completeness of spawning. Scale samples for aging and rearing site determination were collected from all carcasses found.

The numbers of effective female chinook salmon and steelhead trout spawning in the upper Salmon River were estimated as the number of females released above the Sawtooth Fish Hatchery weir multiplied by pre-spawning survival observed at Sawtooth Fish Hatchery (Coonts 1994, Snider 1994). The average fecundity for the females released above the weir was assumed to be the same as the average fecundity for those females taken into the Sawtooth Fish Hatchery and spawned (Coonts 1994, Snider 1994).

The number of female steelhead trout effectively spawning in Crooked River was determined from radio tracking and carcass examinations. Egg deposition for steelhead trout was estimated as the number of effective female spawners multiplied by the average fecundity for B-run steelhead trout observed at the Dworshak National Fish Hatchery (Ralph Rosenberg, personal communication) after adjusting fecundity for estimated egg retention.

The number of female chinook salmon effectively spawning in Crooked River was determined from ground redd counts with an assumed female:redd ratio of 1: 1. Egg deposition for chinook salmon was estimated as the number of effective female spawners multiplied by the average fecundity for chinook salmon observed at the Clearwater Anadramous Fish Hatchery for chinook salmon trapped at Crooked River (George and Davenport 1994) after adjusting for estimated egg retention.

Parr Abundance

Parr abundance by species and age class was estimated in both study areas. Streams in the study areas were divided into strata based on habitat types. Each stratum had at least two study sites. Visual counts were made in each study site by snorkelers. Densities (#/100 m^2) for each site were calculated using the visual counts and the surface area that the count encompassed. Snorkel counts were conducted in July for both study areas. If water was present in July, snorkel surveys were conducted in those streams that are usually dewatered by irrigation diversions . Total abundance of steelhead trout and chinook salmon parr for each study area was estimated by a multistage sampling design with visual estimation methods (Hankin 1986, Hankin and Reeves 1988).

August PIT Tagging

Chinook salmon and steelhead trout parr were PIT-tagged in their summer rearing areas during August in the upper Salmon River and Crooked River. Depending on site suitability and species available, fish were collected for PIT tagging with a minnow seine or with a Smith-Root model 12 electrofisher. Seines were used primarily to sample low gradient sections for chinook salmon parr and the electrofisher was used primarily to sample high gradient sections for steelhead trout parr. The electrofisher was operated with a 30.5 cm diameter anode ring on a 2.0 m pole and a 2.4 m rattail cathode trailing behind. A voltage setting between 200 and 400 V was used due to low conductivities in the two systems. Pulse rates of 90 cycles/sec was used when fishing primarily for chinook salmon and 30 cycles/sec when fishing for steelhead trout. To reduce the incidence of electrical burn marks and fish mortality, nylon netting was tied completely around the anode ring. This modification did not appear to impair capture effectiveness.

When collecting parr with seines, a herder/driver technique was normally used. A snorkeler herded fish upstream until enough fish were concentrated above a suitable seine placement site. A bag or minnow seine was then placed across the stream downstream of the fish. The snorkeler then walked around the fish, got back into the stream, and drove the fish into the seine. This was a very effective method for most areas with adequate stream depth.

Tagging procedures included anesthetizing fish with MS-222 (buffered with sodium bicarbonate) and injecting PIT tags into the body cavity using a 12-gauge hypodermic needle and modified syringe (Kiefer and Lockhart 1995). Prior to use, PIT tags, needles, and syringes were sterilized by soaking in a 70% alcohol solution for at least 10 minutes. Syringes and needles were not reused until they were re-sterilized.

After each tag was inserted, a loop style PIT tag detector was used to detect and send the tag codes to a battery powered laptop computer. The National Marine Fisheries Service (NMFS) has found that once a functional tag has been successfully implanted in a fish, the tag failure rate has been less than 1% (Prentice et al. 1986). Fork length was measured to the nearest mm with a CalComp digitizer scale on all fish that were PIT-tagged and all fish that were too small to tag (< 55 mm for chinook salmon and < 60 mm for steelhead trout). For most fish tagged, the weight was measured to the nearest 0.1 g on a Port-O-Gram balance. Perforated 1.0 m x 0.5 m x 0.7 m plastic tote boxes were used to hold fish before tagging, during recovery, and for 24-hour delayed mortality tests.

To determine 24-hour delayed mortality and tag loss, all tagged fish were held for 24 hours before release in the perforated plastic tote boxes in the stream sections where the fish were tagged. Tags were retrieved from any mortalities.

Emigration Trapping

To monitor fall and spring emigration of juvenile anadromous fish, we used floating scoop traps equipped with a 1 .O m wide inclined traveling screen (manufactured by Midwest Fabrications Inc., Corvallis, Oregon). The upper Salmon River trap was located directly below the permanent weir at the Sawtooth Fish Hatchery. Water was funneled to the upper Salmon River trap from a 3.1 m wide bay at the weir. The funnel was constructed of a picket weir with 3.8 cm spaces. To evaluate the spring emigration, the trap was operated continuously (except for breakdowns) from early March to mid-June. To evaluate the fall emigration, the trap was operated from late August to early November

On Crooked River, the trap was located 0.2 km above the mouth about 20 m below the adult trapping weir. A rock weir installed in 1990 helps direct fish into the trap. To evaluate the spring emigration, the trap operated from early March to mid-June. To evaluate the fall emigration, the trap was operated from early September to early November.

All juvenile chinook salmon and steelhead trout captured were anesthetized and scanned with a PIT tag reader to determine if they had been previously tagged. All untagged juveniles (up to 100 per species and age group) were PIT-tagged using the same procedures described previously. After tagging, these fish were held in perforated live boxes 300 to 400 m upstream of the trap. At dusk, the fish were released. Recaptures of these fish were used to calculate trap efficiency. Daily releases of PIT-tagged juveniles for a particular species and age class were grouped until a large enough release group is made to where we would expect an average of eight recaptures for each group. The proportion recaptured in each group was assumed to represent trap efficiency. During the fall 1994 trapping season, stream flows did not change dramatically and all of the grouped trap efficiency estimates were used to calculate a mean trap efficiency and 90% C.I. During the spring, we estimated a mean and 90% C.I. trap efficiency for different blocks of time (based on major changes in stream flow) during the trapping season.

The overall run estimates and 90% C.I. were obtained by summing the daily run estimates and recalculating confidence intervals. The daily run estimates were calculated by dividing the daily trap catches by the estimated trap efficiencies.

We used the fork length frequency of the steelhead trout caught to estimate age composition of the steelhead trout emigrants. In the fall, steelhead trout parr under 90 mm were considered fry, 90 mm to 124 mm were considered age 1 + , and over 124 mm were considered age 2+ and older. In the spring, steelhead trout under 90 mm were considered age 1 parr, 90 mm to 129 mm were considered age 2 parr, and over 129 mm were considered age 3 and older smolts.

Survival Rates

Estimates of the egg-to-parr survival (parr =age 0 for chinook salmon and age 1 + for steelhead trout) were calculated by dividing the parr population estimate by the estimated egg deposition that produced the parr.

The estimate of steelhead trout survival from age 1 + to age 2 + was calculated using PIT tag detection rates at the smolt collecting dams. For brood year 91 steelhead trout, we divided the proportion of age 1 + parr PIT-tagged in August 1992 and detected at the smolt collecting dams in spring 1994 by the proportion of age 2 + parr PIT-tagged in August 1993 and detected at the smolt collecting dams in spring 1994.

We estimated the survival of age 0 chinook salmon and age 2+ and older steelhead trout PIT-tagged in August to the onset of smolt migration in the spring using PIT tag detections at the smolt collecting dams. For this estimate, we divided the proportion of PIT tag detections at the lower Snake and Columbia river smolt collecting dams of parr PIT-tagged in August by the proportion of PIT tag detections at the dams of smolts PIT-tagged during the spring emigration. We assumed the groups being compared suffered the same tagging mortality and smolts from both groups that survived to the dams were detected at the same rate. The equation for the estimate of August tagged parr-to-smolt was as follows:

$$S_{Study\ Area} = PTD_A / PTD_S$$

Where:

PTD_A = *Proportion of August PIT-tagged parr detected at the dams.*

PTD_S = *Proportion of spring PIT-tagged smolts detected at the dams.*

$S_{Study\ Area}$ = *The proportion of August parr surviving to smolts at the onset of smolt migration.*

We used a similar methodology to estimate survival to smolts reaching the head of Lower Granite Reservoir (LGR) pool for age 0 chinook salmon and age 2 + and older steelhead trout parr PIT-tagged in August, and for chinook salmon and steelhead trout smolts captured and PIT-tagged at our emigrant traps in the spring. For these estimates, we divided the PIT tag detection rates of summer parr or spring emigrants tagged in our study area by the detection rates of wild/natural smolts that were PIT-tagged at traps at the head of LGR pool. For these estimates, we assumed that LGR pool tagged smolts were detected at the dams at the same rate as our tagged juveniles, that both groups suffered the same tagging mortality, and that both groups suffered the same migration mortality through LGR pool. The equation for the estimate was as follows:

$$S_{LGR\ pool} = PTD_{Study\ Area} / PTD_{LGR\ pool}$$

Where:

$S_{LGR\ pool}$ = *The proportion of the study area PIT-tagged parr or smolts surviving to the head of LGR pool.*

$PTD_{Study\ Area}$ = *Proportion of the study area PIT-tagged August parr or emigrating smolts detected at the dams.*

$PTD_{LGR\ pool}$ = *Proportion of LGR pool PIT-tagged smolts detected at the dams.*

RESULTS

Upper Salmon River

Spring 1994 Emigration Trapping

In spring 1994, we operated a juvenile outmigrant trap on the upper Salmon River to estimate smolt emigration for chinook salmon, 0. *nerka,* and steelhead trout. This trap was operated continuously from March 8 to June 9 except for breakdowns that averaged approximately three hours during morning hours on the following dates: March 11, March 20, March 23-25, April 12, May 1, and May 13. We captured 239 chinook salmon smolts, 309 steelhead trout juveniles, and 52 0. *nerka* juveniles, presumably from Alturas Lake.

We estimated spring 1994 upper Salmon River emigrations of 4,345 chinook salmon smolts, 7,023 steelhead trout juveniles, and 945 0. *nerka* juveniles (Appendix A.). Daily run estimates are shown in Figure 3. Age composition of steelhead trout emigrants based on size of trapped fish was 18.1% (1,273) age 1, 11.6% (818) age 2, and 70.2% (4,932) age 3 and older smolts.

On April 9, 72,380 hatchery chinook salmon smolts from Sawtooth Fish Hatchery were released 25 km upstream of our emigrant trap. We captured 1,906 (2.6%) of these hatchery chinook salmon smolts in our emigrant trap. We estimated that 34,654 (47.9% of those released) of these hatchery chinook salmon smolts emigrated past our upper Salmon River emigrant trap site (Appendix A).

Estimated Steelhead Trout Egg Deposition

In spring 1994, 338 (164 female) adult steelhead trout were captured at the Sawtooth Fish Hatchery adult trap (Coonts 1994). All 6 wild/natural adults (5 female) and 12 hatchery adults (4 female) were released immediately above the weir to spawn naturally. Stomach implant radio tags were orally inserted into all but two of the 18 adult steelhead trout released immediately above the weir. One of the adults not radio tagged was a hatchery male that was released 50 m upstream of a female digging a redd in Alturas Lake Creek with no male in the area. The other adult not tagged was a wild female with a torn esophagus. Five adults (2 females and 3 males) regurgitated their tags before spawning. One of the other tags was at a frequency that encountered too much interference and we were unable to track the wild female this tag was inserted in.

With these radio tags we were able to locate six redds, three built by wild females and three by hatchery females. All three redds built by hatchery females were located immediately upstream of the weir. The three redds made by wild females were much more widely distributed. One was located in the Salmon River approximately 3.5 km above the weir, another was in the Salmon River approximately 7 km above the weir, and the third was located in Alturas Lake Creek 1.5 km above the mouth (17 km above the weir).

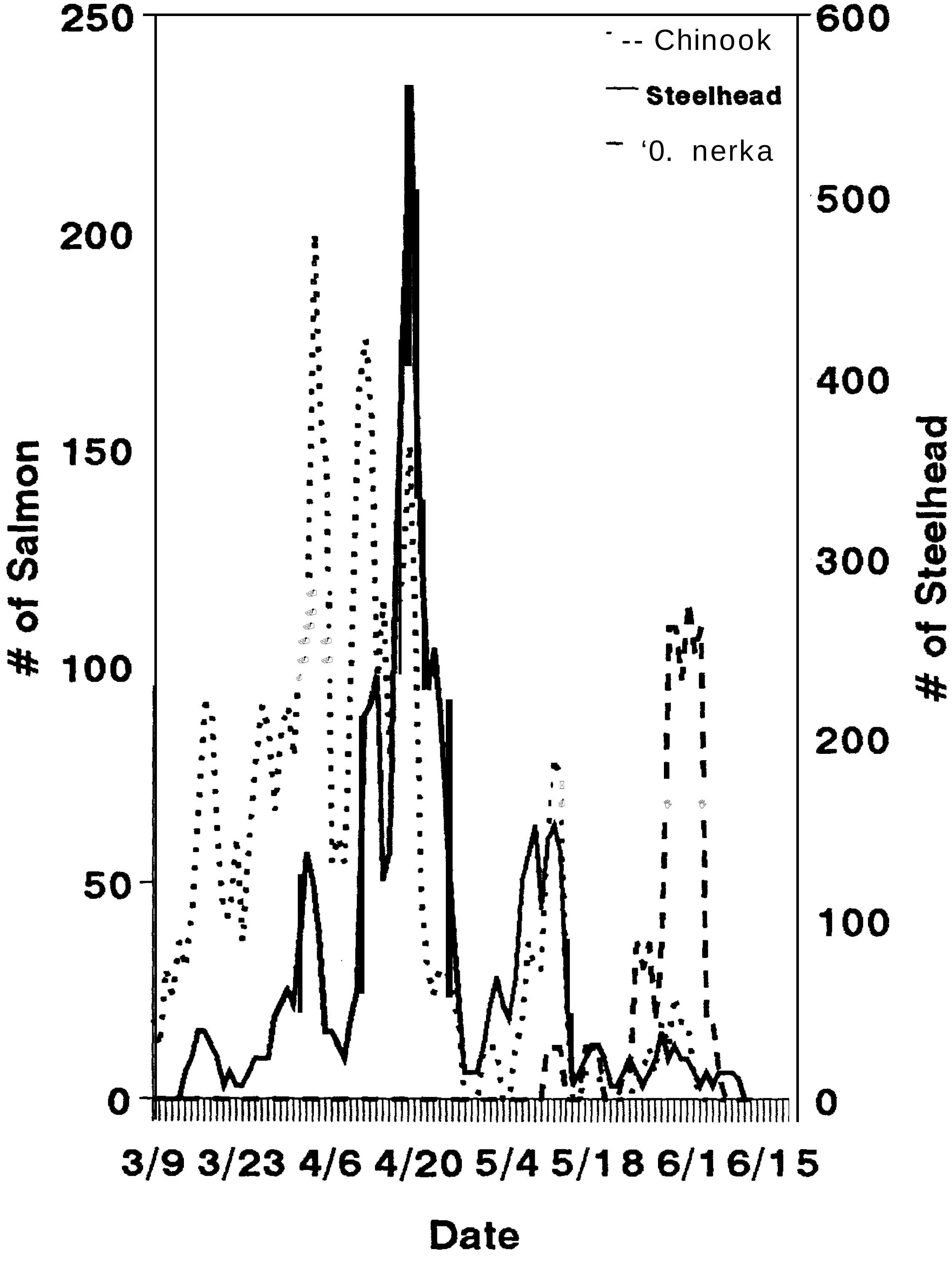

Figure 3. Spring 1994 upper Salmon River chinook salmon, steelhead trout, and daily run estimates (3-day moving average).

The carcasses of all nine females released immediately above the weir were found and examined for egg retention. All nine females had apparently spawned and we observed an average egg retention of 24 eggs/female. The most eggs we found in any female was 150 in one wild fish. The steelhead trout supplementation studies research project outplanted 20 (10 female) adult hatchery steelhead trout on April 22 above a blocking weir on Frenchman Creek and 19 (8 female) above a blocking weir in Beaver Creek between April 28 and May 6. These sections were walked daily until May 16 to monitor spawning. A total of 12 redds were observed in Frenchman creek and 5 redds were observed in Beaver Creek.

For average fecundity we used the average fecundity observed by Coonts (1994) at Sawtooth Fish Hatchery (5,755). We assumed the majority if not all of the parr produced from the three redds built just above the hatchery weir will rear below our study area. We therefore did not count them in our estimate of egg deposition in the upper Salmon River. With this data, we estimated total steelhead trout egg deposition in the upper Salmon River to be 120,351 ([24 - 31 x 15,755 - 24]) (Table 1).

PIT Tag Detections

Detections of PIT-tagged smolts at the lower Snake and Columbia river smolt collecting dams provides information on chinook salmon and steelhead trout smolt migration characteristics. A significant negative correlation was found between travel time to Lower Granite Dam and smolt emigration date for both chinook salmon ($r^2 = 0.53$; F = 12.026; P = 0.002) and steelhead trout (r^2 = 0.38; F = 8.349; P = 0.007) (Figure 4). Mean smolt travel times to Lower Granite Dam and 90% confidence intervals were estimated to be 35.1 $\pm$4.6 days for chinook salmon (n = 30), and 22.4 $\pm$2.6 days for steelhead trout (n = 31).

The combined PIT tag detection rates at the Lower Snake and Columbia river smolt collecting dams for smolts captured and PIT-tagged at the upper Salmon River emigrant trap in spring 1994 were 25.9% (62 of 239) for chinook salmon, and 23.2% (48 of 207) for age 3 and older steelhead trout. The combined detection rate for wild/natural smolts PIT-tagged by Buettner and Brimmer (1995) at their Snake River trap near Lewiston in 1994 was 65.7% for chinook salmon and 73.0% for steelhead trout.

For the fall 1993 upper Salmon River emigrants, the detection rates were 12.0% (12 of 100) for chinook salmon and 8.0% (2 of 25) for age 2 + and older steelhead trout. Detection data for the August 1993 PIT-tagged parr were summed by strata (Table 2). The combined detection rate for upper Salmon River August 1993 PIT-tagged parr was 5.7% (72 of 1,254) chinook salmon and 3.6% (5 of 137) age 2 + and older steelhead trout.

To determine if fish size had an effect on survival, we compared PIT tag detection rate and fish size for spring emigrants (Table 3). In spring 1994 no upper Salmon River chinook salmon smolt length group had a significantly different detection rate (x^2=3.24; $0.75 > P > 0.50$). We assume most of the steelhead smaller than 130 mm will rear another year or more before smolting.

Table 1. Adult steelhead trout escapement, redd counts, and estimate of eggs deposited (in thousands) for the upper Salmon River, brood years 1987 to 1994.

	Brood Year							
	1987	1988	1989	1990	1991	1997	1993	1994
Total escapement	979	635	378	528	91	672	668	57
Female escapement	383	136	157	219	15	175	178	27
Helicopter redd counts - mainstream		-	-	56	15	29	36	
Ground redd counts - tributaries			-	4	2	-	14	21
Eggs per female	4,854	5,069	5,637	4,734	4,019	4,581	4,460	5,731
Estimated eggs deposited	1659.0	689.3	885.0	1,036.7	60.3	760.4	753.7	120.4

Total escapement, female escapement, and eggs/female data are from Sawtooth Fish Hatchery brood year reports. Redd count data are from IDFG redd count reports.

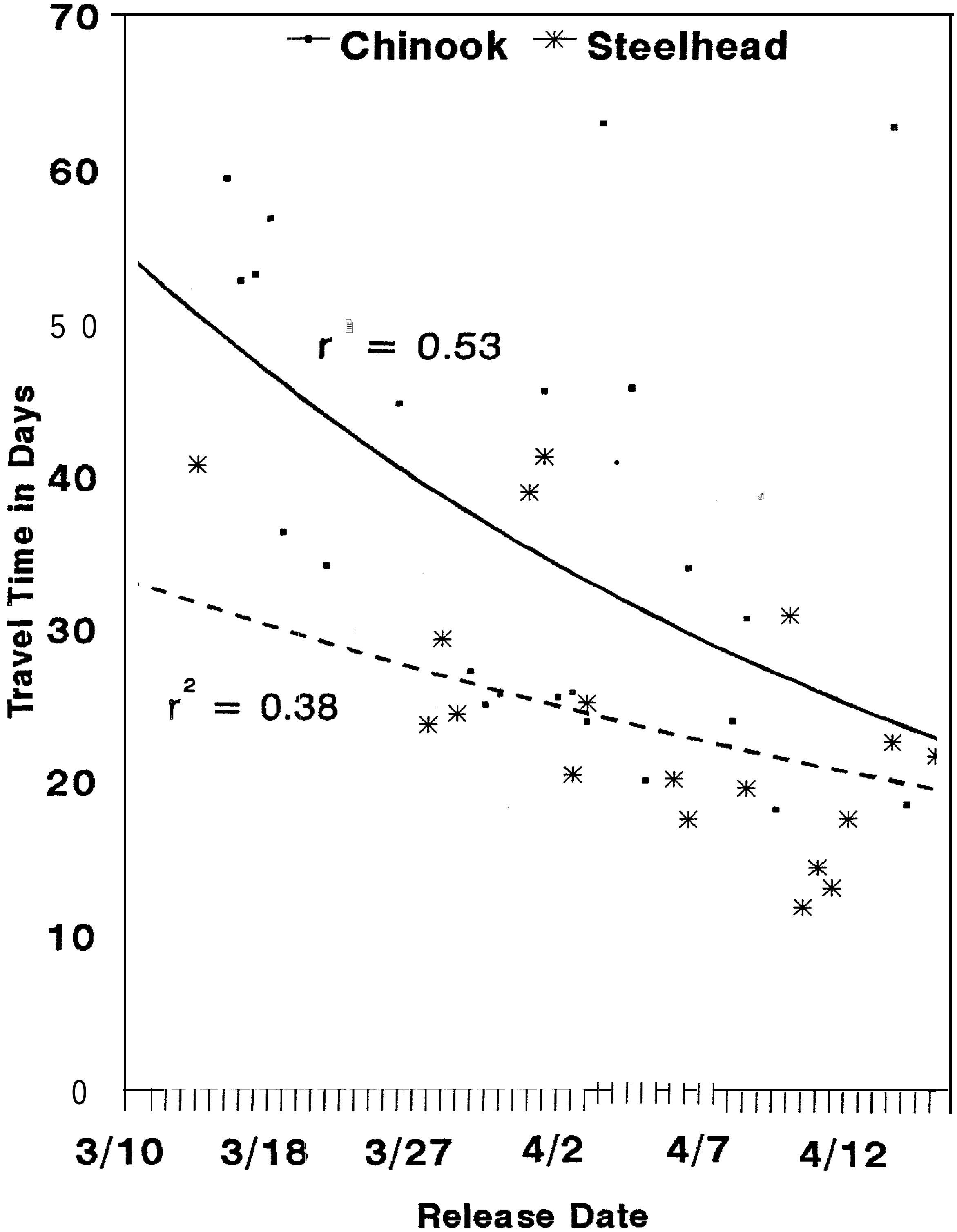

Figure 4. Spring 1994 PIT-tagged chinook salmon and steelhead trout smolt travel time from the upper Salmon River trap to Lower Granite Dam.

Table 2. Detections in 1994 at the Lower Snake and Columbia River smolt collecting dams of August 1993 PIT-tagged parr from the upper Salmon River.

	Chinook aae 0			Steelhead age 7 +		
Stratum [a]	Number Tagged	Number Detected	Percent Detected	Number Tagged	Number Detected	Percent Detected
SIC	514	32	6.2	23	0	0.0
FMC	263	4 [b]	1.5	0	-	
SR-3	477	36	7.5	15	0	0.0
SR-9	2	0	0.0	99	5	5.0
Totals	1,254	72	5.7	137	5	3.6

[a] Stratum key: SIC = Smiley Creek
FMC = Frenchman Creek
SR-3 = Salmon River, Sawtooth Fish Hatchery weir to Williams Creek
SR-9 = Salmon River, Pole Creek to Frenchman Creek

[b] In the past two years, many of the chinook salmon juveniles from Frenchman Creek have not smolted until age 2.

Table 3. Smolt length and PIT tag detection at lower Snake and Columbia river smolt collecting facilities for the upper Salmon River, spring 1994.

Length (mm)	Number Tagged	Number Detected	Percent Detected
	Chinook		
<80	3	1	33.3
80-89	73	14	19.2
90-99	91	24	26.4
100-109	58	20	34.5
>109	14	3	21.4
Total	239	62	25.9
	Steelhead		
<90	55	0	0.0
90-l 29	38	0	0.0
>129	207	48	23.2
Total	300	48	16.0

Parr Abundance

During the second half of July we conducted snorkel counts in established study sites of the upper Salmon River to estimate densities and total abundance of chinook salmon and steelhead trout parr. For the upper Salmon River, estimated total parr abundances were: 152,174 age 0 chinook salmon, 3,907 age 1 + steelhead trout, and 2,143 age 2 + and older steelhead trout (Appendix B).

Estimated total abundance and densities for age 0 chinook salmon were within the mid-range of what we have observed since we began our intensive evaluation in 1987 (Appendix B and Appendix Cl). Estimated total abundance and densities for both age 1 + and age 2 + and older steelhead trout were in the lower range of what we have observed since we began our intensive evaluation in 1987 (Appendix B, Appendix C2, and Appendix C3).

PIT Tagging

During the second half of August we collected and PIT-tagged representative groups of chinook salmon and steelhead trout parr in the upper Salmon River. We PIT-tagged 3,584 age 0 chinook salmon parr and 544 steelhead trout parr.

August collecting mortalities totaled 0.1% (4 of 5,200) for chinook salmon and 0% (0 of 555) for steelhead trout. August PIT tagging and 24-hour delayed mortalities totaled 0.6% (20 of 3,584) for chinook salmon and 0% (0 of 544) for steelhead trout. Most of the parr collected and not tagged were either too small to tag or we had already tagged enough parr for that evaluation group.

The PIT-tagged age 0 chinook salmon were divided into the following seven evaluation groups: Salmon River stratum 3 (531 tagged), Huckleberry Creek (258 tagged), Alturas Lake Creek (519 tagged), Beaver Creek (541 tagged), Smiley Creek (500 tagged), Frenchman Creek (593 tagged), and Salmon River strata 9 and 10 (642 tagged).

The percentage and number of the different steelhead trout parr age groups PIT-tagged were: 15% (80) age 0, 58% (318) age 1 +, and 27% (146) age 2+ and older. Due to the small population, we were only able to collect enough age 2 + and older steelhead trout for one evaluation group.

Fall 1994 Emigration Trapping

During fall 1994, we operated a juvenile outmigrant trap on the upper Salmon River to estimate chinook salmon and steelhead trout pre-smolt emigration. This trap was operated continuously from August 4 to November 8, 1994. We captured 1,144 chinook salmon pre-smolts and 146 steelhead trout juveniles. We estimated total fall 1994 upper Salmon River emigrations of 10,895 chinook salmon pre-smolts and 1,292 steelhead trout juveniles (Appendix D). Daily run estimates are shown in Figure 5.

Age composition of steelhead trout emigrants based on size of trapped fish was 81% (1,047) age 0, 11% (142) age 1 + , and 8% (103) age 2 + and older. The estimated percentages of summer 1994 parr populations that emigrated in the fall were 7% for age 0 chinook salmon, 4% for age 1 + steelhead trout, and 5% for age 2 + and older steelhead trout.

Estimated Chinook Salmon Egg Deposition

In 1994, 83 (33 female) of the 96 (40 female) adult chinook salmon captured at the Sawtooth Fish Hatchery adult trap were released above the weir to spawn naturally (Table 4).

On September 7 and 8, a total of 18 chinook salmon redds were observed via ground counts in all probable natural spawning areas and four redds were observed in the Frenchman Creek adult outplant site (Table 4). On September 12, 10 chinook salmon redds were observed via helicopter in all probable natural spawning areas; the adult outplant site on Frenchman Creek was not counted via helicopter.

The average fecundity in 1994 observed at Sawtooth Fish Hatchery for the same stock of chinook salmon was 4,500 eggs/female (Snider 1994). We examined four post-spawning female carcasses and observed an average egg retention of 9 eggs/female. Potential egg deposition in the upper Salmon River for brood year 1994 chinook salmon adults released above the hatchery weir to spawn naturally was estimated to be 98,802 (14,500 - 91 x 22).

Adult Chinook Salmon outplants

On August 12, 1994 we outplanted seven pair of adult chinook salmon for our carrying capacity research into a section of Frenchman Creek stratum 2, which was blocked with a picket weir on the downstream and upstream ends. This section was surveyed daily to monitor spawning success. During the first two days after release, we found one female pre-spawning mortality each day that were apparently otter kills. To reduce otter predation, we pulled the picket weirs to allow the remaining adults to spread out, set two otter live traps, and had project personnel camp at the release site. During the next week, we observed three more adult chinook mortalities (2 male and 1 female) that appeared to be otter kills. The third female apparently killed by otters appeared to have spawned already (only the head was eaten and no eggs were present).

We observed four separate females on four completed redds. Two of the adult chinook salmon (1 male and 1 female) were not found; we do not know if this female spawned, and assumed she did not. We estimated 17,964 ([4,500 - 91 x 4) chinook salmon eggs were deposited in the Frenchman Creek adult outplant site.

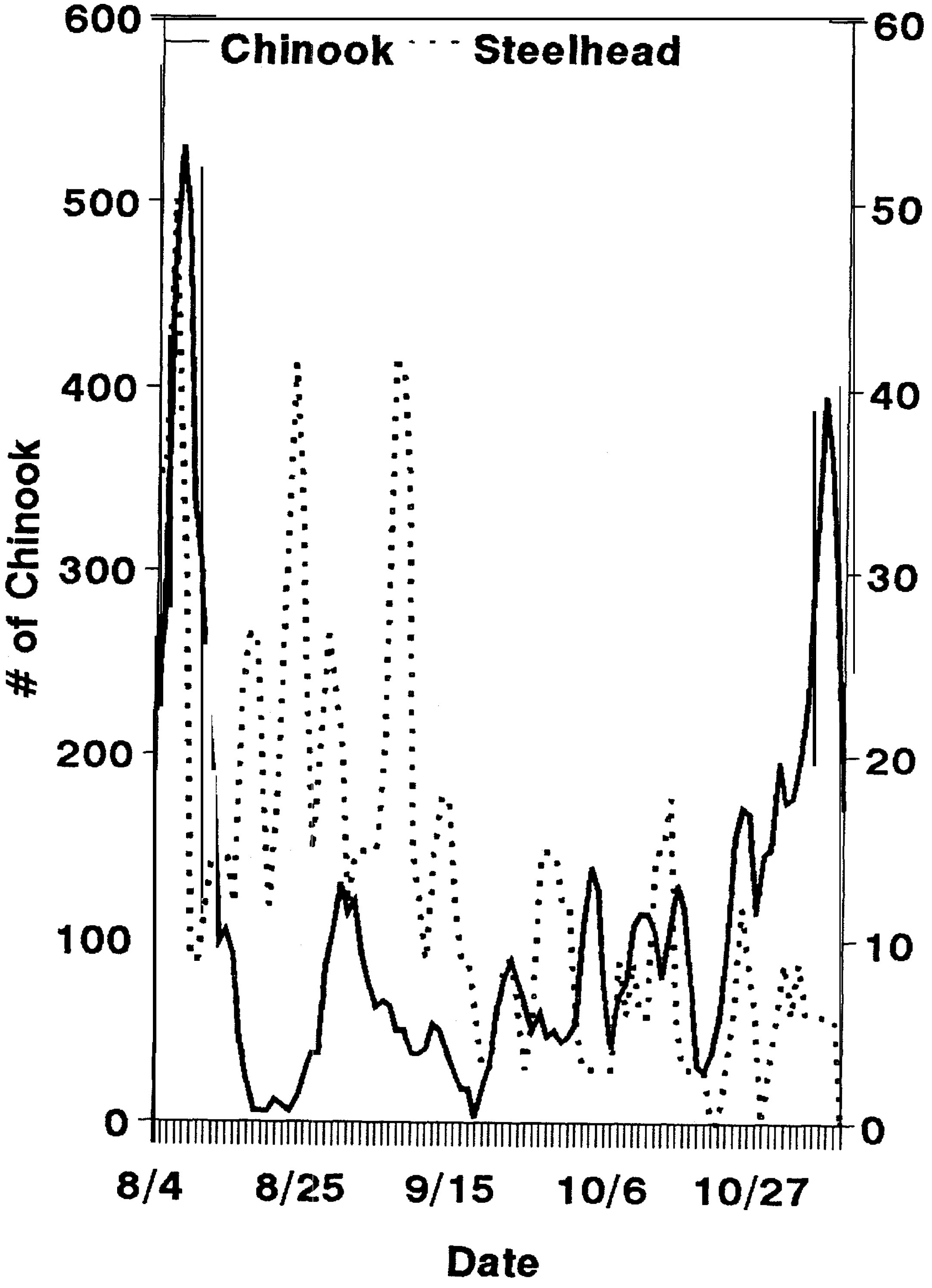

Figure 5. Fall 1994 upper Salmon River chinook salmon and steelhead trout daily run estimates (3-day moving average).

Table 4. Adult chinook salmon escapement, redd counts, and estimate of eggs deposited (in thousands) the for Upper Salmon River, brood years 1986 to 1994. Total escapement, female escapement, and eggs/female data are from Sawtooth Fish Hatchery brood year reports. Redd count data are from IDFG redd count reports.

	Brood Year								
	1986	1987	1988	1989	1990	1991	1992	1993	1994
Total escapement	876	506	552	470[c]	615	238	145	423	83
Female escapement	248	252	275	73[c]	167[d]	94	56	209	33
Helicopter redd counts	105	124	76	52	60	46	29	61	10
Ground redd counts			261	123	100	67	27	127	22
Eggs per female[a]	5,156	5,399	5,653	5,456	4,501	5,192	4,503	4,834	4,491
Estimated eggs deposited[b]	1,278.7	1,360.5	1,554.5	671.1	450.1	347.9	193.7[e]	613.9	98.8

[a] Number is average eggs/female observed at the Sawtooth Fish Hatchery.

[b] Estimates of average egg retention are incorporated in calculating egg deposition.

[c] Portions of the Sawtooth Fish Hatchery weir were pulled due to high water and uncounted fish probably passed the weir.

[d] Chinook escapement above Sawtooth Fish Hatchery was reduced by at least 65 adults due to a rotenone kill.

[e] Because we believe we conducted our redd counts too early in 1992, we used the 1987 to 1992 average prespawning mortality observed at Sawtooth Fish Hatchery (5%) to estimate that 44 females spawned in 1992.

Survival Rates

The brood year 1993 chinook salmon egg-to-parr survival for the headwaters of the Salmon River outplant was estimated to be 56.1% (Table 5). For brood year 1987-1993 the average chinook salmon egg-to-parr survival for the headwaters of the Salmon River averaged 25.2% (90% C.I. = 10.0% to 44.4%) (Table 5).

Estimated brood year 1993 steelhead trout egg-to-age 1 + parr survival rate for the entire upper Salmon River was only 0.2%.

We estimated that winter 1994 parr-to-smolt (at the onset of smolt migration) overwinter survival in the upper Salmon River was 22.0% for age 0 chinook salmon and 15.5% for age 2+ and older steelhead trout. For migration years 1988-1994, chinook salmon overwinter survival averaged 19.4% (90% C.I. = 17.3% to 21.3%) (Table 6), and steelhead trout age 2 + and older overwinter survival averaged 24.9% (90% C.I. = 13.4% to 38.4%) (Table 7).

The estimated survival, to the head of Lower Granite Reservoir, for parr PIT-tagged in August 1993 was 8.7% for age 0 chinook salmon and 4.9% for age 2+ and older steelhead trout. For migration years 1988-1994, survival to the head of Lower Granite Reservoir for chinook salmon parr tagged in August averaged 8.7% (90% C.I. = 7.0% to 10.9%) (Table 6), and 9.5% (90% C.I. = 4.5% to 15.8%) for age 2+ and older steelhead trout (Table 7). For pre-smolts PIT-tagged during the fall 1993 emigration, the estimated survival to the head of Lower Granite Reservoir was 18.3% for age 0 chinook salmon and 11 .O% for age 2 + and older steelhead trout. For smolts PIT-tagged during the spring 1994 smolt emigration, the estimated survival to the head of Lower Granite Reservoir was 39.4% for chinook salmon and 31.8% for steelhead trout. For migration years 1988-1994, the estimated survival to the head of Lower Granite Reservoir for smolts leaving upper Salmon River during the spring emigration averaged 46.7% (90% C.I. = 34.1% to 59.5%) for chinook salmon (Table 6) and 38.8% (90% C.I. = 28.2% to 49.7%) for age 2 -t and older steelhead trout (Table 7).

Crooked River

Spring 1994 Emigration Trapping

In spring 1994, we operated a juvenile outmigrant trap on Crooked River to estimate smolt emigration for chinook salmon and steelhead trout. This trap was operated continuously from March 18 to June 15, 1994. We captured 1,514 chinook salmon smolts when flows were below 3.5 m^3/s with an estimated trapping efficiency of 48.6%, and 215 chinook salmon smolts when flows were above 3.5 m^3/s with an estimated trapping efficiency of 19.4%. We also captured 429 steelhead trout juveniles with an estimated trapping efficiency of 16.2%.

Table 5. Estimated chinook salmon egg-to-parr survival rates (%) from the headwaters of the upper Salmon River adult outplants and natural spawners, brood years 1987 to 1993.

		Brood Year						
Adult Origin	Population Parameter	1987	1988	1989	1990	1991	1992	1993
Adult outplants	Females outplanted	6	30	9	40	13[a]	10	39
	Redds observed	5	30	9	13	10	9	21
Natural spawners	Redds observed	0	6	4	0	0	0	8
Combined numbers	Egg deposition	26,995	203,508	72,800	58,513	51,917	39,627	145,108
	Parr production	8,625	35,938	5,054	18,214	19,838	1,509	81,394
	Egg-to-Parr survival (%)	32.0	17.7	6.9	31.1	38.2	7.1 [b]	56.1

[a] In 1990, we were unable to estimate total egg deposition in two of our outplant streams and data from these streams were not included in estimating egg-to-parr survival.

[b] Parr production estimates were biased downward due to uneven distribution of parr populations in outplant areas and we believe 7.1% to be more accurate.

Table 6. Headwaters upper Salmon River chinook salmon survival rate estimates, brood years 1987 to 1993.

	Brood Year						
	1987”	1988[b]	1989”	1990[d]	1991[e]	1992	1993
Egg-to-Parr [f]	32.0%	17.7%	6.9%	31.1%	38.2%	7.1%	56.1%
Overwinter	20.3%	18.9%	17.4%	18.2%	23.2%	22.0%	10.9%
Parr-to-smolt at Lower Granite pool	9.2%	6.4%	6.9%	5.7%	13.3%	8.7%	6.3%
Smolt migrating trap to Lower Granite pool	45.2%	33.7%	39.6%	31.1%	57.6%	39.4%	57.7%

[a] Data except for egg-to-parr survival from Kiefer and Forster 1990.
[b] Data except for egg-to-parr survival from Kiefer and Forster 1991.
[c] Data except for egg-to-parr survival from Kiefer and Forster 1992.
[d] Data except for egg-to-parr survival from Kiefer and Lockhart 1993.
[e] Data except for egg-to-parr survival from Kiefer and Lockhart 1994.
[f] Data from Table 5.

Table 7. Upper Salmon River age 2+ and older steelhead trout survival rate estimates, migratory years 1988-l 994.

	Migratory Year						
	1988”	1989[b]	1990’	1991[d]	1992”	1993	1994
Overwinter	54.9%	48.0%	24.8%	14.5%	10.2%	16.0%	15.5%
Parr-to-smolt at Lower Granite pool	23.3%	20.5%	7.8%	3.7%	3.0%	11.0%	4.9%
Smolt migration; trap to Lower Granite pool	42.6%	42.4%	31.6%	25.7%	29.5%	68.6%	31.8%

[a] Data from Kiefer and Forster 1990.
[b] Data from Kiefer and Forster 199 1.
[c] Data from Kiefer and Lockhart 1992.
[d] Data from Kiefer and Lockhart 1993.
[e] Data from Kiefer and Lockhart 1995.

We estimated total spring emigrations of 4,223 chinook salmon smolts, and 2,648 steelhead trout juveniles (Appendix E). Daily run estimates are shown in Figure 6. Age composition of steelhead trout emigrants based on size of trapped fish was 53.1% (1,406) age 1, 30.1% (796) age 2, and 16.8% (444) age 3 and older smolts.

Using summer 1993 parr abundance estimates (Kiefer and Lockhart 1995) we estimated that 17.3% of the chinook salmon parr, 29.5% of age 1 + steelhead trout parr, and 14.0% of age 2 + and older steelhead trout parr emigrated from Crooked River in spring 1994.

On April 14, 273,766 Rapid River stock hatchery chinook salmon smolts were released from the hatchery ponds on Crooked River. We captured 79,604 of these smolts at our emigrant trap with an estimated trap efficiency of 42.5%. We estimated that a total of 187,304 (68.4% of those released) hatchery chinook salmon smolts emigrated (Appendix E.). To assist the hatchery evaluation project we PIT-tagged 1 ,110 of the hatchery chinook salmon smolts captured at our emigrant trap.

On April 29, 104,450 Dworshak stock and 71,566 Selway stock steelhead trout smolts were released from the hatchery ponds on Crooked River after two weeks of acclimation. We captured 16,948 of these hatchery steelhead trout smolts in our emigrant trap with an estimated trap efficiency of 24.7%. We estimated that 68,615 (39.0% of those released) hatchery steelhead trout smolts emigrated (Appendix E).

The hatchery steelhead trout smolts released on April 29 included 467 PIT-tagged Dworshak stock and 300 PIT-tagged Selway stock. We passed most of the 16,948 hatchery steelhead trout smolts we captured through a remote PIT tag detector; the remainder were anesthetized and hand scanned during our normal tagging operation at the trap. We detected 36 of 467 of the PIT-tagged Dworshak stock and 6 of 300 of the PIT-tagged Selway stock. Since 0.44% (767 of 176,016) of the total hatchery steelhead trout smolts released were PIT-tagged and we captured 16,948, we expected to detect 74 of these PIT-tagged fish (16,948 x 0.0044 = 74). However, we knew our monitor was not working very efficiently and estimate it only detected 42 (57%) of the expected 74 PIT-tagged hatchery steelhead smolts. We estimated 54.8% of the Dworshak stock and 14.2% of the Selway stock emigrated after adjusting for detector efficiency and trap efficiency. We PIT-tagged 519 of the Selway stock steelhead trout smolts captured at our emigrant trap to assist the hatchery evaluation project.

Estimated Steelhead Trout Egg Deposition

In 1994, a total of six adult steelhead trout (three males and three females) were captured at the Crooked River adult trap. The first fish was trapped on April 24 and the last fish on May 15. Five of the adults captured (two males and three females) were wild/natural fish and were released upstream of the weir to spawn naturally.

The length of all wild/natural steelhead trout adults was measured, and scale samples were collected. A stomach implant radio tag was orally inserted into all five wild adults released above the weir. In addition, a sterilized hole punch was used to collect an anal fin sample from the wild adult steelhead trout for a researcher from the National Biological Survey (NBS).

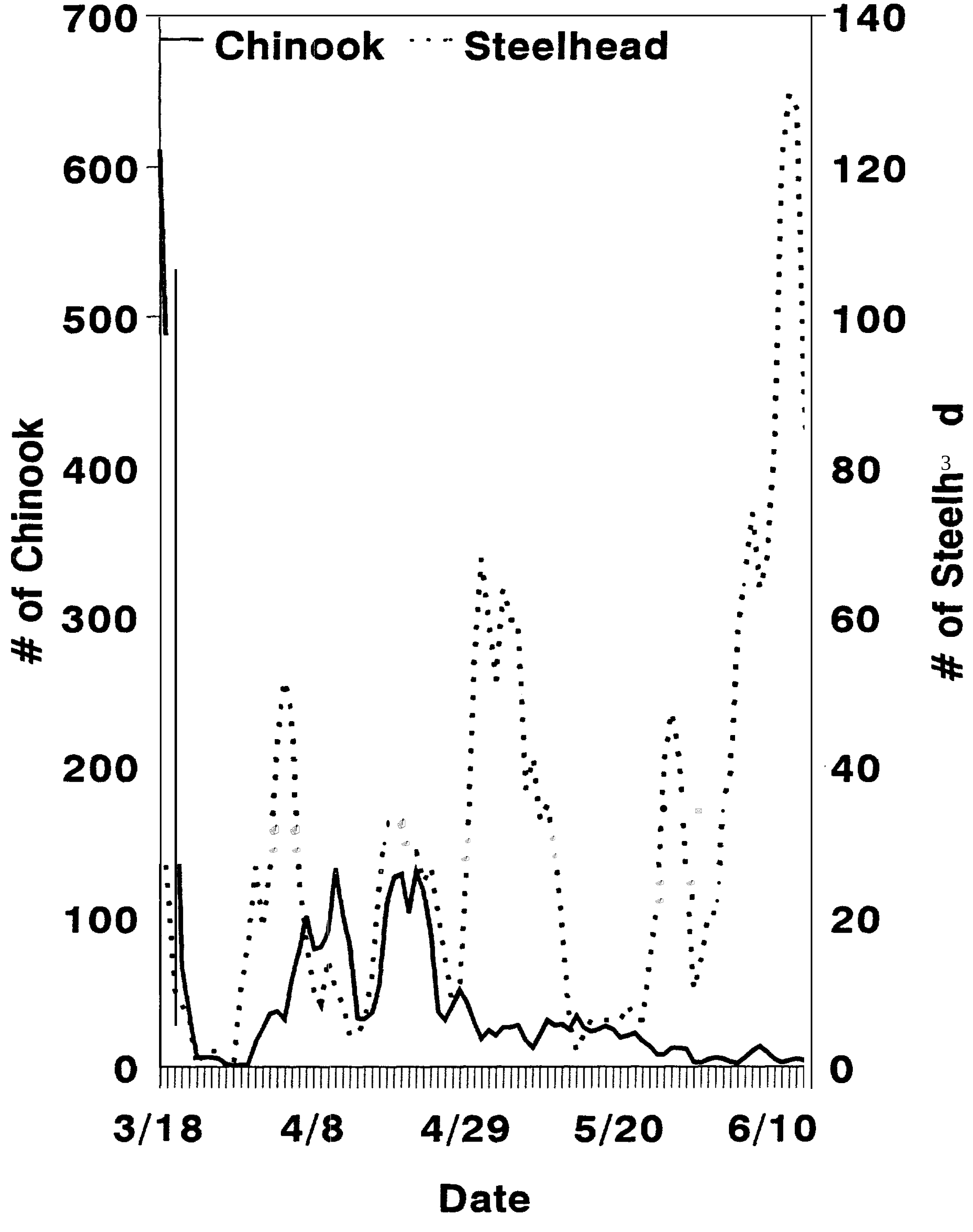

Figure 6. Spring 1994 Crooked River chinook salmon and steelhead trout daily run estimates (3-day moving average).

Shortly after being released, the first adult captured (a wild female) regurgitated her transmitter. She began digging a redd directly above the weir and was observed daily until she died. This female completed her redd before we captured another adult. We observed several juvenile steelhead with her during and after redd construction. We believe this female spawned successfully. After she spawned, we no longer saw juvenile steelhead with her and, at the same time, we captured several precocial male wild/natural steelhead juveniles in our emigrant trap. We believe these juveniles spawned with the female. This belief is further supported by our outmigrant trap capturing steelhead trout fry in early June that we assume originated from this redd. However, since we believe the majority if not all of the juvenile steelhead produced from this redd will rear outside of our study area, we will not count these eggs in our estimate of egg deposition in the study area.

Both of the other female adult steelhead trout retained their radio tags and were tracked daily. One of these females was observed spawning in two separate redds in the upper canyon section, and contained 10 eggs after dying. The other female was very ripe when captured on May 15, and 28 eggs were lost during release. This female may have spawned during the next two days, but low battery power in the radio receiver and high turbid water prevented us from locating her on a redd. When she was found dead on May 31 she still contained 772 eggs.

Our best estimate is that two adult female steelhead trout spawned in Crooked River with an average egg retention of 400 eggs/female, and another female spawned just above the weir and her offspring will rear outside of our study area. The average fecundity for B-run steelhead trout observed at Dworshak National Fish Hatchery in 1994 was 6,399 eggs/female. From this information we estimate that 11,998 (2 x [6,399 - 400] = 11,998) steelhead trout eggs were successfully deposited in Crooked River in 1994.

Aerial steelhead trout redd counts were conducted by fisheries research personnel on May 14. Three redds were observed.

PIT Tag Detections

Detections of PIT-tagged smolts at lower Snake and Columbia river smolt collection facilities provide information on chinook salmon and steelhead trout smolt migration characteristics. A significant negative correlation was found between travel time to Lower Granite Dam and smolt emigration date for both chinook salmon ($r^2=0.25$; $F = 16.005$; $P<0.001$) and steelhead trout ($r^2=0.71$; $F=44.940$; $P<0.001$) (Figure 7). For any given date of emigration from Crooked River, chinook salmon smolts on average take longer to get to Lower Granite Dam than steelhead trout smolts. Mean smolt travel times with 90% Cl. to Lower Granite Dam were estimated to be 69.1 ± 3.8 days for 232 chinook salmon and 14.6 ± 3.1 days for 26 steelhead trout.

The combined PIT tag detection rates at all the lower Snake and Columbia river smolt collection facilities for smolts captured, PIT-tagged, and released at the Crooked River emigrant trap in spring 1994 were 25.3% (436 of 1,726) for chinook salmon and 44.4% (36 of 81) for age 3 and older steelhead trout. For the fall 1993 Crooked River emigrants, the detection rates were 22.0% (81 of 368) for chinook salmon and 39.1% (9 of 23) for age 2 + and older steelhead trout. Detection data for the August 1993 PIT-tagged parr were summed by strata

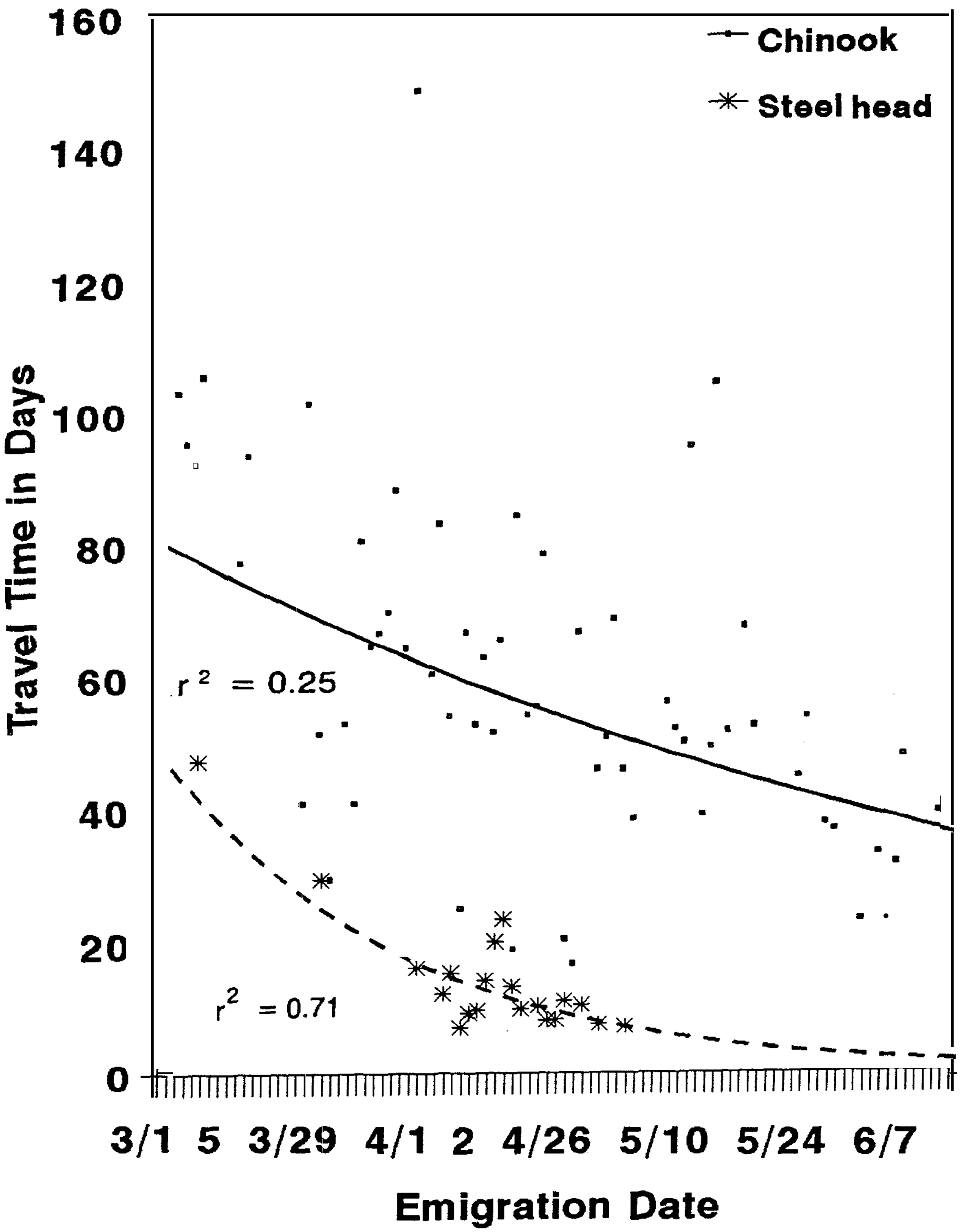

Figure 7. Spring 1994 PIT-tagged chinook salmon and steelhead trout smolt travel time (daily mean) from the Crooked River trap to Lower Granite Dam.

(Table 8). The combined detection rates for Crooked River parr PIT-tagged in August 1993 were 9.9% (198 of 1,990) for chinook salmon and 14.2% (67 of 471) for age 2 + and older steelhead trout. The combined detection rate for wild/natural smolts PIT-tagged by Buettner and Brimmer (1995) at their Clearwater River smolt trap in 1994 were 68.9% for chinook salmon and 54.0% for steelhead trout.

In 1992, we conducted a creel survey on Crooked River and estimated that 2,446 age 1 + steelhead trout parr were fishing mortalities (Kiefer and Lockhart 1994). We also estimated these 2,446 fishing mortalities represented 10.9% of the pre-fishing season age 1 + steelhead trout parr population. With the migratory year 1994 PIT tag detections at the smolt collecting facilities, we were able to estimate the impact these 2,446 fishing mortalities had on 1992 Crooked River age 1 + steelhead trout smolt production.

In spring 1994, we estimated 444 age 3 and older steelhead smolts emigrated from Crooked River. The smolt collecting facilities detected 44.4% (36 of 81) of the age 3 and older steelhead trout smolts we captured, PIT-tagged, and released at our Crooked River trap. If we assume that all 444 age 3 and older steelhead trout smolts were PIT-tagged, then we would expect 197 (444 x 0.444) to have been detected.

In fall 1993, we estimated that 253 age 2+ and older steelhead trout juveniles emigrated from Crooked River. In migratory year 1994, the smolt collecting facilities detected 39.1% (9 of 23) of the age 2 + and older steelhead trout emigrants we captured, PIT-tagged, and released at out Crooked River trap in fall 1993. If we assume that all 253 age 2+ and older steelhead trout emigrants were PIT-tagged, then we would expect 99 (253 x 0.391) to have been detected.

In spring 1993, we estimated that 381 age 2 steelhead trout emigrated from Crooked River. In migratory year 1994, the smolt collecting facilities detected 7.6% (5 of 66) of the age 2 steelhead trout emigrants we captured, PIT-tagged, and released at our Crooked River trap in spring 1993. If we assume that all 381 age 2 steelhead trout emigrants were PIT-tagged, then we would expect 29 (381 x 0.076) to have been detected. In fall 1992, we estimated that 2,787 age 1 + steelhead trout emigrated from Crooked River. In migratory year 1994, the smolt collecting facilities detected 8.1% (25 of 308) of the age 1 + steelhead trout emigrants we captured, PIT-tagged, and released at our Crooked River trap in fall 1992. If we assume that all 2,787 age 1 + steelhead trout emigrants were PIT-tagged, then we would expect 226 (2,787 x 0.081) to have been detected.

In August 1992, we PIT-tagged 1,562 age 1 + steelhead trout in Crooked River and the smolt collecting facilities detected 3.3% (52) of them. If we assume that all of the estimated 2,446 age 1 + steelhead trout fishing mortalities in 1992 had not been caught and had been PIT-tagged, then we would have expected 81 (2,446 x 0.033) to have been detected. If there had been no fishing during 1992 in Crooked River and if we would have PIT-tagged all age 1 + steelhead trout, then we would have expected 632 (197 + 99 + 29 + 226 + 81) of them to have been detected at the smolt collecting facilities. Therefore, we can estimate that angling in 1992 reduced smolt production (in 1994) from age 1 + steelhead trout from Crooked River by 12.8% (81/632 x 100).

Of the 525 Selway stock smolts PIT-tagged or detected at our emigrant trap in spring 1994, 20.4% (107) were detected at the smolt collecting facilities. Of the 36 PIT-tagged Dworshak stock detected at our emigrant trap, 52.8% (19) were detected at the smolt collecting facilities.

Table 8. Detections in 1994 at the lower Snake and Columbia river smolt collecting dams of August 1993 PIT-tagged parr from Crooked River.

Stratum [a]	Number Tagged	Number Detected	Percent Detected
	Chinook		
CR-1 & 2	613	44	7.2
CR - CAN	599	78	13.0
CR - 3 & 4	408	48	11.8
PONDS B	370	28	7.6
Totals	1,990	198	9.9
	Steelhead age 2 +		
CR - 1	101	16	15.8
CR - 2	93	14	15.1
CR - CAN	190	24	12.6
CR - 3 & 4	87	13	14.9
Totals	471	67	14.2

[a] Stratum key:

CR- 1 = Crooked River from the road bridge in the upper meadow to the forks
CR - 2 = Crooked River from the top of the canyon to the bridge in the upper meadow
CR - 3 = More natural river channel section of the lower meadow
CR - 4 = Forced meanders section of the lower meadow
CR - CAN = Canyon secl:ion
PONDS B = Connected off-channel ponds in lower meadow

Three percent (9 of 300) of the PIT-tagged Selway stock and 31.7% (148 of 467) of the PIT-tagged Dworshak stock smolt released at the Crooked River ponds were detected at the smolt collecting facilities. We assumed the ratio of the detection rate of the fish released at the ponds divided by the detection rate of the fish tagged at our trap was equal to the proportion that emigrated from Crooked River. We used this data to estimate that 60.0% (31.7%/0.528) of the Dworshak stock and 14.7% (3.0%/0.204) of the Selway stock emigrated from Crooked River in spring 1994. These two estimates are very similar to those made with a different method in the Spring 1994 Emigration Trapping section above (54.8% and 14.2% respectively).

Parr Abundance

During the first half of July 1994, we conducted snorkel counts in established study sites on Crooked River to estimate densities and abundance of chinook salmon parr and steelhead trout parr. Estimated total parr abundances with 90% confidence intervals were: 45,567 ± 12,512 age 0 chinook salmon, 4,413 ± 635 age 1 + steelhead trout, and 1,816 ± 334 age 2+ and older steelhead trout (Appendix F). We also estimated that 18,000 Selway stock and 9,000 Dworshak stock hatchery steelhead trout residuals were in Crooked River.

Chinook salmon parr densities on average and estimated total abundance were the highest we have estimated since 1989, and were within the range we observed during the period of 1986-1989 (Appendix G1). Steelhead trout age 1 + and age 2 + and older parr densities were among the lowest we have observed in Crooked River (Appendix G2).

PIT Tagging

During the first half of August, we collected and PIT-tagged representative groups of chinook salmon and steelhead trout parr. We PIT-tagged a total of 2,242 age 0 chinook salmon, 189 wild/natural steelhead trout parr, 551 residualized Selway stock steelhead trout smolts, and 336 residualized Dworshak stock steelhead trout smolts. The age composition of wild/natural steelhead trout parr PIT-tagged was: 1.0% (2) age 0, 58.0% (109) age 1 +, and 41 .O% (78) age 2+ and older. August collecting mortalities totaled 0.2% (4 of 2,524) for chinook salmon and 2.2% (4 of 183) for steelhead trout. August PIT tagging and 24-hour delayed mortalities totaled 0.1% (2 of 2,242) for chinook salmon and 0% (0 of 175) for steelhead trout. Most of the parr collected and not tagged were either too small to tag or we had already tagged enough parr in that evaluation group.

The PIT-tagged age 0 chinook salmon were divided into the following four different evaluation groups: Crooked River strata 1 and 2 (613 tagged), canyon stratum (547 tagged), Crooked River stratum 3 (298 tagged), Crooked River stratum 4 (511 tagged), and Ponds B stratum (273 tagged). We PIT-tagged only enough wild/natural age 2+ and older steelhead trout for one evaluation group.

Fall Emigration Trapping

During fall 1994, we operated a juvenile outmigrant trap on Crooked River to estimate chinook salmon and steelhead trout pre-smolt emigration. This trap was operated continuously from August 31 to November 9, 1994. We captured 6,703 chinook salmon pre-smolts with an estimated trapping efficiency of 38.3% and 47 steelhead trout juveniles with an estimated trapping efficiency of 9.3%. We estimated that 17,547 chinook salmon pre-smolts and 503 steelhead trout juveniles emigrated from Crooked River (Appendix H). Daily run estimates are shown in Figure 8. Age composition of steelhead trout emigrants based on size of trapped fish was 13% (64) age 0, 13% (64) age 1 +, and 74% (375) age 2+ and older.

The estimated percentages of the Crooked River 1994 summer parr populations that emigrated in the fall were 39% of the age 0 chinook salmon, 1% of the age 1 + steelhead trout, and 21% of the age 2+ and older steelhead trout.

Estimated Chinook Salmon Egg Deposition

In 1994, 26 (18 females) adult chinook salmon were captured at the Crooked River adult trap. All 26 adult chinook salmon were transported to the Red River Fish Hatchery holding ponds. On August 31, 10 adult chinook salmon (6 females) captured at Crooked River and held at the Red River Fish Hatchery were released back into Crooked River at the South end of the Orogrande airstrip after ripening.

This section of Crooked River was walked daily to monitor spawning and to examine carcasses for estimating average egg retention. Four females were observed on redds within the first week. When these four female carcasses were examined, we observed an average egg retention of only one egg/female. The other two females were not found until September 8. They were both pre-spawning mortalities. These two females were found approximately 1 km below the release site adjacent to the hatchery rearing ponds. These two pre-spawning mortalities were found in a section of Crooked River that was dewatered because of drought and water usage for the hatchery ponds. We do not know if these two females died and drifted down to this dewatered stretch or if they died as a result of the dewatering. Measures have been taken to insure that this dewatering does not recur. No aerial chinook salmon redd counts were conducted on Crooked River.

The average fecundity in 1994 observed at the Red River Fish Hatchery for adult chinook salmon captured at the Crooked River weir was 4,441 (George and Davenport 1994). Based on this fecundity and the observed average egg retention, potential egg deposition in Crooked River was estimated to be 17,760 ([4,441 - 1] x 4 = 17,760) (Table 9).

Survival Rates

The brood year 1993 chinook salmon egg-to-parr survival rate for Crooked River was estimated to be 18.4% (Table 10). For brood year 1989-1993, the average chinook salmon egg-to-parr survival for Crooked River was 14.5% (90% C.I. = 12.1% to 16.9%) (Table 10).

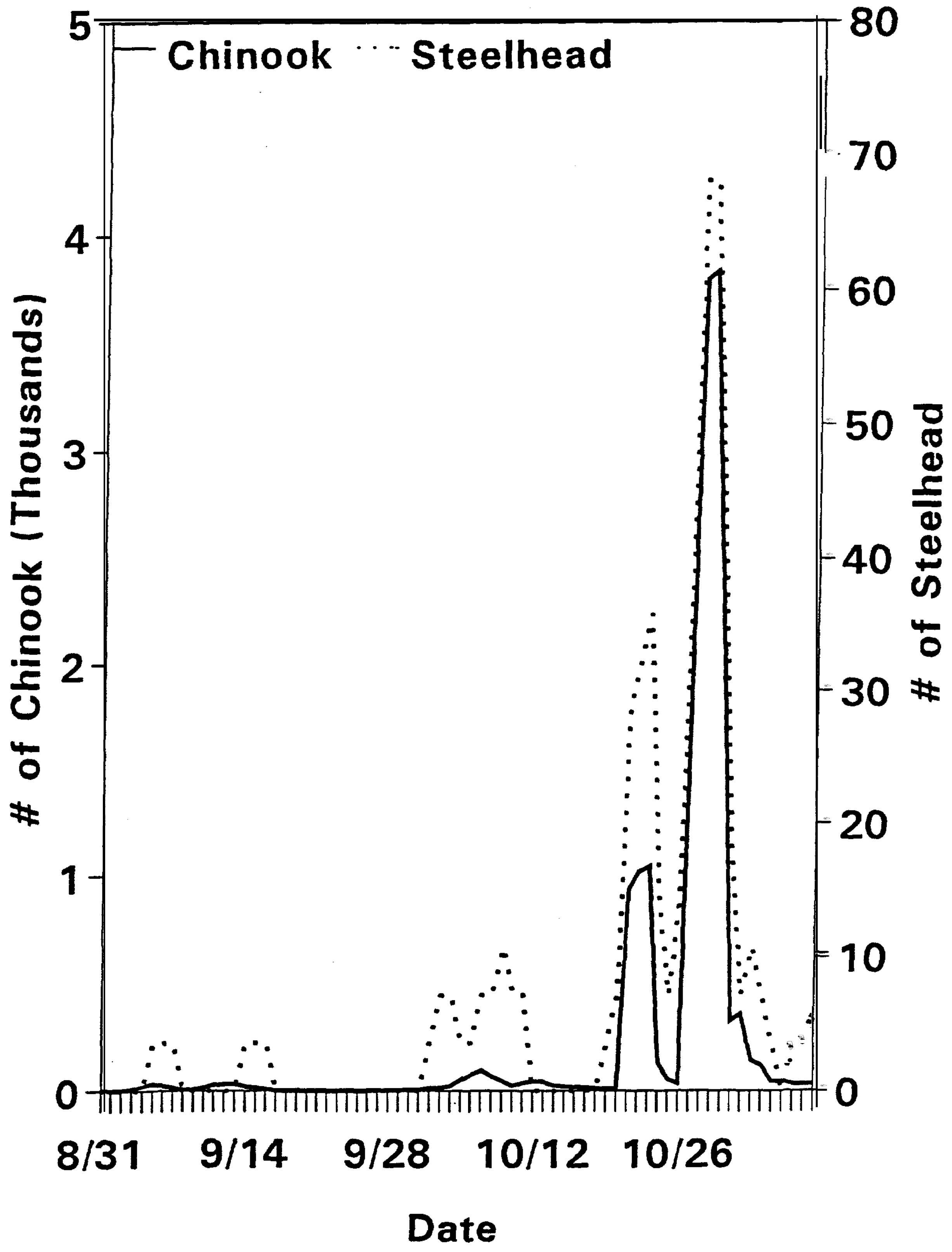

Figure 8. Fall 1994 Crooked River chinook salmon and steelhead trout daily run estimates (3-day moving average).

Table 9. Estimated chinook salmon adult escapement, redd counts, and number of eggs deposited for Crooked River, 1985 to 1994.

Brood Year	Female Escapement [a]	Trend Redd Count	Ground Redd Count	Eggs/Female [b]	Estimated Number of Eggs Deposited (x 1,000)
1985	16	10		-	67.54
1986	14	9			59.09
1987	27	17		4,010	108.27
1988	43	27	43		181.50
1989	15	3	15	4,400	66.00
1990	95		10 [c]	4,200	289.80 [d]
1991	5		4	4,400	17.60
1992	88		54	3,805	205.47
1993	75	-	54	4,766	247.85
1994	6		4	4,440	17.76

[a] Female escapement was estimated for 1985-1987 based on 1: 1 ratio of female escapement to ground counts observed in the upper Salmon River, and 43:27 ratio of ground to trend redd counts observed in 1988. Female escapement in 1988 and 1989 was assumed to equal the ground redd count. Pre-spawning mortality is included.

[b] Average number of eggs/female obtained from nearby Red River trapping facility minus average egg retention observed during ground redd counts.

[c] Redd counts were conducted before 157 adult chinook salmon (86 females) were outplanted into Crooked River from Dworshak National Fish Hatchery.

[d] We estimated 69 of the 95 (72.8%) females successfully spawned (see chinook salmon smolt production section of the discussion).

Table 10. Estimated egg-to-parr survival rates for natural chinook salmon in Crooked River, brood years 1989 to 1993.

	Brood Year				
	1989	1990	1991	1992	1993
Estimated egg deposition in thousands [a]	66.0	289.8	17.60	205.47	247.85
Estimated parr production in thousands	9,893	36,346	2,601	24,435	45,567
Egg-to-Parr survival	15.0%	12.5%	14.8%	11.9%	18.4%

[a] From Table 9.

The estimated brood year 1993 steelhead trout egg-to-age 1 + parr survival rate for Crooked River was 14.6%.

We estimated the brood year 1992 steelhead trout age 1 + to age 2 + parr survival for Crooked River to be 23.4%. This estimate was made by dividing the 1994 detection rate at the smolt collection facilities for age 1 + steelhead trout parr tagged in August 1992 (0.039 [53 of 1.59411 by the 1994 PIT tag detection rate for age 2 + steelhead trout parr tagged in August 1993 (0.142 [67 of 4711).

We estimated that parr-to-smolt (at the onset of smolt migration) overwinter survival in Crooked River was 39.1% for age 0 chinook salmon and 32.0% for age 2 + and older steelhead trout. For migration years 1989-1994, this overwinter survival estimate averaged 23.8% (90% C.I. = 13.8% to 35.4%) for chinook salmon (Table 11) and 39.1% (90% C.I. = 26.1% to 53.0%) for age 2 + and older steelhead trout (Table 12).

The estimated survival, to the head of Lower Granite Reservoir pool, for parr PIT-tagged in August 1993 was 14.4% for age 0 chinook salmon and 26.3 % for age 2 + and older steelhead trout. For migration years 1989-l 994, August parr survival to the head of Lower Granite Reservoir pool averaged 11.7% (90% C.I. = 6.8% to 17.9%) for chinook salmon (Table 11) and 27.2% (90% C.I. = 19.4% to 35.7%) for age 2 + and older steelhead trout (Table 12). For pre-smolts PIT-tagged during the fall 1993 emigration, the estimated survival to the head of Lower Granite Reservoir pool was 31.9% for age 0 chinook salmon and 72.4% for age 2 + and older steelhead trout. For smolts PIT-tagged during the spring 1994 outmigration, the estimated survival to the head of Lower Granite Reservoir pool was 36.7% for chinook salmon and 82.2% for steelhead trout. For migration years 1989-l 994, this smolt migration survival estimate to Lower Granite Reservoir pool averaged 49.8% (90% C.I. = 35.9% to 63.8%) for chinook salmon (Table 11) and 73.6% (90% C.I. = 59.4% to 85.9%) for steelhead trout (Table 12).

DISCUSSION

Smolt Production

Chinook Salmon

We estimated that chinook salmon survival from adult female escapement to successful spawner averaged 72.8% (90% C.I. = 63.7% to 81.0%) for the years we have complete data (Table 4 and Table 9). These estimates have ranged from a low of 59.3% to a high of 94.9%. The low estimate was from Crooked River in 1992. In 1992, we found evidence of illegal adult chinook salmon harvest in Crooked River that probably resulted in part of this low spawner success (Kiefer and Lockhart 1994).

To calculate egg-to-parr survival, we used a multi-stage sampling design with visual estimation methods to estimate parr production (Hankin 1986, Hankin and Reeves 1988). We assume the population estimates with this method to be minimums. We believe this method

Table 11. Crooked River chinook salmon survival rate estimates, brood years 1988 to 1993.

	Brood year					
	1988[a]	1989[b]	1990[c]	1991[d]	1992	1993
Egg-to-Parr[e]		15.0%	12.5%	14.8%	11.9%	18.4%
Overwinter	12.0%	36.2%	34.7%	13.7%	39.1%	44.2%
Parr-to-smolt at Lower Granite pool	5.7%	23.1%	15.8%	10.4%	14.4%	23.4%
Smolt migration; trap to Lower Granite pool	47.4%	63.4%	34.1%	76.0%	36.7%	53.0%

[a] Data from egg-to-parr survival from Kiefer and Forster 1991.
[b] Data from egg-to-parr survival from Kiefer and Forster 1992.
[c] Data from egg-to-parr survival from Kiefer and Lockhart 1993.
[d] Data from egg-to-parr survival from Kiefer and Lockhart 1994.
[e] Data from Table 10.

Table 12. Crooked River age 2+ and older steelhead trout survival rate estimates, migratory years 1989-1994.

	Migratory year					
	1989[a]	1990[b]	1991[c]	1992[d]	1993	1994
Overwinter	62.9%	25.2%	48.4%	48.2%	20.9%	32.0%
Parr-to-smolt at Lower Granite pool	33.5%	14.1%	39.9%	32.8%	19.2%	26.3%
Smolt migration; trap to Lower Granite pool	53.2%	55.8%	82.5%	68.1%	92.1%	82.2%

[a] Data from Kiefer and Forster 1991.
[b] Data from Kiefer and Forster 1992.
[c] Data from Kiefer and Lockhart 1993.
[d] Data from Kiefer and Lockhart 1995.

is fairly accurate under good conditions, but the population is underestimated at an increasing rate under the following conditions:

1. As stream temperatures drop below 10°C;
2. As flow increases above normal summer time levels;
3. As the percentage of small hard-to-sample habitat (tiny side channels, small tributaries, beaver ponds, etc.) increases.

Peery and Bjornn (1992) found that a high percentage of the chinook salmon fry produced from adults spawning above the Sawtooth Fish Hatchery weir emigrate out of the study area before we estimate parr production. Because of this fry emigration, we moved the area we use to estimate egg-to-parr survival to the headwaters of the Salmon River (Salmon River and tributaries above Pole Creek). For brood years 1987-l 993, chinook salmon egg-to-parr survival for the headwaters of the Salmon River averaged 25.2% (90% C.I. = 10.0% to 44.4%). For brood years 1989-l 993, chinook salmon egg-to-parr survival for Crooked River averaged 14.5% (90% C.I. = 12.1% to 16.9%).

We believe the average chinook salmon egg-to-parr survival in Crooked River is lower than in the headwaters of the Salmon River because of habitat, water quality, and/or stock of fish. We believe our estimates of chinook salmon egg-to-parr survival from the headwaters Salmon River have been so variable because of the amount of anchor ice formation. In streams such as the upper Salmon River, the amount of anchor ice will vary from year to year. We believe in years with low stream flows in the fall, low snow fall, and colder temperatures the amount of anchor ice formation will be greater.

We used two methods to estimate chinook salmon egg-to-smolt survival. The first uses comparative PIT tag detection rates at the smolt collecting facilities of fish tagged as summer parr and spring emigrating smolts to calculate a parr-to-smolt survival estimate. This parr-to-smolt survival estimate is then combined with the egg-to-parr survival estimate to calculate an egg-to-smolt survival estimate. We estimated the brood year 1987-l 992 chinook salmon egg-to-smolt survival for the headwaters of the Salmon River averaged 4.1% (90% C.I. = 2.0% to 6.9%). Chinook salmon egg-to-smolt estimate survival for Crooked River averaged 4.0% (90% C.I. = 2.3% to 6.1 %) for brood years 1989-1992.

The second method of estimating egg-to-smolt survival uses our trapping estimates of fall pre-smolt and spring smolt emigrations, and comparative PIT tag detection rates between fish we tag during these two emigrations. The assumption we make is that the ratio of PIT tag detection rates at the smolt collecting facilities of pre-smolts tagged during the fall emigration and smolts tagged during the spring emigration is an estimate of over-winter survival. We then estimate smolt production with the equation (fall emigration x [fall detection rate/spring detection rate] + spring emigration = smolt production).

Using the second method, we estimated brood year 1987-1992 upper Salmon River egg-to-smolt survival averaged 3.6% (90% C.I. = 2.6% to 4.8%), and brood year 1989-1992 Crooked River egg-to-smolt survival averaged 2.7% (90% C.I. = 1.3% to 4.5%).

We believe the lower chinook salmon egg-to-smolt survival in Crooked River is a result of the lower egg-to-parr survival in Crooked River. The emigration method of estimating egg-to-parr survival resulted in a more precise but lower estimate than the summer snorkel and parr PIT tagging method. We stated earlier that we believe our snorkel count method under estimates the true parr production. This suggests to us that there is significant chinook salmon juvenile emigration occurring during the periods we are not currently trapping.

Steelhead Trout

We have been able to estimate age 1 + to age 2 + parr survival and age 2 + parr-to-smolt survival for steelhead trout. We have been unable to accurately estimate egg-to-age 1 + parr survival for steelhead trout. The radio tagging and tracking of adult steelhead trout this past year has allowed us to estimate egg deposition. However, the adult steelhead trout escapement was so low in both study areas that it will be difficult to accurately estimate age 1 + parr production. The continued use of radio tracking and increased adult escapement would allow us to estimate of egg-to-age 1 + survival more accurately.

We have been able to estimate age 1 + to age 2 + steelhead trout survival for brood year 1986 in the upper Salmon River and brood years 1988-l 991 in Crooked River. These combined estimates averaged 24.7% (90% C.I. = 16.2% to 34.4%). These estimates were made by comparing the PIT tag detection rates at the smolt collecting facilities of parr from the same brood year that were tagged as age 1 + parr in one year and as age 2 + parr the following year. We believe this method gives us a fairly accurate estimate of steelhead trout age 1 + to age 2 + survival.

Estimates of age 2 + and older steelhead trout parr-to-smolt survival are made with the same method used for chinook salmon parr-to-smolt survival except we report them by migratory year instead of brood year. For migratory years 1988-1994 in the upper Salmon River steelhead trout age 2 + and older parr-to-smolt survival averaged 24.9% (90% C.I. = 13.4% to 38.4%). and for migratory years 1989-l 994 in Crooked River averaged 39.1% (90% C.I. = 26.1% to 53.0%). In the upper Salmon River, this survival estimate has dropped dramatically from an average of 51.4% for migratory years 1988 and 1989 to an average of 16.2% for migratory years 1990-l 994 (Table 7). This decrease in upper Salmon River steelhead trout age 2 + and older parr-to-smolt survival coincided with the discovery of whirling disease in the upper Salmon River and our observation of a high percentage of the juvenile steelhead trout with visual signs of the disease.

Carrying Capacity and Optimal Smolt Production

Chinook Salmon

We have found that outplanting Sawtooth Fish Hatchery adult chinook salmon to the low gradient meandering headwater streams of the Salmon River results in egg-to-parr survival rates similar to naturally escaping adults in this habitat. We have used natural adult chinook salmon escapement and adult outplants in this habitat to develop a good relationship between redds/hectare and parr density (Figure 9). Because of low adult returns to the upper Salmon River, we have been unwilling to outplant more adults than we estimate could fully seed the habitat, and therefore have been unable to quantify carrying capacity.

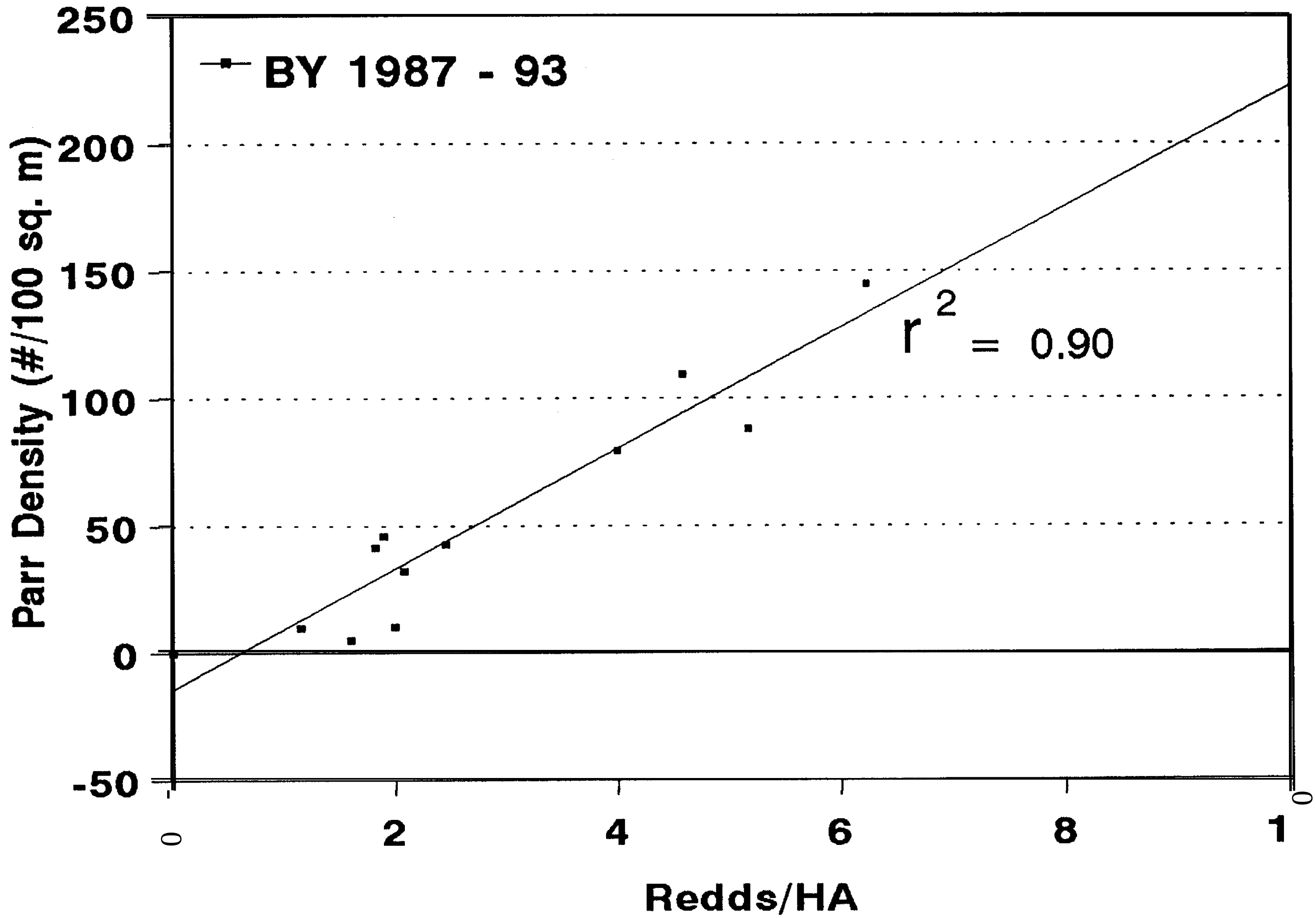

Figure 9. Relationship between chinook salmon redd density and parr density in the headwaters of the Salmon River

Determining optimal smolt production is based on the theory that at carrying capacity there may be a density-dependent reduction in smolt-to-adult survival, and optimal smolt production (producing the most returning adults) may be less than maximum smolt production. Because we have not been able to quantify carrying capacity, we have not been able to test this theory.

Steelhead Trout

By outplanting large numbers of adults into Crooked River, we have been able to measure steelhead trout carrying capacity (Figure 10). Because of the habitat degradation from dredge mining and the low productivity of the water, we believe that our measure of steelhead trout carrying capacity in Crooked River is less than carrying capacity in most of the steelhead trout rearing streams in Idaho.

To be able to determine if optimal smolt production was less than maximum smolt production, we would need several years of data when 10 to 20 females/hectare spawned and much greater smolt-to-adult survival rates than the Snake River system is experiencing currently.

Habitat Factors and Smolt Production

We have been able to answer a fair number of questions concerning the benefits of some stream rehabilitation efforts on smolt production. Research by Scully et al. (1990) found that chinook salmon egg-to-parr survival decreased if sand in the spawning areas was greater than 30%. We have observed a shift in spawning area by adult chinook salmon to cleaner gravel areas produced by habitat rehabilitation structures in Crooked River (Kiefer and Lockhart 1993). We believe in streams with more than 30% sand in spawning areas, habitat structures that collect cleaner gravel will increase smolt production.

Our research indicates that in streams degraded by dredge mining, connecting off-channel ponds to the stream will increase the parr carrying capacity, especially for chinook salmon (Kiefer and Forster 1991). We also found that in streams with low habitat complexity, complex in-stream structures can increase the carrying capacity for steelhead trout parr, but simple sill-log structures do not (Kiefer and Lockhart 1994).

We believe that the amount of anchor ice formation in spawning areas is the primary variable in chinook salmon egg-to-parr survival in high elevation streams like the upper Salmon River. We plan to determine if anchor ice formation in the upper Salmon River during the duration of this project can be estimated. If so, than we will determine if there is a correlation between anchor ice formation and chinook salmon egg-to-parr survival. If there is a relationship, habitat rehabilitation and land use management that reduces anchor ice formation will increase smolt production.

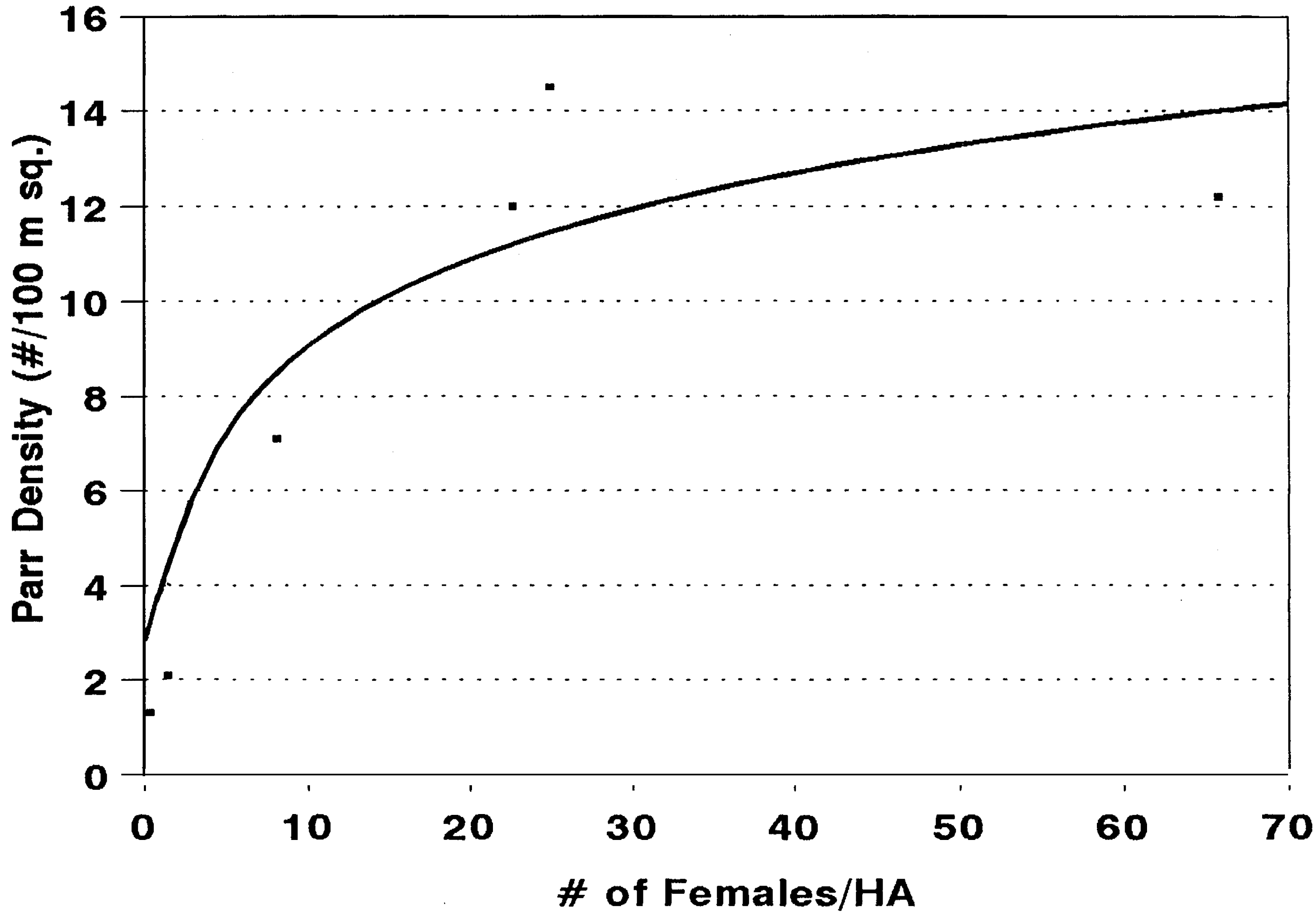

Figure 10. Crooked River steelhead trout adult escapement and resulting age 1+ parr densities (broodyears 1985, 1987, and 1990-1993).

1994 Findings

Spring Trapping

Our data and data from the Hatchery Evaluation Project indicate Dworshak National Fish Hatchery stock steelhead trout smolts released into Crooked River residualized at a higher rate than in any other Dworshak stock release site in the South Fork Clearwater River drainage. In 1994, we estimated the percentage of hatchery steelhead trout smolts that residualited in Crooked River using two independent methods and both estimates were very similar (Dworshak stock, 45.2% and 40.0%; Selway stock, 85.8% and 85.3%). The smolt collecting facilities on the lower Snake and Columbia rivers detected 31 .O% of the PIT-tagged Dworshak stock steelhead trout released into Crooked River while three other releases of Dworshak stock in the South Fork Clearwater River drainage average 63.2% detected. These three other Dworshak stock releases were not detected at significantly different rates ($\chi^2 = 2.89; 0.25 > P < 0.10$). When the Crooked River release is included with these other three releases, the detection rates of all Dworshak stock combined are significantly different ($\chi^2 = 59.21; P < 0.001$).

We believe the main reason the majority of the Selway stock residualized is that they had not reached the threshold size necessary for smoltification. From past results we found most steelhead less than 130 mm fork length in the spring will rear another year or more before smolting. Of the Selway stock steelhead released into Crooked River in 1994, 73% were less than 130 mm in fork length. We graphed the fork lengths of the Selway stock of steelhead trout released into Crooked River in 1994, those captured at our emigrant trap leaving Crooked River, and those that were PIT-tagged and detected at three smolt collecting facilities (Figure 11). Only larger fish were detected. We believe the majority of the Selway stock fish, the smaller fish, will rear another year and then smolt.

PIT Tag Detections

Detections of PIT-tagged smolts at lower Snake and Columbia river smolt collection facilities showed that chinook salmon smolts from Crooked River had the most protracted smolt migration we have ever observed. Mean chinook salmon smolt travel time from the Crooked River emigrant trap to Lower Granite Dam averaged 69.1 days (90% C.I. ± 3.1 days). This is much longer than what we have observed in any other year including the other serious drought year of 1992 (46.1 days). Of the chinook salmon smolts from Crooked River detected at Lower Granite Dam, 32% arrived after June 30 (Figure 12). We do not know why Crooked River chinook salmon smolts took so long to get to Lower Granite Dam in 1994.

Fall Emigration Trapping

We estimated a higher percentage of both age 0 chinook salmon and age 2 + and older steelhead trout emigrated in fall 1994 from Crooked River (39% and 21 %, respectively) than emigrated from upper Salmon River (7% and 5%, respectively). This is the opposite of what we have observed in the past (Kiefer and Lockhart 1993). We previously hypothesized (Kiefer

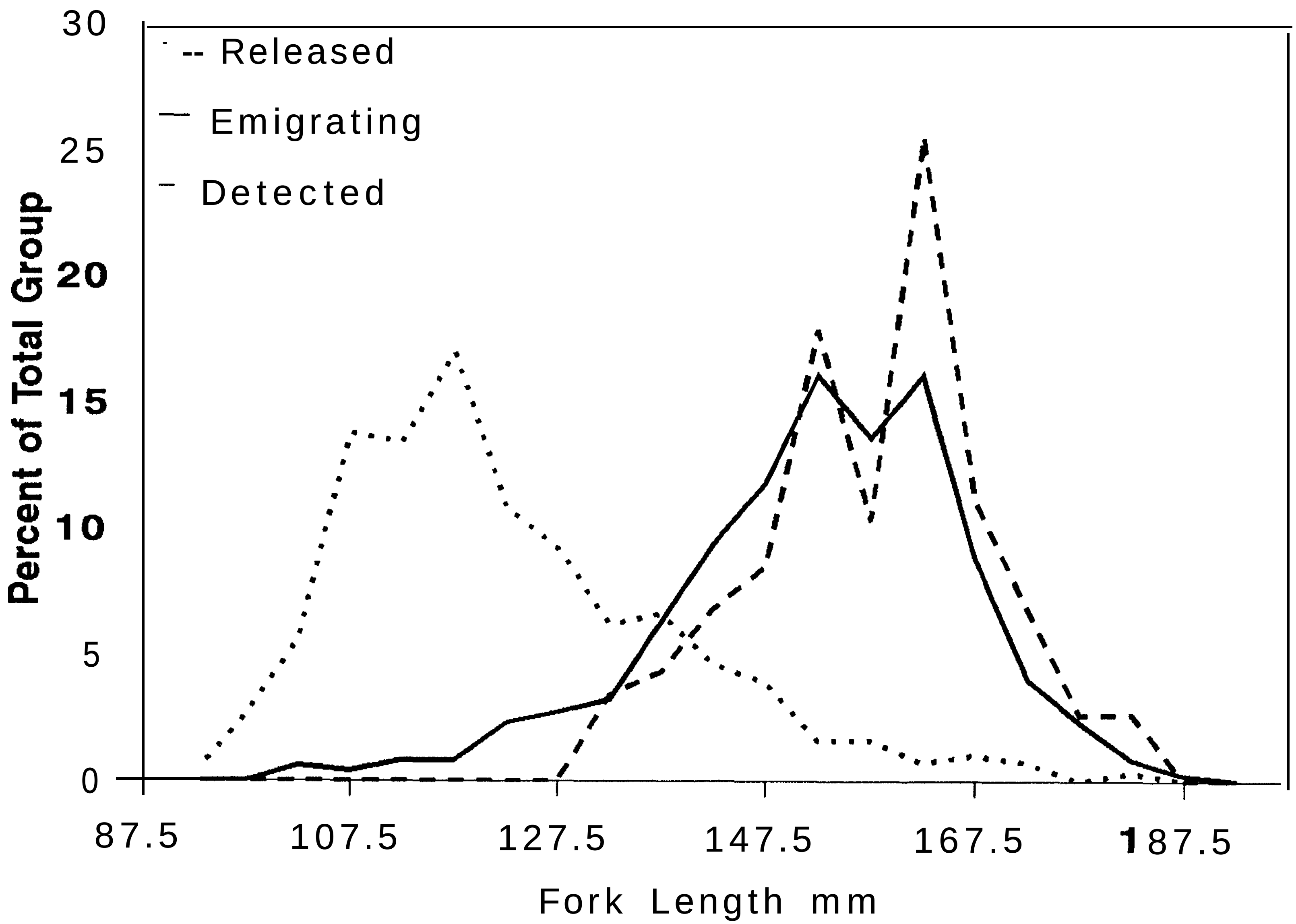

Figure 11. Length frequencies of age 1 Selway River steelhead trout released into Crooked River, emigrating from Crooked River, and detected at the dams in 1994.

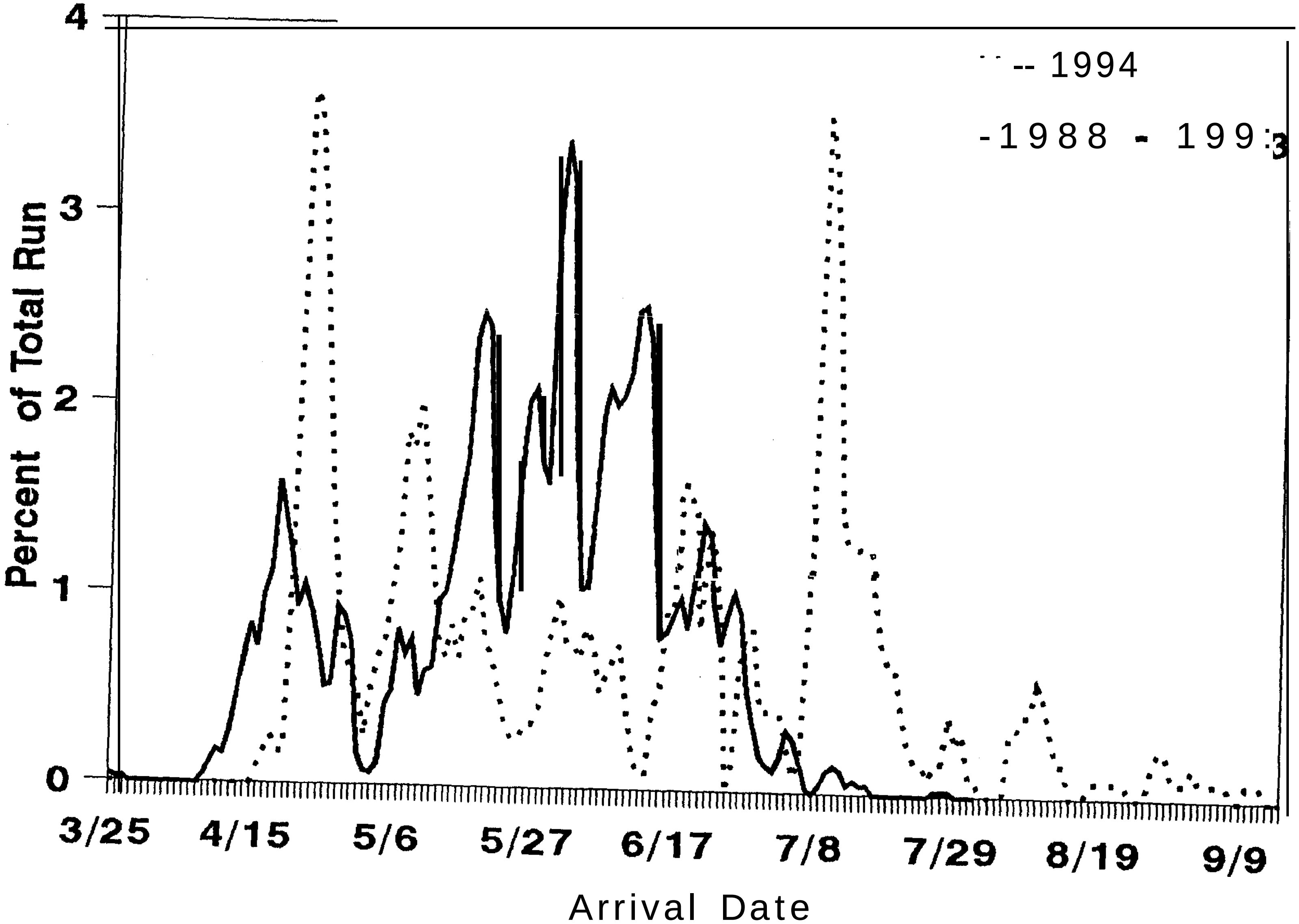

Figure 12. Crooked River PIT-tagged chinook salmon arrival time at Lower Granite Dam (3-day moving average).

and Lockhart 1993) that a higher proportion of parr populations will emigrate in the fall from higher elevation streams (e.g. upper Salmon River). We do not know why our 1994 observation was different from previous observations. We previously observed (Kiefer and Forster 1992) that the proportion of the parr populations emigrating in the fall is unrelated to density. In 1994 the density of age 0 chinook salmon in the upper Salmon River was fairly high, and we observed the smallest proportion of fall emigrants.

Survival Rates

Brood year 1993 chinook salmon egg-to-parr survival averaged 56.1% (n = 4) in the headwaters of the upper Salmon River. This is the highest chinook salmon egg-to-parr survival we have estimated (Table 5 and Table 10). We believe the main reason for this better survival was that 1993 was a relatively good water year and was followed by a mild winter. We believe these two conditions in combination are good for chinook salmon egg-to-parr survival because of the reduction in anchor ice formation.

We estimated brood year 1993 steelhead trout egg-to-age 1 + parr survival in Crooked River to be 14.6%. This estimate is within the range of what we would expect. It is possible that some of the steelhead trout we classified as naturally produced age 1 + fish were actually Selway stock. Misclassifying Selway stock as age 1 + naturally-produced steelhead trout would bias the estimate of egg-to-age 1 + survival upward.

RECOMMENDATIONS

1. We recommend hatchery steelhead trout smolts be at least 130 mm in fork length before release.

2. We recommend research to determine if PIT tag mark/recapture data or another method can be used to more accurately and precisely estimate egg-to-smolt survival than our current methodologies.

3 We recommend research be conducted to determine if anchor ice formation is having an effect on chinook salmon egg-to-parr survival.

4. We recommend only naturally-produced adult steelhead trout captured at the Sawtooth Fish Hatchery trap be released immediately upstream of the weir to spawn naturally.

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APPENDICES

Appendix A. Spring 1994 upper Salmon River trap efficiencies and emigration estimates.

Wild/Natural Chinook Salmon

Release Dates	Number Released	Number Recaptured	Trap Efficiency (%)
318 - 3/31	74	3	4.0
411 - 4/11	77	9	11.7
4/12 - 6/9	83	2	2.4

Trap efficiency estimate: x=5.5%; 90% C.I. = 0.4% to 15.7%.
Total number captured = 239; Run estimate = 4,345; 90% C.I. = 1,522 to 59,750.

Wild/Natural Steelhead Trout

Release Dates	Number Released	Number Recaptured	Trap Efficiency (%)
319 - 4/16	91	3	3.3
4/17 - 4/23	110	6	5.5
4/24 - 6/8	108	5	4.6

Trap efficiency estimate: $\bar{x}$ = 4.4%; 90% C.I. = 2.7% to 6.5%.
Total number captured = 309; Run estimate = 7,023; 90% C.I. = 4,754 to 11,444.

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We assumed trap efficiencies were the same as wild/natural chinook salmon.
Total number captured = 52; Run estimate = 945; 90% Cl. = 331 to 13,000.

Hatchery Chinook Salmon

We assumed trap efficiencies were the same as wild/natural chinook salmon.
Total number recaptured = 11906; Run estimate = 34,654; 90% C.I. = 12,476 to 476,500.

Appendix B. July 1994 upper Salmon River parr abundance estimates and confidence intervals ($\alpha = 0.10$).

Stream/Strata	Area (m^2)	Age 0 Chinook	Age 1 + Steelhead	Age 2+ Steelhead
Salmon River				
SR-3/4	403,470	32,928 ± 39,826	129 ± 150	494 ±605
SR-5/6	136,206	810 ± 1,807	15 ± 35	0
SR-7	58,934	119 ± 415	0	0
SR-8	38,269	26 ± 160	0	0
SR-9/10	51,070	17,601 ± 14,501	795 ± 530	954 ± 723
Stream Total	687,949	51,484 ± 38,811	939 ± 468	1,448 ± 827
Salmon River side channels				
SR-3/4	34,340	19,006 ± 24,006	31 ± 47	20 ± 45
SR-5/6	4,600	6 ± 30	0	0
SR-7/8	9,350	3,823 ± 5,042	43 ± 41	A - - -
Stream total	67,788	22,835 ± 24,079	74 ± 49	20 ± 45
Gold Creek	4,805	484 ± 2,897	21 ± 130	0
Huckleberry Creek	9,006	267 ± 568	4 ± 19	4 ± 19
4th of July Creek	13,335	1,381 ± 1,750	129 ± 226	73 ± 164
Champion Creek	7,471	44 ± 270	0	0
Alturas Lake Creek				
ALC-1	30,767	1 ,176 ± 1,300	6 ± 1 6	0
ALC-2	15,835	1,519 ± 982	18 ± 46	0
ALC-3	17,571	1,628 ± 987	33 ± 90	25 ± 39
ALC-4	94,550	554 ± 3,445	62 ± 383	62 ± 383
ALC-5	56,287	2,112 ± 13,162	0	0
ALC-Tri bs [a]	17,732	2,951 ± 787	62 ± 14	47 ± 134
Stream total	232,741	9,940 ± 4,569	17 ± 141	143 ± 156

Appendix B. Continued.

Stream/Strata	Area (m²)	Ane 0 Chinook	Age 1 + Steelhead	Age 2 + Steelhead
Pole Creek				
PC-1	8,658	0	0	0
PC-2	2 1,000	878 ± 2,029	149 ± 364	33 ± 49
PC-3	18,755	192 ± 1,175	0	0
Stream total	48,413	1,070 ± 1,692	149 ± 293	33 ± 39
Smiley Creek	77,613	12,876 ± 12,560	165 ± 188	321 ± 430
Beaver Creek	40,959	13,533 ± 11,982	2,107 ± 1,187	46 ± 15
Frenchman Creek				
FC-1	3,289	271 ± 369	106 ± 112	21 ± 124
FC-2	25,636	37,115 ± 43,283	34 ± 71	34 ± 71
Stream total	28,925	37,386 ± 43,283	140 ± 84	55 ± 82
Williams Creek	1,918	874 ± 5,377	0	0
Study area total	1,220,923	152,174 ± 55,332	3,907 ± 1,135	2,143 ± 869

“Yellowbelly Lake Creek and Petit Lake Creek combined.

Appendix Cl. Density (number/100 m^2) of age 0 chinook salmon parr in the upper Salmon River during July 1987 to 1994.

Stratum	1987	1988	1989	1990	1991	1992	1993	1994
Salmon River								
3,4	7.0	13.8	9.7	0.4	2.5	3.5	0.2	8.2
5,6	0.3	4.1	3.6	0.1	0.1	0.4	<0.1	0.6
7	20.3	13.3	32.9	3.2	0.1	0.1	0	0.2
8	10.3	3.9	0.6	0	0	0.1	0	<0.1
9	7.4	1.4	2.6	7.1	0	0	0	22.5
10	0.1	0	32:0	9.8	0	0	0	42.5
Salmon River, side channels								
3,4		16.0	24.6	1.0	5.2	19.1	12.2	55.4
5,6		17.9	0.6	1.2	0	0	0	0.1
7		16.1	85.7	4.7	0	1.4	0	49.7
8,9,10		6.8	1.7	0	0	0.4	0	32.1
Pole Creek								
1	25.7	2.0	0.9	0	0	0	0	0
2	2.9	4.3	11.2	0.3	0.1	0	0	4.1
3	0	0.1	55.8	12.6	5:o	0	0.3	l:o
4	0	0'	0.3	0	0	0		
5			0	0	0	0		
Alturas Lake Creek								
1 [a]	18.3	8.6	20.3	1.9	0.3	co.1	0	3.8
2 [a]				0.9	1.3	9.6		
3"				6.4	1.0	9.3		
4"	0.6	0.9	2.5	0.4	0	0.2	0	0.6
5"	0.1	0	7.7	0.1	0	0'	0	3.8
Alturas Lake Creek tributaries [b]								
1					0	4.9	2.9	16.6
Smiley Creek								
1A [c]	35.2	6.9	14.1	0.3	0	0	0.2	10.3
1B [c]				0	1.6	42.3		
2"	1.1	13.5	23.4	0	0.3	0	0	7.4
Beaver Creek								
1		2.1	0.4	0	0	0	0	11.5
2		0.4	20.8	0.1	0	0	0	45.9
Frenchman Creek								
1	0	0.6	4.0	0.4	0.3	0	1.0	8.2
2	0	41.4	109.5	10.2	87.9	79.4	4.7	144.8
Huckleberry Creek								
1					0.2	2.3	0	1.4
2					0.2			4.2
Gold Creek								
1					30.2	0	0	10.1

Appendix Cl. Continued.

Stratum	1987	1988	1989	1990	1991	1992	1993	1994
Fourth of July Creek								
1					0	4.0	0	10.4
2					0			
Champion Creek								
1					0	0	2.0	
2					0	0.6		
Williams Creek								
1 & 2					5.4	45.5		

[a] In 1992, Alturas Lake Creek stratum 1 was subdivided into three strata (1, 2, and 3). Stratum 2 was renamed stratum 4 and stratum 3 was renamed stratum 5.

[b] Alturas Lake Creek tributaries are Pettit Lake Creek and Yellowbelly Lake Creek.

[c] In 1993, Smiley Creek stratum 1 was divided into two strata (stratum 1 A and stratum 1 B).

Appendix C2. Density (number/100 m^2) of age 1 + steelhead trout parr in the upper Salmon River during July 1987 to 1994.

Stratum	1987	1988	1989	1990	1991	1992	1993	1994
Salmon River								
3,4	0.1	0.2	co.1	co.1	0.1	0.1	0	co.1
5,6	<0.1	0.1	0	0	co.1	0	co.1	co.1
7	0.7	0.4	0.2	0.3	0.5	0	0	0
8	0.4	0.4	0	0	0	0	0	0
9	8.5	2.8	2.6	4.5	0.1	0	3.6	[illegible]
10	7.3	3.5	8.4	4.5	0.1	0	3.5	21 1.2
Salmon River, side channels								
3,4		0.6	0.2	0.2	0.1	co.1	<0.1	co.1
5,6		0	0	0	0	0	0	0
7		0	0	0	0	0	0	0.4
8,9,10		0.3	0	0	0.2	0	0	0.5
Pole Creek								
1	3.0	2.1	...0.1	...0.2	0.2	0.4	1.1	
2	5.1	0	0.30.5	0.20.3	1.0	0.3	0.5	0 0.7
3	0	0			0.2	0	0	0
4	1.3	4.8	0.8	0	0	0		
5	0	0	0	0	0	0		
Alturas Lake Creek								
1 [a]	0.8	0.6	0.1	co.1	co.1	0	<0.1	<0.1
2 [a]							0.3	0.1
3 [a]			0	...		00.1	0.4	0.2
4"	0.9	0.4	0.1	<00.11	0	0	0	<0.1
5"	0	0.1			0	0	0	0
Alturas Lake Creek tributaries [b]								
1					0.2	0	0.9	0.4
Smiley Creek								
1A [c]	0.2	0	0.5	0.5	0.1	0	1.1	0.6
1B [c]							0.1	<00.21
2"	0	0.2	0.1	0	0	0		
Beaver Creek								
1		0.5	0.1	0.6	0.3	0	0	
2		0.2	0	2.0	0	0	0	15.6 0.6
Frenchman Creek								
1	1.8	0	1.5	2.6	0	0		3.2
2	0	0.1	0	0	0	0	[illegible]	0.1
Huckleberry Creek								
1					0	0	0	0.1
2					0.5			0
Gold Creek								
1					0	0	0	0.4

Appendix C2. Continued.

Stratum	1987	1988	1989	1990	1991	1992	1993	1994
Fourth of July Creek								
1					0.7	0.1	0.7	1.0
2					0.4			
Champion Creek								
1							1.1	
2						0	0	0
Williams Creek								
1 & 2						0	0.2	0

[a] In 1992, Alturas Lake Creek stratum 1 was subdivided into three strata (1, 2, and 3). Stratum 2 was renamed stratum 4 and stratum 3 was renamed stratum 5.

[b] Alturas Lake Creek tributaries are Pettit Lake Creek and Yellowbelly Lake Creek.

[c] In 1993, Smiley Creek stratum 1 was divided into two strata (stratum 1 A and stratum 1 B).

Appendix C3. Density (number/l 00 m^2) of age 2 + steelhead trout parr in the upper Salmon River during July, 1987 to 1994.

Stratum	1987	1988	1989	1990	1991	1992	1993	1994
Salmon River								
3,4	<0.1	co.1	0.1	co.1	<0.1	co.1	co.1	0.1
5,6	<0.1	co.1	0	0	0	0	0	0
7	0	0.1	0.2	0.1	0.3	0	0	0
8	0.2	0.1	0.7	0	0	0	0	0
9	2.1	0.8	0.9	0.4	0.1	0.6	0.8	2.2
10	2.4	2.9	4.4	0.5	0.2	0.2	0.7	1.7
Salmon River, side channels								
3,4		0	0.2	0	0.1	0	0.2	co.1
5,6		0	0	0	0	0	0	0
7		0	0.4	1.2	0.2	0	0	0
8,9,10		0	0	0	0’	0.1	0	0
Pole Creek								
1		0.6	0.1	0	0	0	0.4	0
2	...1.2	0	0.3	0	0.1	0	co.1	0.2
3	0.11.6	0	1.2	0.1	0	0	0	0
4	1.3	[illegible]	0.9	0.2	0	0.4		
5	0.1	05 0.7	0’	0’	0	0’		
Alturas Lake Creek								
1”	<0.1	<0.1	0.1	<0.1	0	0	co.1	*0*
2 [a]						0	0.2	<0.1
3 [a]						0	0.3	*0.1*
4 ’	0.5	0.3	0.1	0	0	0.1	0	co.1
5”	0	0.1	0.1	0.1	0	<0.1	0	0
Alturas Lake Creek tributaries [b]								
1						<0.1	0.7	0.3
Smiley Creek								
1A [c]	0.6	0	0.6	0.3	0	0	0	0.6
1B [c]						0	0	1.1
2”						0	<0.1	co.1
Beaver Creek								
1		0	0.1	0.4	0	0	0	0.4
2		<0.1	0	0.3	0	0	0	0
Frenchman Creek								
1	2.2	0.6	2.3	1.0	0	0	0.9	0.6
2	0	0.1	0.1	0	0	0	0.2	0.1
Huckleberry Creek								
1						*0*	*0*	0
2								
Gold Creek								
1						*0*	*0*	*0*

Appendix C3. Continued.

Stratum	1987	1988	1989	1990	1991	1992	1993	1994
Fourth of July Creek								
1						0.7	0.2	0.6
2								
Champion Creek								
1						0	0.2	
2						0	0	0
Williams Creek								
1 & 2							0	0

[a] In 1992, Alturas Lake Creek stratum 1 was subdivided into three strata (1, 2, and 3). Stratum 2 was renamed stratum 4 and stratum 3 was renamed stratum 5.

[b] Alturas Lake Creek tributaries are Pettit Lake Creek and Yellowbelly Lake Creek.

[c] In 1993, Smiley Creek stratum 1 was divided into two strata (stratum 1A and stratum 1 B).

Appendix D. Fall 1994 upper Salmon River trap efficiencies and emigration.

	Wild/Natural Chinook Salmon		
Dates	Number Released	Number Recaptured	Trap Efficiency (%)
8/4 - 8/8	211	17	8.1
819 - 9/6	218	26	11.9
9/7 - 10/12	217	18	8.3
10/13 - 10/30	201	24	11.9
10/31 - 11/7	224	29	12.9

Trap efficiency estimate: $\bar{x}$ = 10.5%; 90% C.I. = 8.5% to 12.8%.
Total number captured = 1 ,144; Run estimate = 10,895; 90% C.I. = 8,938 to 13,459.

	Wild/Natural Steelhead Trout		
Dates	Number Released	Number Recaptured	Trap Efficiency (%)
8/4 - 8/30	59	7	14.8
8/31 - 11/7	52	4	17.7

Trap efficiency estimate: $\bar{x}$ = 11.3; 90% C.I. = 5.9% to 18.1%.
Total number captured = 146; Run estimate = 1,292; 90% C.I. = 807 to 2,475.

Appendix E. Spring 1994 Crooked River trap efficiencies and emigration.

Wild/Natural Chinook Salmon when Flows C 3.5 m^3/s			
Release Dates	Number Released	Number Recaptured	Trap Efficiency (%)
3/18	338	176	52.1
3/19	242	147	60.7
3/20 - 4/7	284	141	49.6
4/8 - 5/3	271	128	47.2
5/4 - 6/15	275	133	48.4

Trap efficiency estimate: $\bar{x}$ = 48.6%; 90% C.I. = 45.4% to 51.7%.
Total number captured = 1,514; Run estimate = 3,115; 90% C.I. = 2,928 to 3,335.

Wild/Natural Chinook Salmon when Flows ≥ 3.5 m^3/s			
Release Dates	Number Released	Number Recaptured	Trap Efficiency (%)
4/18	39	5	12.8
4/19	34	4	11.8
4/20-21	35	5	14.3
4/22	20	7	35.0
4/23	36	6	16.7
4124-28	37	11	29.7

Trap efficiency estimate: $\bar{x}$ = 19.4%; 90% C.I. = 12.3% to 27.6%.
Total number captured = 215; Run estimate= 1,108; 90% C.I. = 779 to 1,748.

Total wild/natural Chinook salmon run estimate = 4,223; 90% C.I. = 3,707 to 5,083.

Hatchery Chinook			
Dates	Number Released	Number Recaptured	Trap Efficiency (%)
4/10	137	72	52.6
4/12	100	58	58.0
4/13	100	52	52.0
4/18	100	26	26.0
4/19	100	26	26.0

Trap efficiency estimate: $\bar{x}$ = 42.5%; 90% C.I. = 27.9% to 57.9%.
Total number captured = 79,604 run estimate = 187,304; C.I. = 137,485 to 285,319.

Appendix E. Continued.

Wild/Natural Steelhead Trout			
Dates	Number Released	Number Recaptured	Trap Efficiency (%)
3/18 - 4/5	53	8	15.1
4/6 - 4/23	54	4	7.4
4/24 - 5/3	54	12	22.2
5/4 - 5/10	53	6	11.3
5/11 - 6/1	54	6	11.1
6/2 - 6/8	60	17	28.3
6/9 - 6/12	63	12	19.0
6/13 - 6/14	37	7	18.9

Trap efficiency estimate: $\bar{x}$ = 16.2%; 90% C.I. = 11.8% to 21 .O%.
Total number captured = 429; Run estimate = 2,648; C.I. = 2,043 to 3,636.

Hatchery Steelhead Trout			
Dates	Number Released	Number Recaptured	Trap Efficiency (%)
4/30	58	8	13.8
5/1	86	17	19.8
5/2	36	14	38.9
5/3	31	14	45.2
5/4	46	15	32.6
5/5	111	30	27.0
5/6	44	7	15.9
5/7-8	29	9	23.1
5/9-12	40	5	12.5

Trap efficiency estimate: $\bar{x}$ = 24.7%; 90% Cl. = 18.0% to 32.1%.
Total number captured = 16,948; Run estimate = 68,615; C.I. = 52,797 to 94,156.

Appendix F. July 1994 Crooked River abundance estimates and confidence intervals ($\alpha = 0.10$).

Stream/Strata	Area(m^2)	Age 0 Chinook	Age 1+ Steelhead	Age 2+ Steelhead
Crooked River				
CR-4	29,779	13,682 ± 9,932	968 ± 353	422 ± 115
CR-3	26,693	4,208 ± 10,841	284 ± 277	189 ± 223
CAN	60,356	5,627 ± 7,878	803 ± 378	759 ± 421
RC-1	4,347	369 ± 843	126 ± 72	30 ± 41
RC-2	5,655	0	299 ± 15	95 ± 274
CR-2	36,352	3,761 ± 2,285	422 ± 321	67 ± 65
CR-1	53,834 [a]	11,529 ± 7,417	980 ± 452	89 ± 74
HDW	58,879	0	205 ± 175	83 ± 128
PND-A	2,386	849 ± 384	31 ± 4	2 ± 3
PND-B	18,927	5,542 ± 4,811	295 ± 310	80 ± 128
Study Area Total	297,208	45,567 ± 12,512	4,413 ± 635	1,816 ± 334

‘For 1994, stratum 1 included the Orogrande site from the Headwaters stratum.

Appendix G 1. Density (number/100m^2) of age 0 chinook salmon parr in Crooked River, August 1986 to 1994.

Stratum	1986	1987	1988	1989	1990	1991 [a]	1992	1993	1994
	Year								
Headwaters	-		<0.1	0.1	0.0		0.0		0.0
I	14.0	3.0	23.8	28.4	<0.1		0.0	1.1	21.4”
II	1.1	16.5	19.7	19.7	<0.1	-	0.6	11.2	10.4
Canyon			8.0	10.3	1.0	-	co.1	9.4	9.3
III	57.8	22.3	36.6	58.7	5.0		0.1	11.3	15.8
IV	71.8	15.4	42.2	59.0	4.7	-	0.1	3.1	45.9
Relief Creek			0.8	45.5	0.0		0.9	8.7	5.1
Ponds A [b]	62.9	3.2	65.4	206.1	0.6		0.3	53.4	35.6
Ponds B		-		268.0	8.1		0.0	31.7	29.3
Five Mile Creek				-	-		0.0	0.8	-

[a] Snorkel counts were conducted before the chinook age 0 parr probably emerged from the gravel and none were observed.

[b] In 1986-l 988 the data for connected ponds was combined and is reported here as Ponds A.

[c] For 1994, stratum 1 included the Orogrande site from the Headwaters stratum.

Appendix G2. Density (number/l00 m^2) of age 1 + and age 2 + steelhead trout parr in Crooked River, 1987 to 1994.

Stratum	1987	1988	1989	1990	1991	1992	1993	1994
	Aae 1 + steelhead trout							
Headwaters	-	1.5	0.2	0.4	*0.1*	0.1		0.4
I”	4.3	5.2	1.9	0.2	0.7	3.9	1.7	1.8
II	10.8	8.8	4.4	1.5	7.3	10.5	1.5	1.2
Canyon		11.4	4.1	1.0	4.7	8.4	0.7	1.3
III	6.1	10.3	6.5	2.5	2.8	13.3	1.2	1.1
IV	7.2	7.5	3.4	1.5	3.7	11.4	co.1	3.2
Relief Creek	-	19.1	5.2	0.2	5.3	10.1	2.1	3.9
Ponds A [b]	42.4	17.8	7.2	1.2	0.6	3.4	0.7	1.3
Ponds B			10.1	0.1	1.7	8.3	0.0	1.6
Five Mile Creek	-					0.5	7.1	
	Age 2 + steelhead trout							
Headwaters		0.2	0.3	0.1	0	co.1	-	0.1
I”	0.7	0.2	0.8	0.3	0.1	0.8	1.3	0.2
II	3.7	0.4	1.4	1.3	0.4	2.0	1.7	0.2
Canyon		1.2	2.1	1.2	0.4	2.2	1.8	1.3
III	2.8	0.5	1.8	1.4	0.1	2.4	1.4	0.7
IV	1.5	7.1	1.5	1.1	0.1	1.7	0.2	1.4
Relief Creek		0.6	1.8	0.1	0.5	2.4	0.7	1.1
Ponds A [b]	4.8	1.6	1.7	1.0	co.1	1.2	0.8	<0.1
Ponds B			2.2	0.3	0.2	0.8	0.0	0.4
Five Mile Creek	-	-	-	-	-	0.0	0.5	-

[a] For 1994, stratum 1 included the Orogrande site from the Headwaters stratum.
[b] In 1986-l 988, data for connected ponds was combined and is reported here as Ponds A.

Appendix H. Fall 1994 Crooked River trap efficiencies and emigration.

	Wild/Natural Chinook Salmon		
Dates	Number Released	Number Recaptured	Trap Efficiency (%)
8/31 - 10/8	220	73	33.2
10/9 - 10/22	209	99	47.4
10/23 - 10/24	126	56	44.4
10/25 - 10/28	137	61	44.5
10/29	101	40	39.6
10/30 - 10/31	151	50	33.1
11/1 - 11/2	129	47	36.4
11/3 - 11/8	78	22	28.2

Trap efficiency estimate: $\bar{x}$ = 38.2%; 90% C.I. = 33.7% to 42.9%.
Total number captured = 6,703; Run estimate = 17,547; 90% C.I. = 15,625 to 19,890.

	Wild/Natural Steelhead Trout		
Dates	Number Released	Number Recaptured	Trap Efficiency (%)
8/31 - 11/7	43	4	9.3

Trap efficiency estimate: $\bar{x}$ = 9.3; Unable to calculate confidence intervals.
Total number captured = 47; Run estimate = 503

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