IDAHO HABITAT & NATURAL PRODUCTION MONITORING: PART II

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Prepared by:

Russell B. Kiefer, Senior Fishery Research Biologist
Jerald N. Lockhart, Senior Fishery Technician

Fisheries Research Section
Idaho Department of Fish and Game

Prepared for:

U.S. Department of Energy
Bonneville Power Administration
Division of Fish and Wildlife
P.O. Box 3621
Portland, OR 97283-3621

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ABSTRACT

The objectives of this research project are:

1. To determine the mathematical relationship between spawning escapement, parr production, and smolt production.

2. Estimate carrying capacity and optimal smolt production.

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

Field work began in 1987 in upper Salmon River and Crooked River (South Fork Clearwater River tributary).

Major findings of the project to date are:

1. Peak arrival at Lower Granite Dam for PIT tagged natural spring chinook salmon Oncorhvnchus tshawytscha smolts from upper Salmon River and Crooked River has been later in all years studied (1988-91) than the peak of the total spring chinook salmon smolt run. This difference results from earlier arrival of hatchery smolts which greatly outnumber the wild/natural smolts. The upper Salmon River and Crooked River natural chinook salmon smolts arrive at Lower Granite Dam over an extended period. Natural spring chinook salmon smolts from each of these drainages appears to have its own unique arrival timing curve at Lower Granite Dam. Data from the National Marine Fisheries Service (NMFS) (Mathews et al. 1991) for other wild/natural spring chinook salmon stocks in the upper Snake River corroborate these findings.

2. Estimates of spring chinook salmon egg-to-parr survival rates in headwater streams of upper Salmon River from natural spawners and adult outplants averaged 20.2% (range 4.6% to 32.0%) over 4 years.

3. Estimates of upper Salmon River parr-to-smolt survival to the head of Lower Granite Pool during run year 1988-91 averaged 8.9% (range 6.4% to 12.3%) for chinook salmon and averaged 13.8% (range 3.7% to 23.3%) for age 2+ and older steelhead trout O. mykiss. Run year 1989-91 estimates of Crooked River parr-to-smolt detections to the head of Lower Granite Pool averaged 11.4% (range 5.2% to 23.2%) for chinook salmon and averaged 29.2% (range 14.1% to 39.9%) for steelhead trout age 2+ and older.

4. Estimates of upper Salmon River parr-to-smolt survival to the head of Lower Granite Pool for age 2+ and older steelhead trout have dropped from an average of 21.8% in migratory years 1988 and 1989 to an average of 5.5% in migratory years 1990 and 1991.

5. Lower Granite Dam is not very efficient at collecting sockeye/kokanee salmon O. nerka smolts.

6. In 1991, upper Salmon River sockeye/kokanee salmon smolts and late emigrating chinook salmon smolts from upper Salmon River and Crooked River

detections to the head of Lower Granite Pool were at a significantly higher rate than we have observed during any other period of this study. We believe this is a result of heavy late spring rains in 1991 which increased flows, velocities, and turbidities through the Snake River system.

7. Sawtooth Fish Hatchery adult steelhead trout released above the weir are **have not** produced a self sustaining natural population.

Other findings:

1. On **smaller** spawning streams a total ground count just after the peak spawning time can accurately estimate female chinook salmon escapement with an assumed female to redd ratio of 1:1.

2. Habitat improvement structures that trap sediment (sill logs, K-dams, rock weirs, etc.) can provide clean gravel that attracts chinook salmon spawners.

3. Chinook salmon and steelhead trout juveniles generally key on the same stimuli for emigration. Storm events are the primary stimulus in the spring. Sharp drops in water temperature, moon phase, and storm events are the primary stimuli in the fall.

4. Higher elevation (harsher winters) streams have a higher percentage of parr emigrate from the stream in the fall. Age 0 chinook salmon and age 2+ and older steelhead trout emigrating at similar proportions for a particular stream.

5. The Busterback, Alturas Lake Creek, Fourth of July Creek, Champion Creek, Fisher Creek, Williams Creek, and Beaver Creek diversions block adult chinook salmon from reaching the headwater streams of the upper Salmon River. We estimated two times greater egg-to-parr survival in these stream as compared to the Salmon River below these diversions.

6. Chinook salmon and steelhead trout juveniles from the mainstem Salmon River move during the spring into some of the tributaries with irrigation diversions.

INTRODUCTION

The goals of this project is to provide escapement objectives for wild/natural anadromous stocks that will 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, **redd** counts, and carcass surveys; (2) use snorkel counts and stratified random sampling to estimate parr abundance and egg-to-parr survival; (3) PIT tag representative groups of parr and use PIT tag detections at the smolt collecting dams to estimate Parr-to-smolt survival; and (4) use adult outplants into tributary streams to estimate carrying capacity. A realistic 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.

DESCRIPTION OF STUDY AREA

Upper Salmon River

The Salmon River originates in the Sawtooth, Smokey, and White Cloud mountains in south central Idaho (Figure 1). The upper Salmon River (USR) study site is the Salmon River drainage upstream of the Sawtooth Fish Hatchery weir. Study sections are located throughout the upper basin above 1,980 m elevation. The USR is a major production area for spring chinook salmon and to a lesser degree A-run summer steelhead trout (Petrosky and Holubetz 1985). Other salmonids include native rainbow trout, westslope cutthroat trout O. clarki lewisi, bull trout Salvelinus malma, mountain whitefish Prosopium williamsoni, and non-native brook trout S. fontinalis (Mallet 1974).

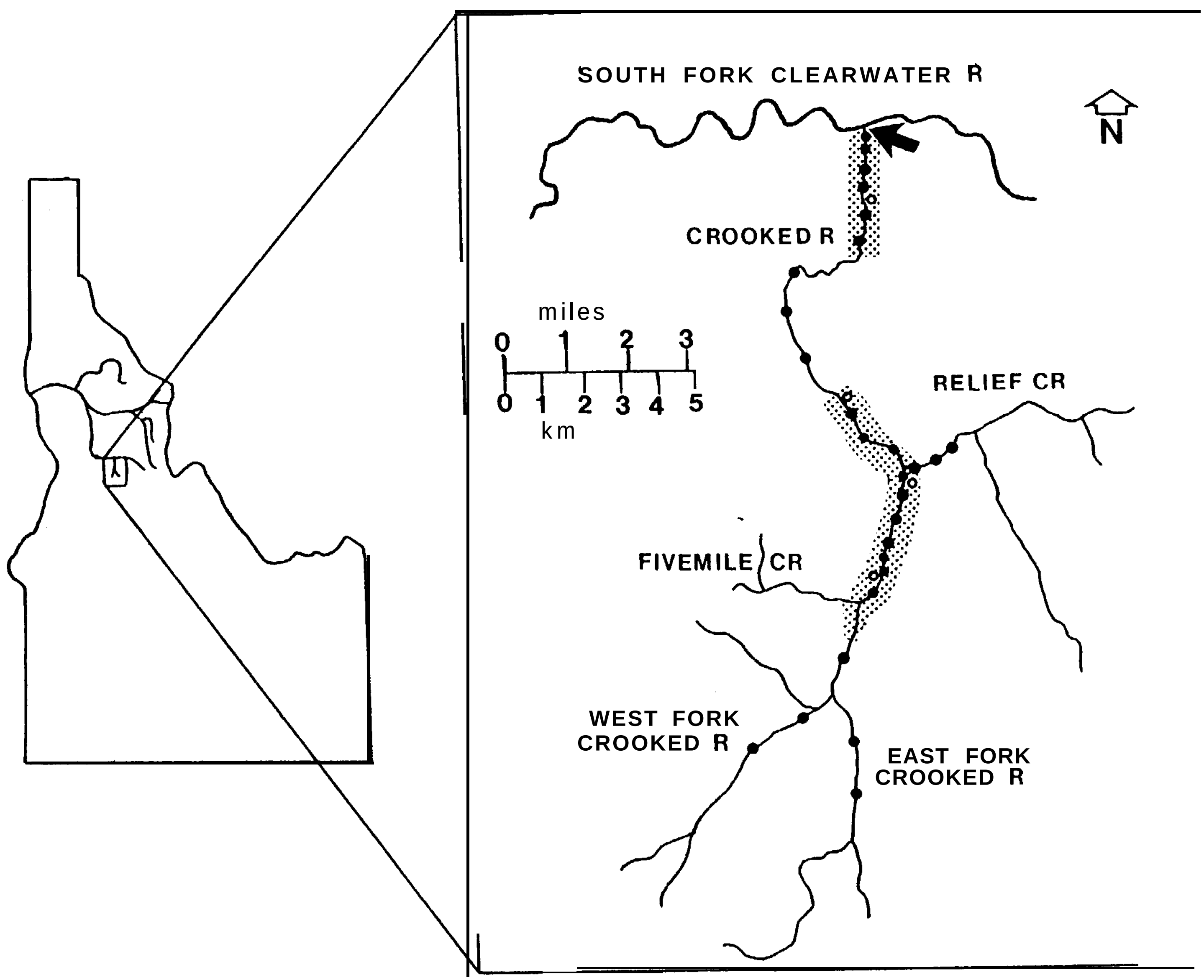

Figure 1. Locations of Crooked River, meadows degraded by dredging (shaded), and river (●) and pond (o) study section locations. Arrow indicates location of trapping facility.

Historically, sockeye/kokanee salmon existed in all moraine lakes in the Stanley Basin (Everman 1895). A remnant run of sockeye/kokanee salmon returns to Redfish Lake. The outlet of Redfish Lake enters the Salmon River 2.7 km downstream from Sawtooth Fish Hatchery. Adult sockeye/kokanee salmon have been seen in Alturas Lake Creek (K. Ball, Idaho Department of Fish and Game (IDFG), personal communication), but an irrigation diversion that completely dewatersthe creek every summer makes adult passage to the lake unlikely (Bowles and Cochnauer 1984).

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

Livestock grazing and hay production are the predominant uses of private land throughout the USR basin. In localized areas, grazing within riparian zones has degraded aquatic habitat (Petrosky and Holubetz 1985). Irrigation diversions from the river and its tributaries has reduced the production potential for chinook salmon and steelhead trout (Petrosky and Holubetz 1985). In an average flow year, the Busterback diversion between Alturas Lake Creek and Pole creek dewaters the river for approximately 3 km from July through September. The lower reaches of four major tributary creeks in the USR (Fourth of July, Champion, Fisher, and Beaver creeks) are dewatered during the summer and early fall.

In 1982, a water user along Pole Creek converted from flood irrigation to overhead sprinkler irrigation, leaving more water instream for fish passage and rearing. In 1983, a fish screen for the Pole Creek irrigation diversion was installed.

The Sawtooth Fish Hatchery was constructed to mitigate for the Lower Snake River hydroelectric dams. The hatchery program traps, spawns, and rears chinook salmon and steelhead trout for release to the Salmon rivers. The hatchery can 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 mitigation goal is to release 4.5 million steelhead trout smolts at Sawtooth Fish Hatchery. At least 33% of the adult chinook salmon and steelhead trout captured at the trap are released upstream of the hatchery to spawn naturally.

Two irrigation screen bypass pipes on the Salmon River in the Challis Valley were selected for installation of remote PIT tag monitors. The two diversions selected for these monitors were S27 on the south side at river kilometer 523, and S29 on the north side at river kilometer 525.

The Challis Valley is a fluvial valley located between semi-arid mountain ranges, 118-144 km downstream of the Sawtooth Fish Hatchery Weir. The Salmon River enters the valley as a single channel and spreads out across the valley floor in several channels and then leaves the valley as a single channel. As in the USR area, livestock grazing and hay production are the major agricultural activities in this area.

Rock weirs have been built in the Salmon River to divert water for irrigation. In the Challis Valley, all of the diversions of the Salmon River have had screens installed across them to prevent fish losses. At the screens, bypass pipes carry the fish back to the Salmon River.

Crooked River

Crooked River (CR) 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 kilometer 94 at an elevation of 1,140 m (Figure 2). The study area includes the entire CR 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 CR. Other salmonids in the CR drainage are native rainbow trout, cutthroat trout, bull trout, mountain whitefish, and non-native brook trout (Petrosky and Holubetz 1986). Measured flows on CR from March 14, 1991 through May 9, 1991 ranged from **0.44-5.68 m^3/s.** Conductivity ranges from 29-39 μmhos/cm in flowing sections and 38-51 μmhos/cm in ponds (Mann and Von Lindern 1987).

Dredge mining during the 1950s degraded habitat within the two meadow reaches of CR. Mining in the upstream meadow resulted in a mostly straight, high gradient channel. Dredge tailings in the lower meadow forces the stream into long meanders with many ponds and sloughs. Juvenile trout and salmon are often trapped in these ponds and sloughs as flows recede after spring runoff (Petrosky and Holubetz 1985).

In 1984 densities of juvenile chinook salmon and steelhead trout in the two meadow reaches were lower than typical for other Idaho streams (Petrosky and Holubetz 1985). Densities of chinook salmon parr in the pools and high velocity sections were similar to each other. The lack of a relationship between chinook salmon parr density and habitat type indicates that CR was under seeded in 1984. Habitat improvement work was initiated in 1984. A series of log structures, rock and boulder deflectors, organic debris structures, and loose rock weirs were built in the upper meadow stream section. Streambanks 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.

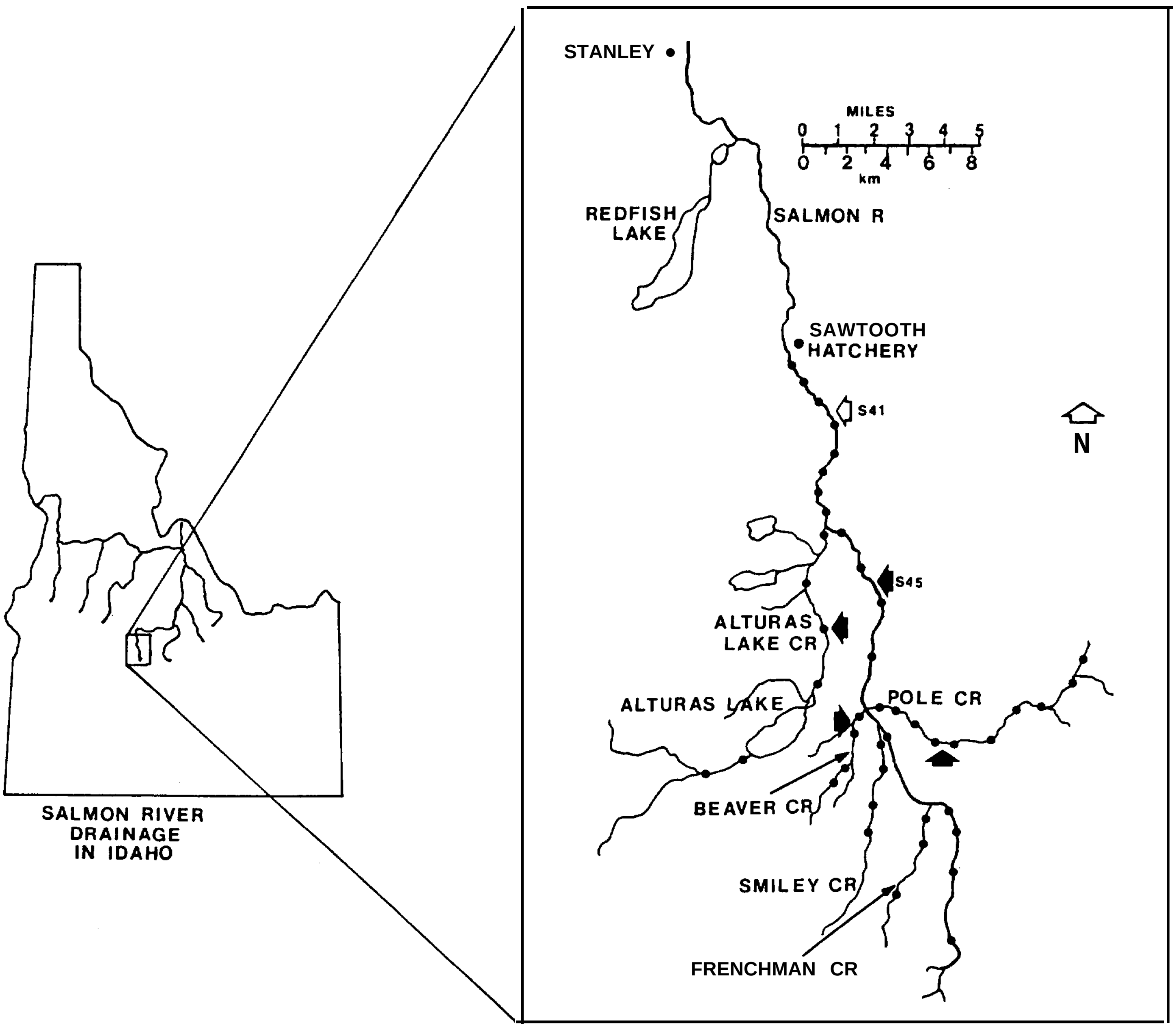

Figure 2. Location of the upper Salmon River study area and study sections (•). Solid arrow indicates major irrigation diversions.

METHODS

Physical Habitat

Physical habitat **surveys** were conducted using the Idaho ocular method (Petrosky and Holubetz 1987). For each study section, transects are established at 10 m intervals. Stream width is measured at each transect. Depth, velocity, substrate composition, embeddedness, and habitat type (ie. pool, run, riffle, pocket water, or backwater as described by Shepard [1983]) are measured or determined at the one-quarter, one-half, and three-quarter widths of each stream transect. Proportions of sand (O-O.5 cm diameter), gravel (>0.5-7.4 cm), rubble (>7.5-30.4 cm), boulder (>30.4 cm), and bedrock that comprise the substrate are estimated visually. Embeddedness (the proportion of surface area of gravel, rubble, and boulder surrounded by sand) is estimated in 5% intervals from 0% to 100%. Stream gradient is measured with a surveyor's transit and stadia rod. Stream channel type is classified according to Rosgen (1985). For future measurements and reference, all sections were flagged and photographed.

During 1991, in the USR study area, a physical habitat survey was conducted on one study site, and in the CR study area, physical habitat surveys were conducted on six study sites. Project data have been entered into the IDFG physical habitat database (Rich et al. 1992).

Adult Escapement, Redd Counts, and Potential Eqq Deposition

Adult Escapement

Escapements for adult chinook salmon and steelhead trout in the USR consisted of fish that were collected in the hatchery trap and then released directly upstream ortransportedto specific outplant sites and released to spawn naturally (Alsager 1991). Adult chinook salmon escapement into CR was obtained from CR adult collection facility records **(McGehee** 1991). Escapements for adult steelhead trout in CR were obtained from trap records (Kiefer and Forster 1991) and from known Dworshak National Fish Hatchery returns outplanted into CR (Ralph Roseberg, personal communication).

Outplants of adult chinook salmon and steelhead trout are used to estimate egg-to-Parr survival at higher seeding levels than are achieved naturally with current depressed status of adult returns. Annual seeding levels for these outplants were based upon projected adult returns and seeding levels needed for evaluation. The selection of sites for adult outplants were based on habitat suitability and the absence of natural reproduction as determined by past ground redd counts. Picket weirs are used to block adults into the outplant sites. Spawning activity in adult outplant sites were monitored on alternate days. Carcasses were measured (fork length) and cut open to confirm sex and determine completeness of spawning.

For USR in 1991, five pair of adult steelhead trout were outplanted into Pole Creek, and 13 female and 24 male adult chinook salmon were outplanted into Frenchman Creek. For CR in 1991, 15 adult chinook salmon (4 females, 9 males, and 2 jacks) were outplanted into Relief Creek, and 516 female and 260 male adult steelhead trout from Dworshak National Fish Hatchery were released into the mainstem CR.

Redd Counts

Annual Trend counts for chinook salmon redds have been conducted by regional fisheries personnel since 1957 for USR and 1974 for CR (Hassemer 1993a). The trend count for the USR was a one-day peak count by helicopter on September 5, 1991, that covered the entire probable spawning area. The trend count for CR was not conducted in 1991 because only one female and three male adult chinook salmon were released to spawn naturally and we had already observed the redd made by this female.

In addition to the aerial trend count, project personnel conducted a one-day ground redd count of the entire probable chinook salmon spawning areas of USR just after the historic peak of spawning. This ground count was conducted to better estimate potential egg deposition in our study area, to check the accuracy of aerial redd counts, and to validate redd counts as an estimator of escapement in streams without adult traps. We used the methodologies outlined in the IDFG Redd Count Manual (Hassemer 1993b in progress). The 1991 ground count on the USR was conducted on September 4, and the data is reported in Hassemer 1993a. All carcasses which were found were measured (fork length and mid-eye to hypural length) and cut open to confirm sex and completeness of spawning. No chinook salmon redd ground count of the total probable spawning area was conducted in CR in 1991. The reason we did not conduct this redd count was that only one female and three males were released above the weir, and a single redd was observed prior to the scheduled redd count.

To evaluate the spawning success and potential egg deposition of steelhead trout, helicopter redd counts were conducted in both study areas and ground counts were conducted in the upper meadow section of CR. On May 14, 1991 the helicopter count was conducted on the USR from Sawtooth Fish Hatchery weir to Frenchman Creek. In CR, the two meadow sections were counted by helicopter on May 15, 1991. The first CR steelhead ground redd count was conducted on April 30 and May 1, 1991. The second count was conducted on May 25, 1991. For the steelhead trout ground redd counts we followed the same methodologies used for chinook salmon redd counts described above.

Potential Egg Deposition

The number of female chinook salmon and steelhead trout spawning in the USR was estimated as the number of females released above the Sawtooth Fish Hatchery weir multiplied by pre-spawning survival observed at Sawtooth Fish Hatchery (0.936 for chinook salmon, 0.98 for steelhead trout; Alsager 1991). Egg deposition was estimated as the number of female spawners multiplied by the average fecundity (5,193 eggs/female for chinook salmon, 4,019 eggs/female for steelhead trout Alsager 1991).

The potential egg deposition for chinook salmon and steelhead trout in CR was estimated with different methods in 1991. Only one female chinook salmon was known to spawn naturally in CR outside of our adult outplant site in Relief Creek. Three females spawned in our Relief Creek site, and we estimated average egg retention for these females. We used the average chinook salmon fecundity (4,400 eggs/female) from the nearby Red River trapping facility (McGehee 1991), the average egg retention, and the number of spawners to estimate chinook salmon potential egg deposition in CR. The number of female steelhead trout spawning in CR was estimated as the number of females released above the weir or outplanted from Dworshak National Fish Hatchery multiplied by pre-spawning survival estimated by our carcass surveys. Egg deposition was estimated as the number of female spawners multiplied by (the average fecundity observed at Dworshak National Fish Hatchery minus the average egg retention observed during our carcass surveys). In 1991, steelhead trout fecundity for steelhead trout at Dworshak National Fish Hatchery was 7,115 eggs/female (Ralph Roseberg, personal communication).

Parr Abundance

Parr abundance by species and age class was estimated by snorkeling through established sections (Petrosky and Holubetz 1985). Surveys were conducted in 35 sections on CR during June 26-30, 1991, and in 88 sections on the USR during July 10-16, 1991. Total abundance of steelhead trout and chinook salmon parr were estimated by stratified sampling (Schaeffer et. al. 1979).

For this stratified sampling method of estimating parr abundance, we divided each study area into several strata. The decision on where to separate the strata was based upon stream habitat, with each stratum having a similar habitat type. We then randomly selected several study sections approximately 100 m in length within each stratum. Snorkel counts were then conducted in July with enough snorkelers moving upstream parallel to each other in order to see the entire stream width. Immediately after a site was snorkeled its total length and five widths were measured. From these measurements the surface area of the section snorkeled was estimated and the parr densities (number of fish of a particular species and age group per 100^2 m) were estimated. A topographical map and digitizer was used to estimate each stratum length. The total surface area of the stratum was estimated by multiplying the stratum length by the average widths of the study sections sampled. By using the sample section densities as estimates of the total stratum density and the estimate of the stratum surface area, we then estimated for each stratum the abundance of each species and age group with a mean and confidence interval. The individual stratum abundance and variance estimates for each species and age group were added and an overall estimate of abundance and a confidence interval were calculated for the entire study area. We set alpha equal to 0.10.

In addition to our regular snorkel sections, we estimated total parr abundance for the 1990 adult outplant sites. For each outplant site, we established three strata and six sections, extending from 1.0 km above to 2.0 km below the outplant site. These strata were based upon distance from the outplant site. The abundance of parr produced from these outplants was estimated in the same way as overall study area abundance.

PIT Taqqinq

Chinook salmon and steelhead trout parr were PIT tagged in their summer rearing areas in order for us to estimated Parr-to-smolt survival and smolt production. In 1991, we PIT tagged in CR during July 24 - 31, and in USR during August 7-15. Additional parr and pre-smolts were collected and PIT-tagged during the fall and spring emigration trapping operations (see emigration trapping sections).

Depending on site suitability and species available, we collected fish for PIT-tagging with a Smith-Root model 12 electrofisher or with a minnow seine. Seines were primarily used to sample pools for chinook salmon parr and the electrofisher was used to sample riffles for steelhead trout Parr. The electrofisher was operated with a 30.5 cm diameter anode ring on a 2.0 m pole, 2.4 m rat-tail cathode, voltage setting between 200 and 400 V DC, and pulse rates of 90 cycles/s when fishing primarily for chinook salmon and 30 cycles/s when fishing for steelhead trout. Conductivity in the USR drainage ranges from 37 μmhos/cm to 218 μmhos/cm (Emmett 1975). The conductivity in CR ranges from 35 μmhos/cm to 50 μmhos/cm (Mann and Von Lindern 1987).

Tagging procedures included anesthetizing fish with MS-222 and injecting PIT tags into the body cavity using a 12-gauge hypodermic needle and modified syringe. The needle was oriented anteriorly to posteriorly and inserted just off the mid-ventral line about l/4 of the distance between the tip of the pectoral fin and the pelvic girdle. Immediately after the needle entered the body cavity, it was rotated to change the angle so the bevel of the needle made contact with the inner surface of the body wall. The tag was then inserted.

After each tag was inserted, tag presence was confirmed using a hand-held detection and decoding device. Fork length was measured to the nearest 1 mm on all fish that were PIT-tagged and all fish that were too small to tag (<55 mm). On most of the fish tagged, fish weight was measured on a Port-O-Gram balance to the nearest 0.1 g. We summarized length data by location for both chinook and steelhead. Perforated 5 X 4 m plastic tote boxes were used to hold fish before tagging, during reccvery, and for 24-hour delayed mortality tests.

A hand-held PIT tag detector was used to detect and send the tag codes to a battery powered laptop computer. The laptop computer used a program supplied by NMFS to organize tag codes and associated data into tag files. Copies and print outs of these tag files were made daily.

To determine a 24 h delayed mortality and tag loss for all tagged fish, we conducted tests on chinook salmon and steelhead trout in both study areas. Fish were held 24 h in perforated plastic tote boxes in the stream sections they were tagged in. After the 24 h holding period all fish were scanned to confirm tag presence and then released. Tags were retrieved from any mortalities.

Emiqration Trapping

To better estimate smolt production and determinemigration characteristics, we monitored the fall and spring emigrations, and PIT tagged juvenile anadromous fish captured during this monitoring. We used floating scoop traps equipped with a 1.0 m wide inclined traveling screen (Midwest Fabrications Inc., Corvallis, Oregon). The USR trap was located directly below the permanent weir at Sawtooth Fish Hatchery. Water was funneled to the trap from a 3.1 m wide bay of the weir. The funnel was constructed of a picket weir with 3.8 cm spaces that acted as a louver. To evaluate the spring 1991 (chinook brood year [BY] 1989) emigration, the trap was operated continuously (except for breakdowns) from March 7 **to** May 31, 1991. To evaluate fall emigration (BY 1990) the trap was operated from August 16 to October 31, 1991.

On CR, the trap was located 0.2 km above the mouth of CR about 20 m below the adult trapping weir. A rock weir was installed in 1990 to funnel fish to the trap. To evaluate the spring emigration, the trap operated from March 14 to June 5, 1991. Ice flows, high water, and mechanical problems caused the trap to be out of operation on May 20 and May 25. On May 8 and 9, during daylight hours, the trap was shut down for repairs. Due to dangerous water conditions, the trap was repositioned on April 4, 6, and 7 and May 26 and 29. For the fall 1991 emigration, the trap was operated from August 23 to November 16. The trap was shut down for repairs on August 25, 26, 27, 29, and 30.

The total emigration estimates are the sum of each daily estimate. Daily estimates are the product of daily trap efficiencies multiplied by daily trap catches. Trap efficiencies were calculated by releasing the PIT tagged juveniles captured by the trap, 0.5 km back upstream at twilight of the day of their initial capture. Trap efficiencies were estimated for several ranges of flows in a particular emigration season. Since naturally produced steelhead trout parr numbers in the USR were low, we combined the hatchery steelhead trout parr from the fall 1990 fry outplants with the naturally produced steelhead trout parr to obtain a better estimate of steelhead trout trapping efficiency. We used the length frequency of the steelhead trout juvenile catch to estimate age composition of the total emigration.

Survival Rates

To estimate survival to the head of Lower Granite Pool we used PIT tag detections at the Lower Snake and Columbia River dams. We PIT tagged representative groups of parr from our parr population estimate areas. We then compare the detection rates of these PIT tag groups at the lower Snake River and Columbia River smolt collection facilities with the detections for fish PIT tagged at the head of Lower Granite Pool (Buettner and Nelson 1991). We assumed that both groups are detected at the dams at the same rate, and that both groups suffer the same tagging and migration mortality through Lower Granite Reservoir. To make this estimate we used the following equation:

$$PTD_{USR} \;/\; PTD_{LGR\ pool} = S_{LGR\ pool} \qquad (1)$$

Where:

PTD_{USR} = proportion of the USR PIT-tagged parr and emigrants detected at LGR dam

$PTD_{LGR\ pool}$ = proportion of LGR pool PIT-tagged smolts detected at LGR dam

$S_{LGR\ pool}$ = the proportion of the USR PIT-tagged fish surviving to head of LGR pool.

We multiply this estimate of the proportion of PIT tagged parr and emigrants surviving to the head of Lower Granite Pool by the parr population estimate to get the estimate of smolts surviving to the head of Lower Granite Pool.

Delaved Mortality Study

We initiated a two-month study to asses the delayed mortality of PIT tagged natural chinook salmon parr in a natural stream environment. On August 14, 1991, a 200 m section of a side channel of the Salmon River was screened to prevent fish movement. The stream section was seined and electrofished and 412 chinook salmon parr collected. Two hundred forty-two of these chinook salmon were PIT tagged and upper caudal clipped. The remaining 170 were lower caudal clipped. All 412 were held for 24-h mortality test and returned to the screened stream section. Before the fish were returned to the stream, a snorkel count was conducted and an additional 275 chinook salmon parr were counted in the section. On October 30, 1991, the side channel was electrofished three times to determine survival among groups, and 298 chinook salmon pre-smolts were collected.

Remote Monitors

During fall 1991, we conducted a pilot study to determine the feasibility of using remote PIT tag monitors on irrigation diversion screen bypass pipes. The hypothesized utility of these remote PIT tag monitors is that they can help determine where the fall emigrants from USR are overwintering and USR smolt migration and survival rates. On August 29, 1991 (for S29) and September 3, 1991 (for S27), in the Challis, Idaho area, PIT tag remote monitors were installed on two irrigation diversion screen bypass pipes. The monitors consist of two parts. One part is a metal housing unit with a 1.2 m long 10 cm diameter PVC pipe running through it. Surrounding the pipe are detector loops and exciter cards. The other part is a housing unit that contains a PIT tag recorder, a computer to store the data, and a 12 volt battery to provide 24 hours of operation. The battery was changed on a daily basis.

When a PIT tagged fish is detected by the monitor, the tagcode, date, and time is recorded on a daily computer file.

Bypass monitor efficiencies were tested by attaching PIT tags to floating material and passing them through the bypass pipes. In addition, PIT tagged fish were released into the Salmon River above the diversions and in each diversion.

The monitors were operated until the irrigation diversions were closed for the winter season (October 13, 1991 for 529 and October 25, 1991 for S27).

RESULTS

Upper Salmon River

Physical Habitat

Physical habitat data for 1991 have been entered into the IDFG physical habitat data base. The management of this data base is reported in the Idaho Habitat Evaluation for Off-Site Mitigation Record 1991 annual report (Rich et al. 1993 in progress).

Adult Escapement, Redd Counts, and Egg Deposition

In 1991, 201 (81 females) of the 498 adult chinook salmon captured at the Sawtooth Fish Hatchery adult trap were released above the weir to spawn naturally (Table 1). In addition, 37 (13 females) adult chinook salmon were transported to the Frenchman Creek outplant site.

A total of 57 chinook salmon redds were observed by ground counts, and 46 by helicopter counts in the entire probable natural spawning areas (Table 1). An additional, 10 redds were counted from the ground in our supplementation section which was not counted from the air. In 1991, 81 (10 females) of the 261 adult steelhead returning to Sawtooth Fish Hatchery weir were released above the weir to spawn naturally (Table 2). On May 14, 1991, 15 steelhead trout redds were observed from a helicopter during counts on USR from the Sawtooth Fish Hatchery Weir to Pole Creek. In addition, five pair of the adults were outplanted into upper Pole Creek. Upper Pole Creek is not counted during the helicopter redd count.

In the Pole Creek adult steelhead trout outplant section, we observed two redds during our ground counts. We found pieces of adult steelhead trout carcasses associated with bear sign, but not complete female carcasses to check for egg retention.

Table 1. Adult escapement, redd counts, and estimate of eggs deposited (in thousands) for Upper Salmon River chinook salmon, BY 1986-91.

	Brood Year					
	1986	1987	1988	1989	1990	1991
Total escapement	876	506	552	470[b]	615	238
Female escapement	248	252	275	73[b]	167[c]	94
Helicopter redd count	105	124	76	52	60	46
Ground redd count			261	123	100	67
Eggs Per female[a]	5,156	5,399	5,653	5,456	4,501	5,192
Estimated eggs deposited	1,278.7	1,360.5	1,554.5	671.1	450.1	347.9

[a] Number is average eggs/female observed at Sawtooth Fish Hatchery.
[b] Portions of the Sawtooth Fish Hatchery weir were pulled due to high water and uncounted fish probably passed the weir.
[c] Chinook escapement above Sawtooth Fish Hatchery was reduced by at least 65 fish due to rotenone kill.

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

TABLE_1.91

Table 2. Adult steelhead trout escapement, redd counts, and estimate of eggs deposited (in thousands) for Upper Salmon River, BY 1986-91.

	Brood Year					
	1986	1987	1988	1989	1990	1991
Total escapement	1,956	979	635	378	528	91
Female escapement	322	383	136	157	219	15
Helicopter redd counts; mainstream					56	15
Ground redd counts; tributaries					4	2
Eggs Per female	4,468	4,854	5,069	5,637	4,734	4,019
Estimated eggs deposited	1,438.7	1,859.0	689.3	885.0	1,036.7	60.3

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

TABLE-2.91

Potential egg depositions in USR for BY 1991 for adults released above the hatchery weir to spawn naturally were, 347,900 chinook salmon eggs and 60,300 steelhead trout eggs. In addition, we estimated 51,920 chinook salmon eggs were deposited in our adult outplant study sites.

Adult Outplants

In 1991, a total of 37 (13 female) adult chinook salmon, and 5 pair adult steelhead trout were outplanted into the USR (Table 3 & 4) (Alsager 1991).

Estimated abundance of chinook salmon parr produced from the 40 female adult chinook salmon outplanted in 1990 was 18,214 + 18,582 (a = 0.05).

Parr Abundance

Estimates for total parr abundance from snorkel counts in the USR during summer 1991 were: 30,589 i 18,894 (a = 0.05) age 0 chinook salmon; 1,359 f 475 age l+ steelhead trout; and 703 f 604 age 2+ steelhead trout. The age 0 chinook salmon population estimate was the second lowest observed since we began intensive evaluation in 1987 (Table 5). Densities of both age l+ and 2+ steelhead trout were among the lowest observed by this project (Tables 6 and 7), and the population estimates for these steelhead trout age groups were both the lowest calculated.

PIT Tagging

We PIT-tagged 1,996 chinook salmon parr and 435 steelhead trout parr in USR during August 1991 (Table 8). These numbers were below our goals of 2,500 chinook salmon and 900 steelhead trout, and reflects the low densities of Parr. During August, we also PIT tagged 100 hatchery steelhead trout parr that were from the 1990 fall parr outplants. Collecting, tagging, and 24-hour delayed mortalities for August PIT tagging totaled 0.7% for chinook trout and 1.6% for steelhead trout Parr.

In addition to our August PIT tagging we also tagged and released 405 chinook salmon parr of unknown origin, 97 hatchery steelhead trout Parr, and 20 natural steelhead trout parr for efficiency tests on our remote PIT tag monitors in Challis. During October, to complete our delayed mortality study we also PIT tagged 451 natural chinook salmon Parr, 51 natural steelhead trout Parr, and 16 hatchery steelhead trout Parr.

In general, the chinook salmon parr resulting from adult outplants were smaller than chinook salmon parr from natural spawners (Table 8).

Table 3. Upper Salmon River chinook salmon supplementation, summary by BY 1986-91.

	Brood Year					
	1986	1987	1988	1989	1990	1991
Adult females	0	6	30	9	40	13
Eyed Eggs	0	28,000	56,530	0	0	0
Fry	0	48,000	326,000	0	0	0
Fall Parr	0	43,000	0	2,000	0	

Table 4. Upper Salmon River steelhead trout supplementation in thousands (except for adults), summary by BY 1986-91.

	Brood Year					
	1986	1987	1988	1989	1990	1991
Adult Females	1,055	0	83	0	114	5
Fry	832.4	678.6	537.7	361.0	0	0
Fall parr	0	0	0	0	311.1	0

Table 5. Density (fish/100 m^2) of age 0 chinook salmon in the upper Salmon River during July, 1987 to 1991.

Stratum	1987	1988	1989	1990	1991
Salmon River					
3,4	7.0	13.8	9.7	0.4	2.5
5,6	0.3	4.1	3.6	0.1	0.1
7	20.3	13.3	32.9	3.2	0.1
8	10.3	3.9	0.6	0	0
9	7.4	1.4	2.6	7.1	0
10	0.1	0	32.0	9.8	0
Salmon River side channels					
3,4		16.0	24.6	1.0	5.2
5,6		17.9	0.6	1.2	0
7		16.1	85.7	4.7	0
8,9,io		6.8	1.7	0	0
Pole Creek					
1	25.7	2.0	0.9	0	0
2	2.9	4.3	11.2	0.3	0.1
3	0	0.1	55.8	12.6	5.0
4	0	0	0.3	0	0
5			0	0	0
Alturas Lake Creek					
1	18.3	8.6	20.3	1.9	0.3
2	0.6	0.9	2.5	0.4	0
3	0.1	0	7.7	0.1	0
Smiley Creek					
1	35.2	6.9	14.1	0.3	0
2	1.1	13.5	23.4	0	0.3
Beaver Creek					
1		2.1	0.4	0	0
2-	0.4	20.8	0.1	0	
Frenchman Creek					
1	0	0.6	4.0	0.4	0.3
2	0	41.4	109.5	10.2	87.9
Huckleberry Creek					
1					0.2
2					0.2
Gold Creek					
1					30.2
4th of July Creek					
1					O
2					O
Yellowbelly Creek					
1					O
Pettit Lake Creek					
1					O
Champion Creek					
1					O

TABLE-5.91

Table 6. Density (fish/100m²) of age 1+ steelhead trout parr in the upper Salmon River during July, 1987 to 1991.

Stratum	1987	1988	1989	1990	1991
Salmon River					
3, 4	0.1	0.2	<0.1	co.1	0.1
5, 6	co.1	0.1	0	0	<0.1
7	0.7	0.4	0.2	0.3	0.5
8	0.4	0.4	0	0	0
9	a.5	2.8	2.6	4.5	0.1
10	7.3	3.5	8.4	4.5	0.1
Salmon River side channels					
3, 4		0.6	0.2	0.2	0.1
5, 6		0	0	0	0
7		0	0	0	0
8, 9, 10		0.3	0	0	0.2
Pole Creek					
1	3.0	2.1	0.1	0.2	0.2
2	5.1	0	0.5	0.3	1.0
3	0	0	0.3	0.2	0.2
4	1.3	4.8	0.8	0	0
5	0	0	0	0	0
Alturas Lake Creek					
1	0.8	0.6	0.1	<0.1	co.1
2	0.9	0.4	0	<0.1	0
3	0	0.1	0.1	0.1	0
Smiley Creek					
1	0.2	0	0.5	0.5	0.1
2	0	0.2	0.1	0	0
Beaver Creek					
1		0.5	0.1	0.6	0.3
2		0.2	0	2.0	0
Frenchman Creek					
1	1.8	0	1.5	2.6	0
2	0	0.1	0	0	0
Huckleberry Creek					
1					0
2					0.5
Gold Creek					
1					0
4th of July Creek					
1					0.7
2					0.4
Yellowbelly Creek					
1					0.1
Petit Lake Creek					
1					0.4
Champion Creek					
1					0

TABLE_6.91

Table 7. Density (fish/100 m^2) of age 2+ steelhead trout parr in the upper Salmon River during July, 1987 to 1991.

Stratum	1987	1988	1989	1990	1991
Salmon River					
3, 4	<0.1	co.1	0.1	<0.1	<0.1
5, 6	<0.1	<0.1	0	0	0
7	0	0.1	0.2	0.1	0.3
8	0.2	0.1	0.7	0	0
9	2.1	0.8	0.9	0.4	0.1
10	2.4	2.9	4.4	0.5	0.2
Salmon River side channels					
3, 4		0	0.2	0	0.1
5, 6		0	0	0	0
7		0	0.4	1.2	0.2
8, 9, 10		0	0	0	0.1
Pole Creek					
1	1.2	0.6	0.1	0	0
2	1.6	0	0.3	0	0.1
3	0.1	0	1.2	0.1	0
4	1.3	0.5	0.9	0.2	0
5	0.1	0.7	0	0	0
Alturas Lake Creek					
1	<0.1	co.1	0.1	<0.1	0
2	0.5	0.3	0.1	0	0
3	0	0.1	0.1	0.1	0
Smiley Creek					
1	0.6	0	0.6	0.3	0
2	<0.1	co.1	<0.1	0.1	0
Beaver Creek					
1		0	0.1	0.4	0
2		co.1	0	0.3	0
Frenchman Creek					
1	2.2	0.6	2.3	1.0	0
2	0	0.1	0.1	0	0
Huckleberry Creek					
1					0.2
2					0.3
Gold Creek					
1					0
2					0
4th of July Creek					
1					0.2
2					0
Yellowbelly Creek					
1					0.4
Petit Lake Creek					
1					0.3
Champion Creek					
1					0

TABLE_7.91

Table 8. Mean fork lengths (mm) of PIT tagged parr from upper Salmon River, August 1991.

Tag Site	Chinook outplant method	Number chinook measured	Chinook average length	Number steelhead measured	Steelhead average length
SALR-3HSC	Natural	242	75	33	82
SALR-3SA	Natural	170	73	8	100
SALR-3BRB	Natural	353	79	5	99
SALR-4BRB	Natural	295	79	20	119
SALR-9	Natural	3	70	62	138
SALR-10	Natural	0	0	40	168
HUCKLC	Natural	183	72	18	139
4JULYC	Natural	16	80	206	109
ALTULC	Natural	155	76	2	176
POLEC	Natural	6	69	40	154
FRENCC	Adult	573	60	1	126
Total	Adult	573	60	1	
Total	Natural	1,423	75	434	
Grand Total		1,996	73	435	122

TABLE_8.91

The delayed mortality study we conducted from August to October showed no difference of PIT tagged chinook salmon parr than fin clipped chinook salmon Parr. Of the 242 chinook salmon parr we PIT tagged, we recaptured 57 (23.6%), and of the 170 lower caudal clipped chinook salmon Parr, we recaptured 34 (20%). One of the 57 PIT tagged fish had a broken tag in it that was no longer working. We found marked fish outside of our delayed mortality study section indicating our weirs did not block parr movement. The comparison between marked and un-handled chinook salmon parr portion of the study was compromised.

Spring 1991 Emigration Trapping

We captured 434 chinook salmon smolts with an estimated overall trapping efficiency of 16.3%, and 164 steelhead trout juveniles with an overall estimated trapping efficiency of 6.3% during spring 1991. We estimated total spring 1991 USR emigrations of 2,663 chinook salmon smolts and 2,603 steelhead trout juveniles. We also captured 149 emigrating sockeye/kokanee smolts juveniles, presumably from Alturas Lake (Figure 3). We assumed that these fish were captured by our trap with the same trap efficiency as chinook salmon smolts during this period (16.3%), and estimated a total emigration of 914.

Estimated age composition of steelhead trout emigrants was 53.7% (1,398) age 1, 11.7% (305) age 2, and 34.6% (901) age 3 and older. Using summer 1990 parr abundance estimates (Kiefer and Forster 1991), we estimated that 18.7% of the chinook salmon Parr, 7.4% of age l+ steelhead trout Parr, and 68.7% of age 2+ and older steelhead trout parr emigrated in spring 1991.

Fall 1991 Emigration Trapping

We captured 806 chinook salmon parr with an overall trapping efficiency of 10.4%, and 58 natural steelhead trout with an overall trapping efficiency of 14.1% during fall 1991. We estimated total fall 1991 USR emigrations of 7,750 chinook salmon parr and 411 steelhead trout Parr. Estimated age composition of steelhead trout emigrants were 21% (86) age 0, 7% (29) age l+, and 72% (296) age 2+ and older. The estimated percentages of summer parr populations that emigrated in the fall were 25.3% for chinook salmon, 2.1% for age l+ steelhead trout, and 42.1% age 2+ steelhead trout. In fall 1991, both chinook salmon and steelhead trout parr peak emigrations were similar (Figure 4).

During fall 1931, we also captured and PIT tagged 41 adipose fin-clipped hatchery steelhead trout parr from the outplant of 304,907 age 0 parr released into the USR on October 5, 10, and 17, 1990. We estimated that 291 of these hatchery steelhead trout parr emigrated in fall 1991. Thus, 41% of the fall 1991 steelhead trout age 2+ and older emigrants were hatchery fish.

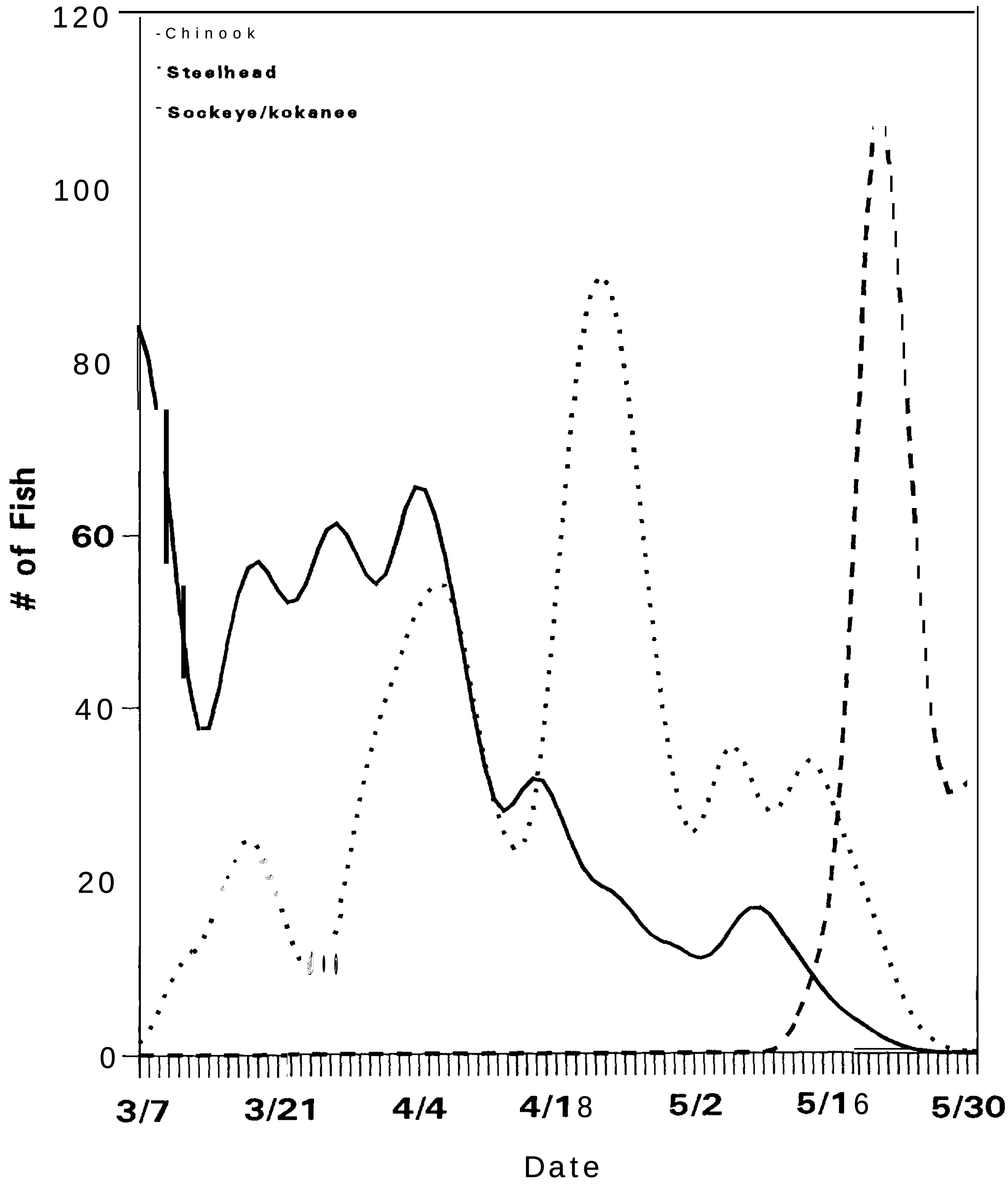

Figure 3. Spring 1991 upper Salmon River chinook salmon, steelhead trout, and sockeye/kokanee salmon emigration timing (3-day moving average).

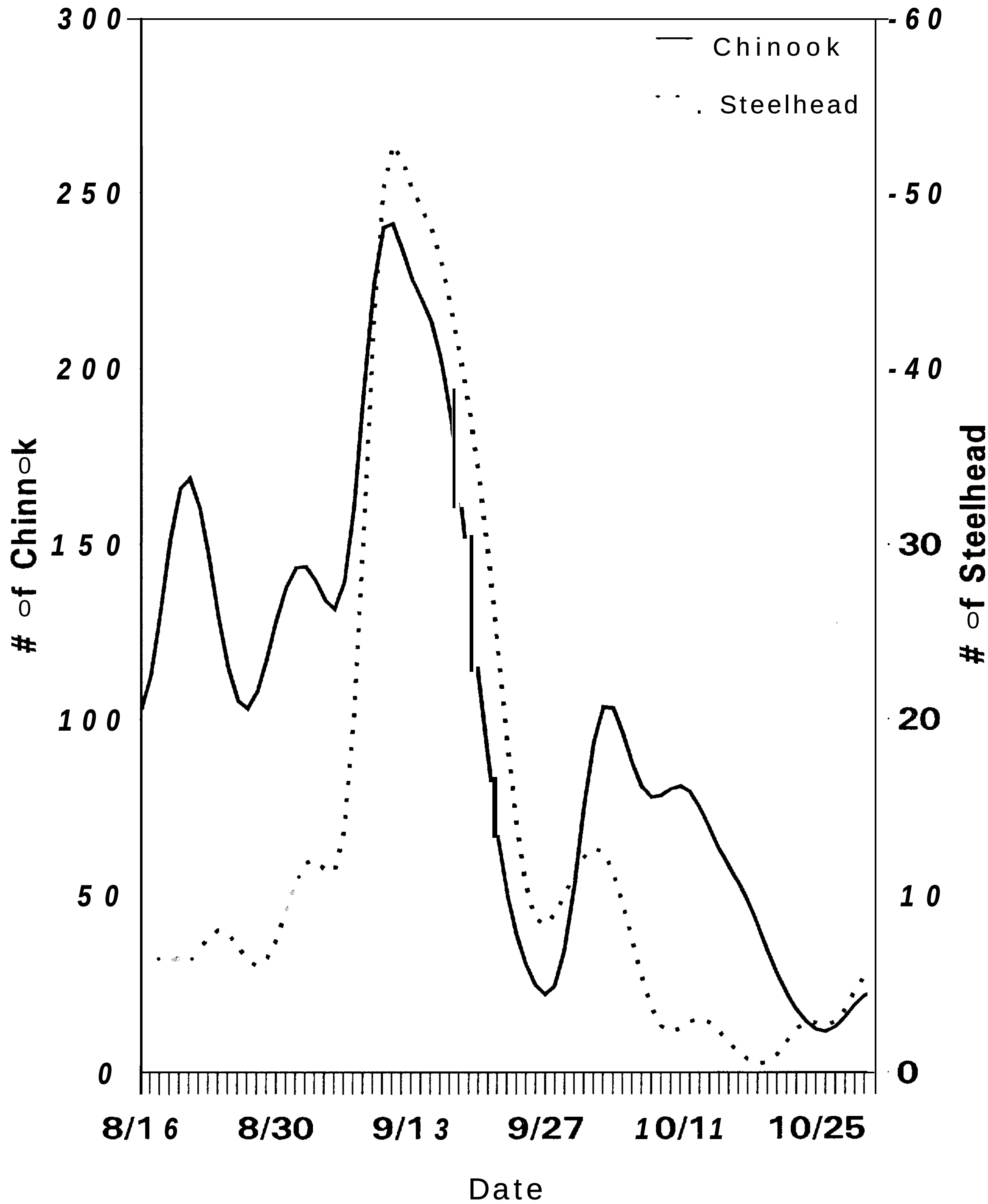

Figure 4. Fall 1991 upper Salmon River chinook salmon and steelhead trout emigration timing (3-day moving average).

Remote PIT Tag Monitors

On October 9, 1991, 524 fish (407 naturally produced chinook salmon, 97 hatchery chinook salmon, and 20 naturally produced steelhead trout) were collected with seines and PIT tagged from the two diversion canals in which we had installed the remote monitors. One hundred five fish (79 naturally produced chinook salmon, 20 hatchery chinook salmon, and 6 naturally produced steelhead trout), were released into the south side diversion canal (S27). One hundred seven fish (77 naturally produced chinook salmon, 26 hatchery chinook salmon, and 4 naturally produced steelhead trout), were released into the north side diversion canal (S29). The remaining three hundred twelve fish (251 naturally produced chinook salmon, 51 hatchery chinook salmon, and 10 steelheadtrout) were released into the Salmon River upstream of the monitors.

The monitor in the North side irrigation diversion (S29) detected 62% (66 of 107) PIT tagged fish released into that diversion. The South side monitor (527) was out of operation during a period of time that we would have expected a significant proportion of the efficiency test fish to move through the bypass, and we were unable to directly estimate the efficiency of this monitor. Both monitors had detected similar proportions of the tagged fish released into their respective canals (48% for S27 and 53% for S29) during the period of time after the efficiency test fish were released and before the S27 monitor was shorted out.

We inadvertently released the in-river test group below the intakes to the upper (S29) diversion, and none of these fish were detected by this monitor. Twenty-two of the 312 PIT tagged fish from the in-river release group were detected by the S27 monitor while it was working. Nineteen of the 70 PIT tagged fish (27%) detected by the upstream (S29) monitor while both monitors were operating were also detected by the downstream (527) monitor.

The monitors detected six chinook salmon and four steelhead trout parr that were originally captured and PIT tagged at our USR emigrant trap during fall 1991. Two of the six chinook salmon that were detected were originally tagged at our USR trap before September 1, and they took an average of 56 d to get to Challis. The four chinook salmon tagged at our USR trap after September 1 took and average of 4.25 d to get to Challis. The four steelhead trout parr took an average of 7.75 d to get to Challis. On September 19, 1991 Sawtooth Fish Hatchery made a release 1,500 PIT tagged chinook salmon pre-smolts, and three (0.2%) were detected by our monitors in Challis. These three hatchery chinook salmon took an average of 23.3 d to get to Challis. In addition, these monitors detected 14 chinook out of a total release of 976 (1.4%) originally tagged and released during August 1991 in the East Fork Salmon River drainage (Steve Achord, NMFS personal communications). None of 969 chinook salmon parr PIT tagged and released in Valley Creek during August by Achord's NMFS crew or the chinook salmon and steelhead trout parr we PIT tagged in USR were detected.

Dam Detections

A significant negative correlation was found for USR chinook salmon and steelhead trout smolt emigration date and travel time to Lower Granite Dam (Figure 5). Steelhead trout smolts had a lower travel time for a given release date. Mean travel time to Lower Granite Dam was estimated to be 46.2 +5.4 d (alpha = 0.10) for 73 chinook salmon, 25.1 ± 7.8 d (alpha = 0.10) for 10 steelhead trout, and 10.9 ± 2.3 d (alpha = 0.10) for 10 sockeye/kokanee salmon.

The combined PIT tag detection rates at the Lower Snake and Columbia River smolt collecting dams for the spring 1991 USR smolts were 27.0% for chinook salmon, 56.8% for sockeye/kokanee salmon, and 21.4% for age 3 and older steelhead trout. For the fall 1990 USR emigrants, the detection rates were 9.5% for chinook salmon and 6.1% for age 2+ and older steelhead trout. Detection data for the August 1990 PIT-tagged parr were summed by strata (Table 9). Overall, the smolt collecting dams detected 4.7% of the PIT-tagged chinook salmon and 3.1% of the age 2+ and older steelhead trout parr from the August 1990 tagging. The combined PIT tag detection rates for the smolts tagged at the Snake River trap in 1991 were 68.2% for all chinook salmon and 83.3% for wild\natural steelhead trout (Buettner and Nelson 1991).

Lower Granite Dam is not as efficient at collecting sockeye/kokanee salmon smolts as Little Goose Dam. In spring 1991, Lower Granite Dam detected 10 of the 37 (27.0%) sockeye/kokanee salmon smolts we PIT tagged and released from Redfish Lake Creek, and Little Goose Dam detected 11 of the 37 (29.7%). Since the smolts collected at Lower Granite Dam are transported, for Little Goose dam to collect virtually identical numbers indicates that Little Goose dam is more efficient at collecting sockeye/kokanee salmon smolts.

In spring 1991, no USR chinook salmon smolt length group had a significantly different PIT tag detection rate (a = 0.05) than the other length groups (Table 10). Those steelhead trout juveniles smaller than 130 mm will presumably rear another year or more before emigrating.

Survival Rates

Bys 1987 through 1990 egg-to-Parr survival rates in the headwaters of the USR for adult outplants and natural spawners averaged 20.2% (Table 11). Estimated egg-to-Parr survival rates in the entire USR for naturally spawning chinook salmon for 6 of the past 7 years that we have data averaged 5.2% (Table 12).

In past years, we have observed chinook salmon fry in our emigrant trap during the spring trapping season. We have no fry emigration estimates because our emigrant trap has screen openings too large to effectively capture fry. Unaccounted fry emigration from the study area would result in underestimates of egg-to-Parr survival. In spring 1991, the University of Idaho operated fry traps at the Sawtooth Fish Hatchery Weir to estimate chinook salmon fry emigration from USR. They estimated that 93,651 chinook salmon fry emigrated from the USR during

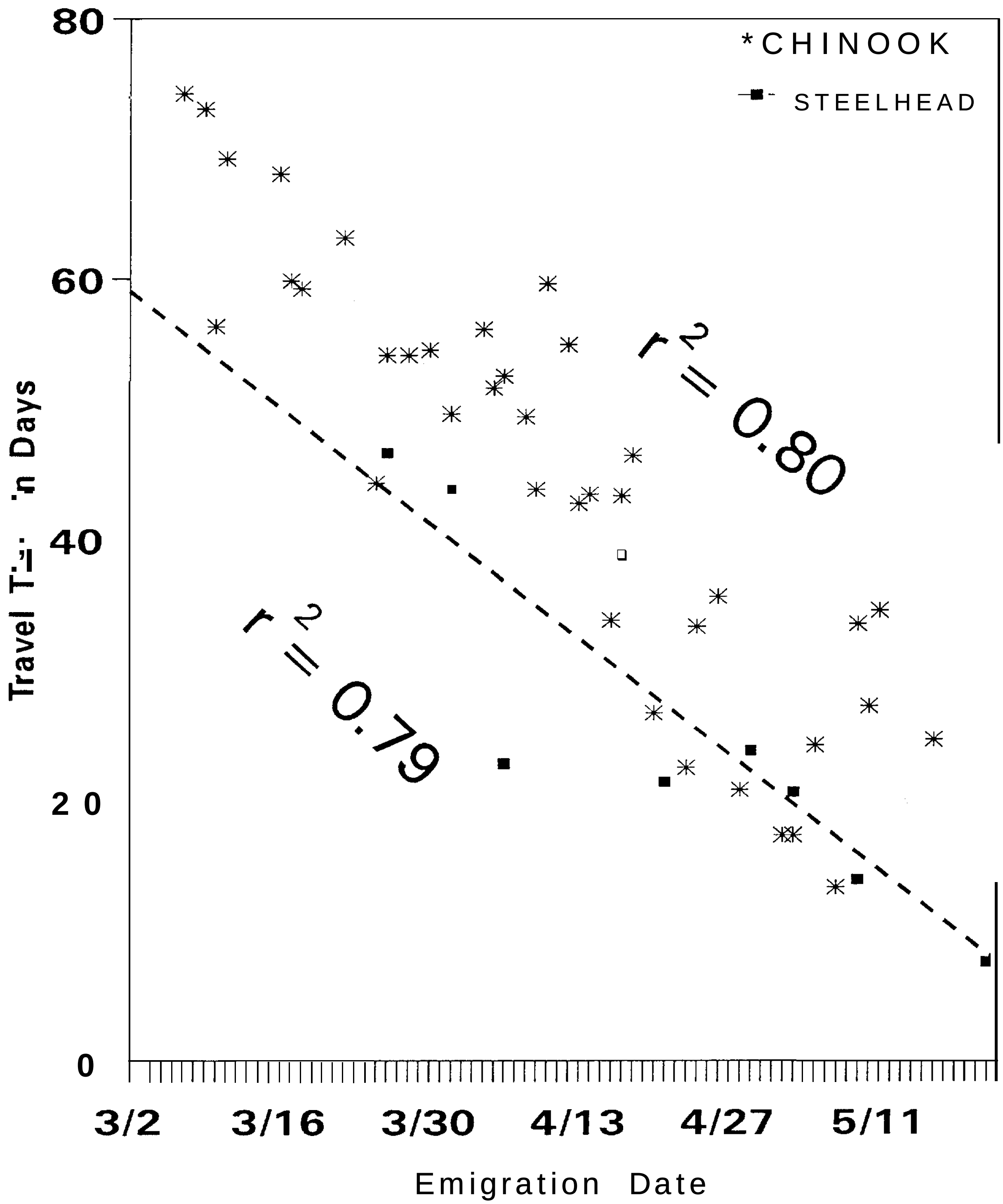

Figure 5. Spring 1991 chinook salmon and steelhead trout smolt travel time from upper Salmon River trap to Lower Granite Dam.

Table 9. Detections in 1991 at the Lower Snake River and Columbia River smolt collecting dams of August 1990 PIT tagged parr from Upper Salmon River.

	Chinook			Steelhead age 2+		
Stratum	Number tagged	Number detected	Percent detected	Number tagged	Number detected	Percent detected
SR-3	85	2	2.4	51	O	0
SR-7	25	0	0	0	-	
SR-9	70	3	4.3	141	3	2.1
SR-10	69	3	4.3	95	2	2.1
HC-1	5	0	0	6	O	0
FC-1	7	0	0	18	O	0
FC-3	195	5	2.6	1	O	0
SC-1	3	0	0	24	3	12.5
ALC-1	407	24	5.9	19	2	10.5
PC-1	13	0	0	60	3	5.0
PC-3	196	13	6.6	0	-	
Totals	1,075	50	4.7	415	13	3.1

TABLE _9.91

Table 10. Smolt fork length and PIT tag detection at Lower Snake River and Columbia River smolt collecting dams for upper Salmon River, spring 1991.

Length (mm)	Number tagsed	Number detected	Percent detected
	Chinook Salmon		
<80	29	7	24.1
80 - 89	133	41	30.8
90 - 99	162	48	29.6
>99	95	21	22.1
Total	419	117	27.9
	Steelhead Trout		
<90	61	1	1.6
90 - 129	46	0	0
>129	55	11	20.0
Total	162	12	7.4

TABLE_10.91

Table 11. Estimated chinook salmon egg-to-parr survival rates (%) from the headwaters of the upper Salmon River adult outplants and natural spawners, BYs 1987-90.

Adult origin	parameter	Brood years			
		1987	1988	1989	1990
	Females	5	30	9	13
Adult Outplants	Egg deposition	26,995	169,590	50,400	58,513
	Parr production	8,625	27,438	2,295	18,214
	Egg-to-Parr survival	32.0	16.1	4.6	31.1
	Redds observed	0	6	4	0
Natural Spawners	Egg deposition		33,918	22,400	
	Parr production		8,500	2,759	
	Egg-to-Parr survival		25.1	12.3	

TABLE-11.91

Table 12. Egg-to-Parr survival rates for natural chinook salmon in upper Salmon River, BYs 1984-90.

	Brood year					
	1984	1986	1987	1988	1989	1990
Estimated egg deposition in thousands[a]	1,095-l	1,287.7	1,360.5	1,724.2	688.8	450.1
Parr production in thousands	73.5	65.7	70.3	88.0	14.2	30.6
Egg-to-Parr survival	6.7%	5.1%	5.2%	5.1%	2.1%	6.8%

[a] From Table 2.

TABLE_12.91

spring 1991 based on mark recaptures at their traps (Perry and Bjornn 1992). When they used a catch per unit area method, they only estimated that 25,227 chinook salmon fry emigrated. They believe that their estimate of 93,651 based on mark recaptures to be more accurate.

We estimated that in 1991 approximately 55% of the spring chinook salmon juveniles produced by natural spawners in the USR emigrated out of our study area as fry before we conducted our snorkel counts. Fast et al. (1986) estimated spring chinook salmon egg-to-fry survival in the Yakima River to be 508. For the USR headwaters, we estimated spring chinook salmon egg-to-parr survival to be 20.2%. If USR spring chinook salmon egg-to-fry survival is similar to what Fast et al. (1986) estimated for the Yakima then USR fry-to-parr survival should be around 40%. Scully and Petrosky (1991) estimated fry-to-parr survival for hatchery spring chinook salmon fry outplants to average 18.9% (range 7%-30%) for several Salmon River and Clearwater River tributaries. We assumed that naturally produced fry would survive at a higher rate than fry outplanted from a hatchery. If the USR fry-to-parr survival is around 40%, then approximately 37,460 parr would have been produced from the 93,651 fry that Perry and Bjornn estimated emigrated from the USR. From our snorkel counts, we estimated the USR chinook salmon parr population in 1991 to be 30,589. We can, therefore, estimate the total number of chinook salmon parr produced from the spring chinook salmon adults naturally spawning above the Sawtooth Fish Hatchery weir to be 68,049, and 37,460 is approximately 55% of 68,049.

With BY 1990 steelhead trout we were able for the first time to estimate egg-to-age 1+ parr survival. However, the resulting survival estimate was extremely low, 0.1%.

To estimate survival to the head of Lower Granite pool, we used PIT tag comparative detections at Lower Snake River and Columbia River dams from our study and Snake River trap information (Buettner and Nelson 1991). For parr PIT tagged in August 1990, the estimated parr-to-smolt survival to the head of Lower Granite pool was 6.9% for chinook salmon and 3.7% for age 2+ and older steelhead trout. For fall 1990 emigrants, we estimate that 13.9% of the age 0 chinook salmon emigrants and 7.3% of the age 2+ and older steelhead trout emigrants survived to Lower Granite pool. For spring 1991 emigrants, the USR to Lower Granite pool survival rates were 39.6% and 25.7% for age 0 chinook salmon and age 3 and older steelhead trout, respectively. The estimated survival rates for the age 2+ and older steelhead trout for August parr, fall emigrants, and spring emigrants were the lowest we have observed except for spring 1989 when we believe small sample size biased our estimate (Table 13).

We released 37 of the sockeye/kokanee salmon smolts we captured and PIT tagged from Redfish Lake Creek in spring 1991. Of these fish, 21 were detected at the smolt collecting dams for a detection rate of 56.8%. From this detection rate and the detection rate of Snake River chinook salmon smolts tagged by Buettner (1991)(68.2%), we estimate that 83% of the sockeye/kokanee salmon smolts survived to the head of Lower Granite pool in 1991. This estimate is based on the assumption that the smolt collecting dams will detect PIT tagged sockeye/kokanee salmon smolts at the same rate as chinook salmon smolts.

Table 13. Yearly comparison of percent total PIT tag detections at Lower Snake River and Columbia River smolt collection facilities and estimated survival to the head of Lower Granite pool for age 2+ and older upper Salmon River steelhead trout.

	August Parr Tagging		Fall Emigration Tagging		Spring Emigration Tagging	
Smolt run year	Detected (%)	Estimated survival (%)	Detected (%)	Estimated survival (%)	Detected (%)	Estimated survival (%)
1988	14.0	23.3			23.5	42.4
1989	16.7	20.4	15.3	18.8	14.3[a]	17.5[a]
1990	6.2	7.8	9.8	12.4	25.8	31.6
1991	3.1	3.7	6.1	7.3	21.4	25.7

[a] Estimate is probably biased due to small sample size in spring 1989. Only 21 steelhead trout smolts were PIT tagged and only three were detected at the smolt collection facilities.

TABLE _ 13.91

Crooked River

Physical Habitat

Physical habitat data for 1991 have been entered into the IDFG physical habitat data base. The management of this data base is reported in the Idaho Habitat Evaluation for Off-Site Mitigation Record report (Rich et al. 1993).

Adult Escapement, Redd Counts, and Egg Deposition

Accurate adult escapement numbers were available for the first time from CR with the completion of the weir and trap in summer 1990. In 1991 the total adult chinook salmon escapement to CR was 5 females, 18 males, and 2 jacks. Four females were transported to the Red River holding ponds until ripe, then returned and released into the Relief Creek supplementation site. Chinook salmon female escapement and total egg deposition estimates for 1985-91 are provided in Table 14.

On September 1, 1991, we observed a redd, presumably from the one female released to spawn naturally. This redd was located in a side channel of the forced meander section in the lower meadow. The helicopter and ground counts were not conducted because all probable redds had already been observed.

The Relief Creek supplementation site was walked every other day to observe spawning activity, count redds, and check female mortalities for egg retention. Three of the four females were found and examined. Two were completely spawned out and one had about 30 eggs remaining. Four male carcasses were found. Three redds were observed. The other adults (1 female, 8 males) were unaccounted for.

On April 15, 17, and 18, 1991, a total of 776 adult steelhead (516 females) from Dworshak National Fish Hatchery were outplanted in CR. Of these adults, 26 (12 female) were transport mortalities. Adult steelhead returns to the CR trap numbered 49 total and 22 females. Only 5 of the 49 adults returning to CR were naturally produced fish.

On May 15, 1991, we counted a total of 50 redds in CR from the mouth to the Orogrande townsite excluding the canyon stratum from a helicopter. On April 30 and May 1, we conducted ground counts on CR from the canyon to Orogrande and observed 12 redds. Nine redds in this same section were counted by helicopter 2 weeks later.

We collected a total of 516 adult steelhead trout carcasses at the CR weir, 353 were females. We found 80 (23%) pre-spawning female mortalities. The remaining 273 females contained a mean egg retention of 1,503.

Data on chinook salmon and steelehad trout supplementation (1986-91) in CR is summarized in Tables 15 and 16, respectively.

Table 14. Estimated chinook **salmon** adult escapement, redd counts, and number of eggs deposited for Crooked River, 1985 to 1991.

ESTIMATED EGG	**67.54**	**59.09**	**108.27**	**181.50**	**4,400**	**399.00**	**17.60**
	Chinook Salmon Brood Year						
	1985	1986	1987	1988	1989	1990	1991
Female escapement'	16	14	**27**	**43**	**15**	**95**	**5**
Trend redd count	10	9	17	**27**	**3**		
Ground redd count				**43**	**15**	10[b]	**4**
Eggs per female'			4,010		**4,400**	**4,200**	**4,400**
Estimated eggs deposited (X1000)	**67.54**	**59.09**	**108.27**	**181.50**	**66.00**	**399.00**	**17.60**

[a] Female escapement was estimated for 1985-87 based on l/l ratio of female escapement to ground redd counts observed in USR, and 43/27 ration 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] Redd counts were conducted before 157 adult chinook salmon (86 females) were outplanted into Crooked River from Dworshak National Fish Hatchery.

[c] Average number of eggs/female obtained from nearby Red River trapping facility.

TABLE_14.91

Table 15. Crooked River chinook salmon supplementation in thousands (except adults) summary by brood year, 1986 to 1991.

	Brood Year					
	1986	1987	1988	1989	1990	1991
Adult females	0	0	0	0	92	0
Fry	0	200.1	401.5	0	0	
Fall parr	227.5	0	0	339.1		
Smolts	0	199.7	300.4	0	0	

Table 16. Crooked River steelhead trout supplementation, summary by brood year, 1986 to 1991.

	Brood Year					
	1986	1987	1988	1989	1990	1991
Adult females	0	468	0	0	167	516
Fry	87,750	0	0	0	0	0
Fall parr	0	0	0	0	0	
Smolts	200,162	201,325	109,898	214,633	0	

TAB15&16.91

Parr Abundance

We conducted snorkel counts on CR between June 26 and June 30; two weeks earlier than normal. With the late cold spring, the chinook salmon age 0 parr were not out of the gravel yet, since we did not observe any (Table 17). The mean stream temperature during our snorkel counts in 1991 was 7.9°C, as compared to 12.6 to 12.7°C in 1987-90.

Steelheadtrout age 2+ parr densities in 1991 were the lowest observed since 1986, while age 1+ steelhead trout densities were in the mid-range of values observed since 1986 (Table 18). We estimated the CR steelhead trout parr abundance in 1991 to be 9,129 ± 2,788 age 1+ and 566 ± 241 age 2+ (alpha = 0.05). Our analysis of fall 1991 emigrant trapping data (see fall 1991 Emigration Trapping Section) indicates that a significant portion of the CR steelhead trout parr may still have been in their winter hiding locations (within the boulder/gravel substrate) and not observable when we conducted our snorkel counts.

PIT Tagging

We PIT-tagged a total of 23 chinook salmon and 2,048 steelhead trout parr in CR during July 24-31, 1991. We decided not to target chinook salmon parr for PIT tagging because approximately 75% of those collected were below the minimum tagging size of 55 mm fork length. We held all tagged fish for 24-hour delayed mortality tests. Collecting, tagging, and 24-hour delayed mortalities for July PIT tagging totaled 1.3% for chinook salmon and 0.4% for steelhead trout.

The number of steelhead trout PIT tagged in CR during July (2,048) resulted from not targeting chinook salmon and the moderately high densities of age 1+ steelhead trout. We tagged a total of 410 age 2+ and older steelhead trout.

Spring 1991 Emigration Trapping

We captured 235 chinook salmon smolts with an overall trapping efficiency of 35.1%, and 142 steelhead trout juveniles with an overall trapping efficiency of 10.3% during spring 1991. We estimated total spring 1991 emigration for chinook salmon and steelhead trout to be 670 and 1,379 respectively. During spring 1991, increases in discharge were associated with increases in emigration for both chinook salmon and steelhead trout smolts from CR (Figure 6).

Estimated age composition of steelhead trout emigrants were 49% (676) age7 1, 13% (179) age 2, and 38% (524) age 3 and older. Based on the summer 1990 parr abundance (Kiefer and Forster 1992) we estimated that 6.8% of chinook salmon parr, and 4.2% of age 1+ steelhead trout, and 28.7% age 2+ and older steelhead trout emigrated in spring 1991.

Table 17. Density (fish/100 m^2) of age 0 chinook salmon in Crooked River, August 1986 to 1991.

Stratum	1986	1987	1988	1989	1990	1991
Headwaters			co.1	0.1	0	–[a]
I	14.0	3.0	23.8	28.4	<0.1	
II	1.1	16.5	19.7	19.7	<0.1	
Canyon			8.0	10.3	1.0	
III	57.8	22.3	36.6	58.7	5.0	
IV	71.8	15.4	42.2	59.0	4.7	
Relief Creek			0.8	45.5	0	
Ponds A[b]	62.9	3.2	65.4	206.1	0.6	
Ponds B				268.0	8.1	

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

[b] In 1986-88, the data for connected ponds was combined and is reported here as Ponds A.

Table 18. Density (fish/100 m^2) of age 1+ and age 2+ steelhead trout parr for Crooked River, 1986 to 1991.

Stratum	1986	1987	1988	1989	1990	1991
			Age 1+ Steelhead Trout			
Headwaters			1.5	0.2	0.4	0.1
I	6.8	4.3	5.2	1.9	0.2	0.7
II	11.7	10.8	8.8	4.4	1.5	7.3
Canyon			11.4	4.1	1.0	4.7
III	6.2	6.1	10.3	6.5	2.5	2.8
IV	7.2	7.2	7.5	3.4	1.5	3.7
Relief Creek			19.1	5.2	0.2	5.3
Ponds A[a]	4.8	42.4	17.8	7.2	1.2	0.6
Ponds B				10.1	0.1	1.7
			Age 2+ Steelhead Trout			
Headwaters	-		0.2	0.3	0.1	0
I	0.2	0.7	0.2	0.8	0.3	0.1
II	1.1	3.7	0.4	1.4	1.3	0.4
Canyon	-		1.2	2.1	1.2	0.4
III	0.2	2.8	0.5	1.8	1.4	0.1
IV	0.3	1.5	7.1	1.5	1.1	0.1
Relief Creek	-		0.6	1.8	0.1	0.5
Ponds A[a]	0.3	4.8	1.6	1.7	1.0	co.1
Ponds B	-			2.2	0.3	0.2

[a] In 1986-88, the data for connected ponds was combined and is reported here as Ponds A.

TABLE 18.91

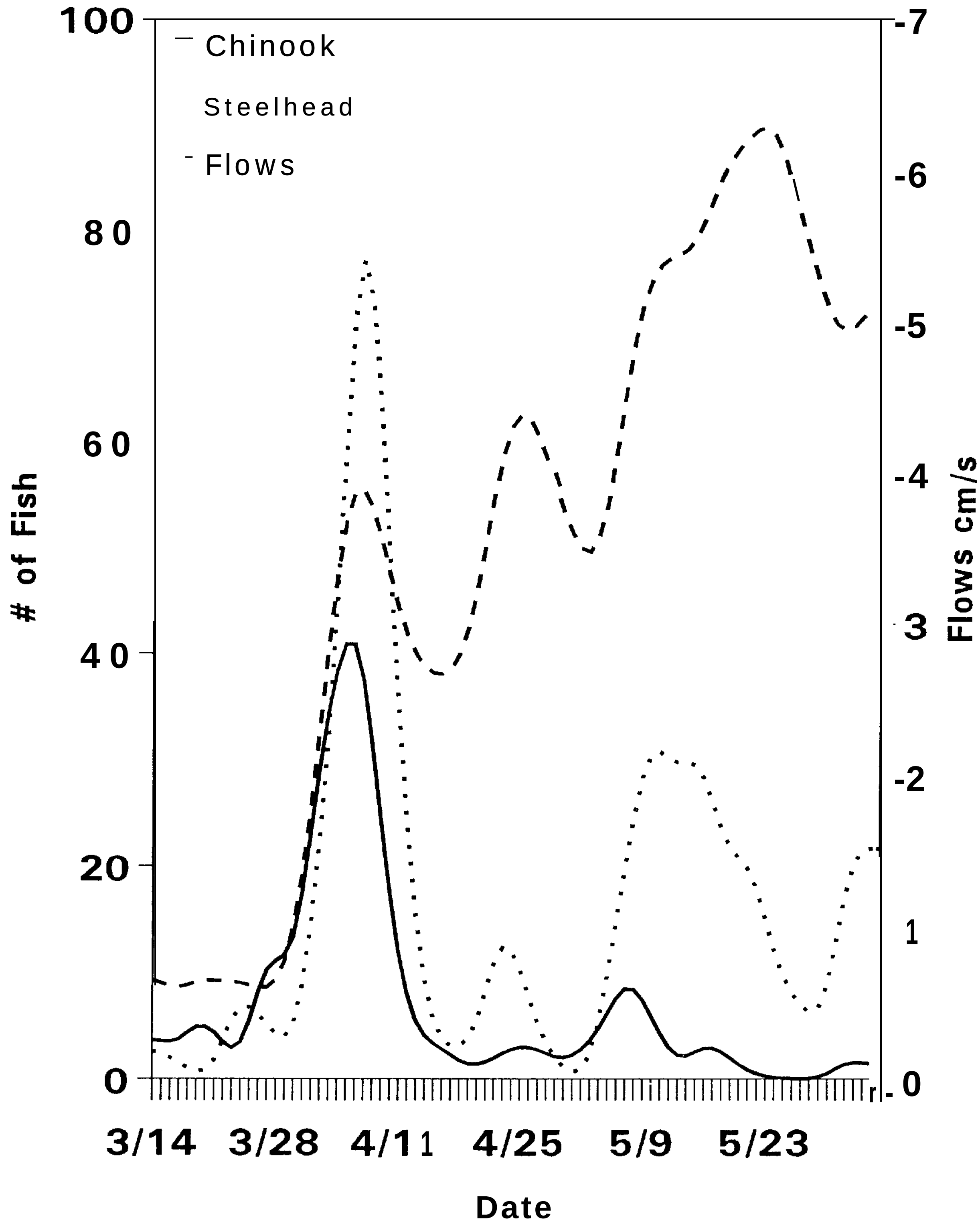

Figure 6. Spring 1991 Crooked River chinook salmon and steelhead trout emigration timing and flows (3-day moving average).

Fall 1991 Emigration Trapping

During fall 1991, we captured 2,267 chinook salmon parr with an overall trapping efficiency of 26.3%, and 1,478 steelhead trout parr with an overall trapping efficiency of 20.2%. We estimated the total emigration for chinook salmon and steelhead trout to be 8,723 and 7,390 respectively. In fall 1991, both chinook salmon and steelhead trout parr emigration peaks were similar (Figure 7). Estimated age composition of steelhead trout emigrants was 45.1% (3,333) age 0, 33.5% (2,476) age 1+ steelhead trout, and 21.4% (1,581) age 2t and older. The estimated percentages of summer steelhead trout parr populations that emigrated in the fall were 27.1% for age 1+ steelhead trout, and 279.3% for age 2+ steelhead. Obviously, we have a data problem if we estimated that 279.3% of the summer age 2+ and older steelhead trout population emigrated in the fall. We believe that this data discrepancy was caused by conducting the CR snorkel counts in 1991 when many of the parr were still in their winter cover locations.

Dam Detections

Mean travel time was calculated during the spring 1991 emigration from PIT tagged chinook salmon and steelhead trout smolts captured at CR Trap and later detected at Lower Granite Dam, 266 km downstream. A significant negative correlation was found between travel time and date of emigration (Figure 8). Chinook salmon smolts take longer to get to Lower Granite dam than steelhead trout smolts. The best fit for steelhead trout smolt travel time was an exponential curve with the formula; travel time = 1/exp (-7.215 + 0.037 x emigration julian date).

The combined PIT tag detection rates at the Lower Snake and Columbia River smolt-collecting dams for spring 1991 CR smelts were 38.7% for chinook salmon, and 61.1% for age 3 and older steelhead trout. For fall 1990 CR emigrants, the detection rates were 19.3% for chinook salmon, and 36.9.% for age 2t and older steelhead trout. Detection data for the August 1990 PIT tagged parr were summed by strata (Table 19). Overall, the smolt collecting dams collected 12.6% of the PIT tagged chinook salmon, and 29.6% of the age 2+ and older steelheadtrout parr from the August 1990 tagging. However, we believe the 92 small and emmaciated natural chinook salmon parr we PIT tagged from the intake structure to the hatchery rearing ponds were not representative of the general population, and without these 92 chinook salmon the smolt collecting dams detected 14.0%. The combined PIT tag detection rates for the smolts tagged at the Clearwater River Trap by Buettner and Nelson (1991) were 60.5% for chinook salmon and 74.1% for steelhead trout.

Only those chinook salmon smolts from CR having a fork length of greater than 99 mm had a significantly different (higher) PIT tag detection rate (a = 0.05) than the other length groups analyzed (Table 20). For steelhead trout, predominately only those larger than 129 mm (age 3 and older) were detected at the smolt collecting dams.

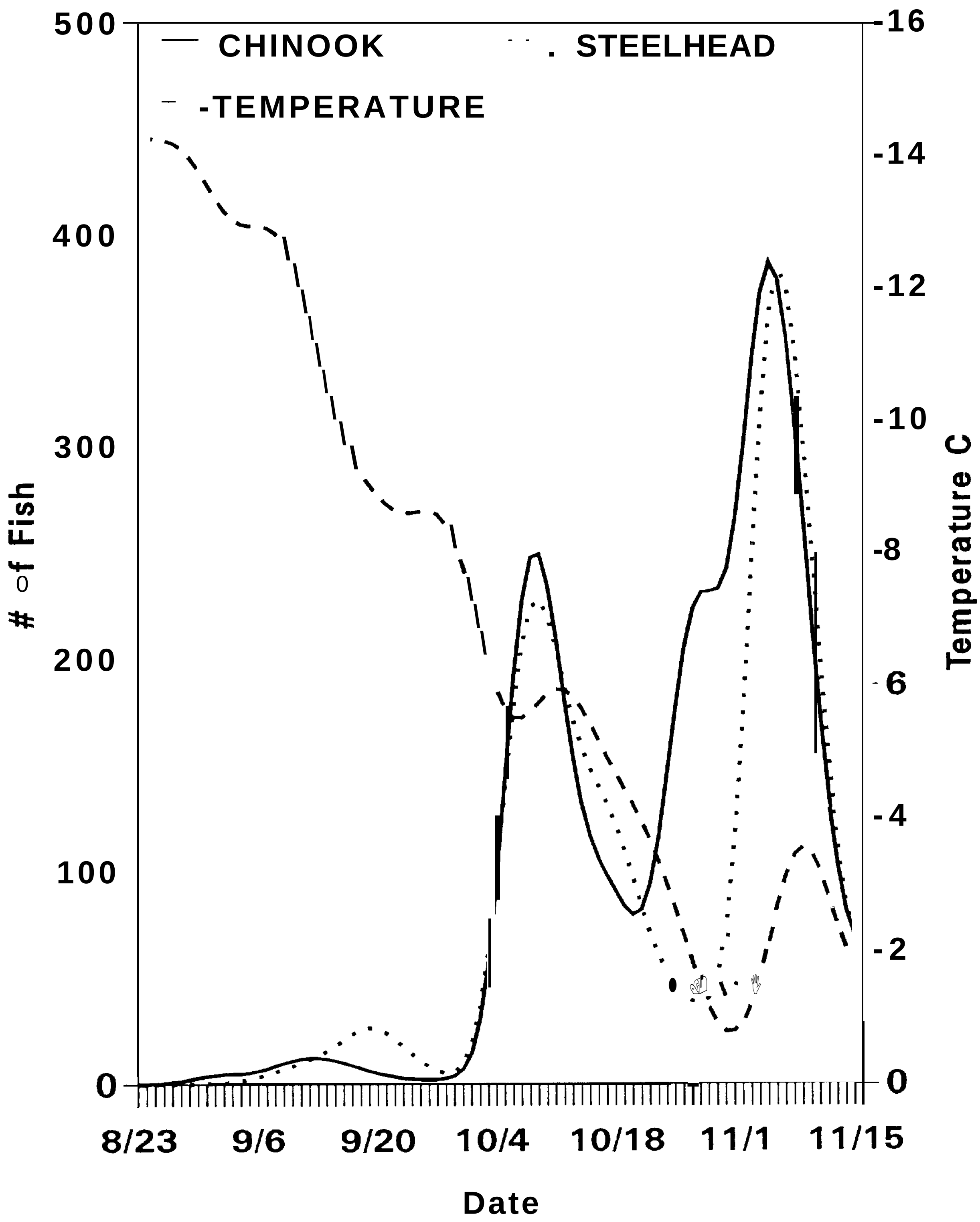

Figure 7. Fall 199 1 Crooked River chinook salmon and steelhead trout emigration timing and temperature (3-day moving average).

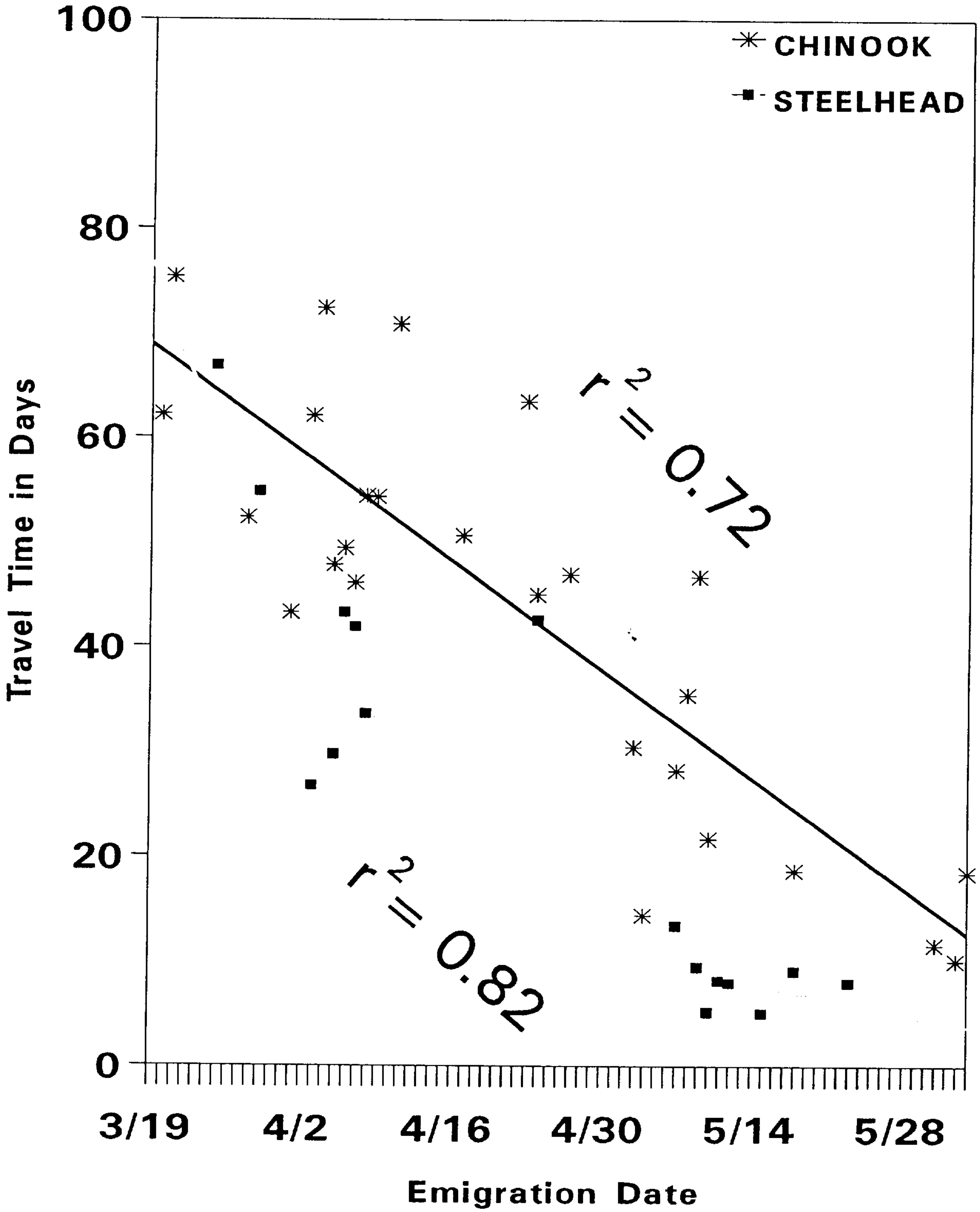

Figure 8. Spring 1991 chinook salmon and steelhead trout smolt travel time from the Crooked River Trap to Lower Granite Dam.

Table 19. 1991 detections at the Lower Snake and Columbia River smolt collecting dams of August, 1990 PIT tagged parr from Crooked River.

	Chinook Salmon			Steelhead Trout age 2+		
Stratum	Number tagged	Number detected	Percent detected	Number tagged	Number detected	Percent detected
CR-I[a]	92	2	2.2			
CR-II	95	13	13.7	41[b]	13	31.7
CR-III	218	29	13.3	36	8	22.2
CR-IV	201	27	13.4	140	42	30.0
Canyon	141	23	16.3	101	31	30.7
Totals	747	94	12.6	318	94	29.6

[a] Chinook parr tagged in Strata I were collected from the intake system to the hatchery rearing ponds. These fish were emaciated and smaller than those tagged in other areas of Crooked River.

[b] Due to low steelhead trout numbers, Strata I and II were combined.

TABLE-19.91

Table 20. Smolt fork length and PIT tag detection for Crooked River, spring 1991.

Length (mm)	Number tagged	Number detected	Percent detected
	Chinook Salmon		
<80	40	13	32.5
80 - 89	112	46	41.1
90 - 99	70	22	31.4
>99	13	10	76.9
Total	235	91	38.7
	Steelhead Trout		
<90	68	0	0.0
90 - 129	20	3	15.0
>129	54	33	61.1
Total	142	36	25.4

TABLE_20.91

Survival Rates

Chinook salmon egg-to-parr survival for BY 1990 was not directly calculable because the parr were not out of the gravel when we conducted our snorkel counts. We assumed that on average 24% of the summer chinook salmon parr population in CR emigrates in the fall (Kiefer and Forster 1991). Based on our 1991 estimate of 8,723 chinook salmon fall emigrants we calculated a rough estimate **of 36,346** summer parr in 1991. In 1990, we had an estimate of adult female chinook salmon successful spawner of 88 and an average of 4,400 eggs/female, for an estimated egg deposition of 387,000. From this data, we can make a rough estimate of chinook salmon egg-to-parr survival for BY 1990 of 9%.

From our aerial and ground steelhead trout redd counts in 1990 our best estimate of the number of adult steelhead trout females spawning in CR is 180. The estimate of the number of eggs/female for adult steelhead trout returning to Dworshak National Fish Hatchery in 1990 was 6,880. From these two numbers, we can make an estimate of 1,238,400 steelhead trout eggs deposited in CR in 1990. The 1991 estimate of age l+ steelhead trout parr in CR was 9,129. From these numbers, we calculate a rough minimum estimate of steelhead trout egg-to age l+ parr survival of 0.78 for BY 1990 in CR.

We believe that many of the age l+ steelhead trout parr were not visible due to cold temperatures when we conducted our snorkel counts on CR. Thus, the egg-to-age 1+ parr survival rate is probably higher than 0.7%.

For August 1990 parr, the estimated parr-to-smolt survival to the head of Lower Granite pool was 23.2% ± 2.3% (a = 0.10) for age 0 chinook salmon, and 39.98 ± 4.3% (a = 0.10) for age 2+ and older steelhead trout. The parr-to-smolt survival estimates for CR chinook salmon is approximately four times higher than we have calculated in the past, and the steelhead trout survival is also the highest we have calculated but only slightly above the second highest year (1989, **35.3%).**

In addition, we used detection rates for PIT-tagged emigrants and Buettner and Nelson's (1991) detection rates to estimate fall and spring emigrant-to-smolt survival at the head of Lower Granite pool. For fall 1990 emigrants, we estimate that 31.9% of the age 0 chinook salmon emigrants and 49.8% of the age 2+ and older steelhead trout emigrants survived to Lower Granite pool. For spring 1991 emigrants, the CR to Lower Granite pool survival rates were 64.08 for age 0 chinook, and 82.5% for age 3 and older steelhead. These estimates of survival to the head of Lower Granite pool are all the highest we have observed for each respective species and emigration period.

Smolt Production

We estimated smolt production from CR to the head of Lower Granite pool to be 2,297 chinook salmon and 729 steelhead trout. This is based on our estimates of parr abundance using snorkel counts and parr-to-smolt survival to the head of Lower Granite pool using comparative PIT tag detection rates.

DISCUSSION

Physical Habitat

Analysis for correlations between physical habitat, parr densities, **and** smolt production was scheduled to be conducted in winter 1992. However, with the extremely low densities observed in both study areas during the past several years, we decided to concentrate our analysis time on other data for this report.

Adult Escapement and Redd Counts

The adult weirs at both study sites allow us to obtain accurate adult escapement numbers. This is critical to our efforts to determine the relationship between adult escapement and smolt production.

The ground and helicopter redd counts provide us with additional adult spawning information. Since we are working in study areas with known escapements, we can estimate the efficiency of each method in counting redds. Our data indicate that a total ground count just after the peak spawning time can accurately estimate chinook salmon escapement in smaller streams with an assumed female to redd ratio of 1:1. This has allowed us to estimate total female chinook salmon escapement in CR before the adult trap was built in 1990 and in the USR in 1989 when high water forced Sawtooth Fish Hatchery personnel to remove weir panels during the adult chinook migration. However, 3 years of intensive ground counts on Red River (Southfork Clearwater Tributary) by IDFG **regional** fisheries personnel resulted in a female/redd ratio of 1/1.6 (Tim Cochnauer, IDFG personal communications).

The redd counts also show us where spawning has occurred. This information allows us to estimate egg-to-parr survival rates for natural chinook salmon spawners in headwater tributary streams, and helps prioritize ares for parr PIT tagging.

Chinook salmon and steelheadtrout escapements during the period of analysis (1984 to 1991) have been variable, but typically less than 25% of estimates of full seeding (IDFG 1990) for both study areas.

The preferred chinook salmon spawning areas in CR may be changing in response to some of the habitat rehabilitation work conducted there. Gravel cleaned during the habitat work in the lower meander section is associated with more adult chinook salmon spawning verses the upper meadow where they had previously spawned.

Adult Outplants

Adult outplants of chinook salmon in the USR headwater streams resulted in similar egg-to-parr survival as naturally spawned fish (Table 11). Based on this information, we decided to use adult outplants to increase seeding levels in USR tributaries in order to help define adult escapement to smolt production relationships. We recommend supplementation with other life stages be discontinued in both study areas, except where incorporated into the supplementation research projects currently being developed.

Our experience with outplanting adult steelhead trout is fairly limited to date, and our results have been mixed. Adult steelhead trout from Dworshak National Fish Hatchery outplanted in 1990 appeared to be fairly successful at spawning (3% pre-spawning mortality and an average egg retention of 16), and resulted in a 1991 steelhead trout age 1+ parr population of 9,129 and density of 3.4 fish/100 m^2. We believe that the true 1991 age 1+ steelhead trout population may actually be larger than this because many of the steelhead trout parr were not visible to count because of low stream temperatures when we conducted our snorkel counts.

In 1991, the adult steelhead trout outplants did not spawn well (23% pre-spawning mortality and average egg retention of 1,503). Several factors may have contributed to this lower success of our CR adult steelhead trout outplants in 1991. First, in 1991 we outplanted a greater number of steelhead trout adults (516 females) than in 1990 (167 females), and we stocked beyond spawning ground capacity. We estimate that it would take 268 steelhead trout females to fully seed CR. Second, coordination with Dworshak National Fish Hatchery personnel was insufficient to ensure quality adults at the right time. And third, many of the adults to be released in the upper meadow were mistakenly released in the lower meadow on top of the adults already released there.

The five pair of adult steelhead trout released into upper Pole Creek was the first time this project has supplemented the USR with adult steelhead trout. We were unable to locate any intact female carcasses from this outplant and observed only two redds. Our inability to determine spawning success was because of difficult access conditions, the predominance of snow bridges, and bears eating the carcasses. The low numbers of steelhead trout fry observed in the Pole Creek during July 1991 also indicates that this outplant was not very successful.

The smaller size of chinook salmon parr produced from adult outplants in upper Frenchman Creek ($\bar{x}$ = 60 mm) as compared to naturally produced USR parr ($\bar{x}$ = 75 mm) probably resulted from colder water temperatures in Frenchman Creek. The limited temperature data we have collected (mid-day temperatures taken during snorkel counts and PIT tagging operations) and our August chinook salmon parr lengths show a relation between USR study site temperature and fish length (Kiefer and Forster 1992).

Parr Abundance

Overall, chinook salmon parr densities during the study period 1987 to 1991 appear to be related to adult escapements and supplementation levels. In 1991 chinook salmon parr abundance in both study areas were among the lowest observed since we began collecting data in 1984. We attribute this to the low natural escapements in 1990, low levels of supplementation, and the high estimated percentage (55%) of the USR chinook salmon that emigrate as fry. We hypothesize fry emigration is related to chinook salmon spawning just upstream of the weir, and to the predominant habitat (fast runs) in this section of the USR. Hillman and Chapman (1989) reported similar emigrations of chinook salmon fry in the Wenatchee River and attributed it to the limited amount of habitat that provided protection from high velocity water and predation. We have not detected a large fry emigration from the USR meandering headwaters streams or from CR.

Steelhead trout parr populations in USR have dropped with the elimination or reduction in supplementation. Our estimate of USR steelhead trout egg-to-parr for BY 1990 was extremely low (0.1%). Part of this low survival may actually be caused by steelhead trout juveniles spawned in our study area rearing downstream (similar to chinook salmon).

In 1991, we conducted snorkel count surveys on several of the smaller tributaries that we had not surveyed in the past. We found chinook salmon and steelhead trout parr rearing in many of these tributaries. Surprisingly, we observed both chinook salmon and steelhead trout parr above the dewatered sections of Fourth of July and Champion creeks. Chinook salmon must move into these tributaries as fry in the spring.

We hypothesize that our snorkel counts on CR in 1991 were conducted to early (June 24 - 31) and stream temperatures were too low ($\bar{x}$ = 7.9" C), which resulted in many of the parr not being observable. Hillman et al. (1989) observed that juvenile chinook salmon and steelheadtrout concealed themselves in the substrate when stream temperatures remained below 10" C. We did not observe a single chinook salmon parr during these snorkel counts, but we captured 2,267 during our fall trapping and estimated a total fall emigration of 8,723. In 1990, we estimated that on average 24% of the CR chinook salmon parr population will emigrate in the fall (kiefer and Forster 1992). We assumed that 24% emigrated in fall 1991 and estimated a summer chinook salmon parr population of 36,346 (8,723/0.24 = 36,346). We also estimated that almost three times as many age 2+ and older steelhead trout emigrated in fall 1991 from CR than our estimate of summer abundance. We believe that our snorkel count method has not suffered this bias in past years in CR or in USR.

PIT Tagging

The numbers of chinook salmon parr PIT-tagged from both study areas in 1991 were below what we estimate is necessary to obtain enough detections at the dams for good statistical comparisons. The primary reasons for the low numbers were that chinook salmon densities were too low in the USR to make collecting efficient, and in CR besides the population being low, 75% of the chinook salmon parr captured were too small to tag. We did not tag enough steelhead trout **in** the USR because of their low densities, and we spent most of our effort there tagging chinook salmon.

In all years, we PIT tagged in both study areas (1988 to 1991) the naturally produced chinook salmon parr from the USR were significantly larger (alpha = 0.05) than those from CR. This is contrary to what elevation and thermal units for growth would predict. Possible explanations are the higher conductivity (more productivity) in USR, and genetic differences in stocks.

Short-term (24-hour) mortalities for PIT tagging operations were well within our goal of less than 5%, and were similar to other PIT tagging studies (Prentice et. al 1986; Matthews et. al 1992).

Our delayed mortality study indicated that there was no significant (alpha = 0.05) difference in the survival rate between caudal nipped chinook salmon parr and caudal nipped and PIT tagged chinook salmon parr from mid August to late **October**. This study also indicated that there is no significant tag loss or failure for August PIT tagged parr. Because our migration barriers failed, we were unable to determine if there was a difference in survival **between** PIT tagged chinook salmon parr and un-handled chinook salmon parr. We plan to conduct the study again in 1992 to answer this question.

Spring Emigration

Contrary to what we expected, the chinook salmon smolt migration from USR occurs slightly earlier than from CR (Figure 9). We had originally hypothesized that since CR is lower in elevation and has earlier increases in discharge and water temperature, that the smolts from CR would begin emigrating earlier. A possible explanation for the USR chinook salmon smolts migrating earlier **may be** the greater distance to travel to the ocean may have selected for stocks that leave earlier. In 1991, we began to operate the USR trap earlier to make sure we are not missing part of the USR run.

Fall Emigration

Our data suggest that higher elevation (harsher climate) streams will have a higher proportion of parr emigrate in the fall and emigrate earlier (Figure 10). The 1988 to 1990 averages of the chinook salmon and age 2+ and older steelhead trout summer parr populations emigrating in fall from CR were 24% and 17%, respectively, while both chinook salmon and age 2+ and older steelhead trout from the USR averaged 62%. In both study areas during this period, fewer age 1+ steelhead trout emigrated in the fall than age 2+ and older steelhead trout, and a higher percentage of age 1+ steelhead trout emigrated from USR (14%) then from CR (5%).

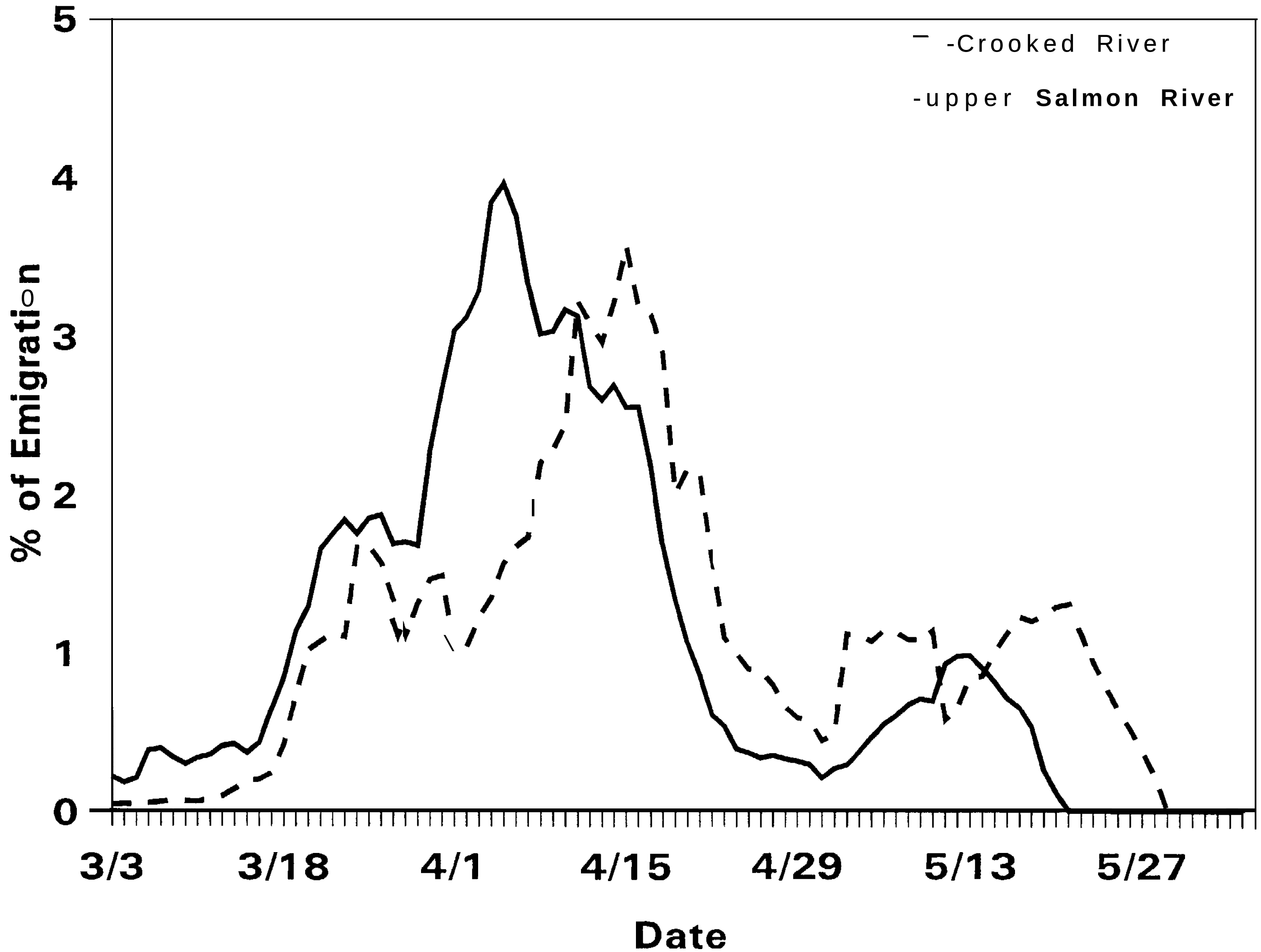

Figure 9. Chinook salmon spring emigration timing from Crooked River and upper Salmon River (7-day moving averages of 1988-9 1 data).

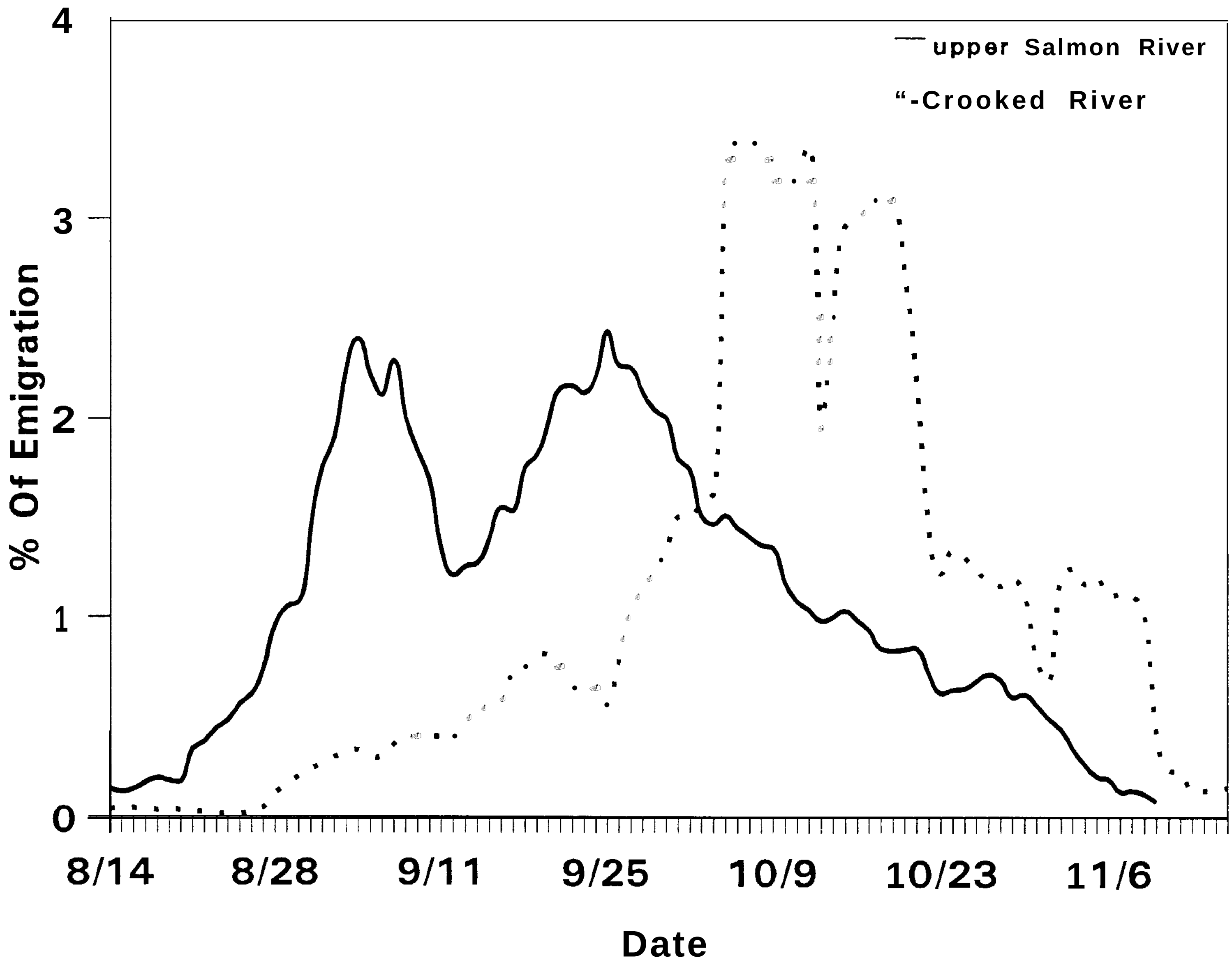

Figure 10. Chinook salmon fall emigration timing from Crooked River and upper Salmon River (7-day moving averages of 1988-91 data).

In fall 1991, the percentages of the USR summer parr populations for both chinook salmon (25.3%) and age 2+ steelhead trout (42.1%) were lower than the consistent 1988-1990 average for both groups of 62%. Reasons for this drop are not known at this time. For CR chinook salmon, we were not able to accurately estimate the summer parr populations because all chinook salmon and many steelhead trout were still in the gravel when we conducted our snorkel Counts.

In fall 1990, a higher percentage of all parr groups (except CR chinook salmon) emigrated than in the previous 2 years, and the percent of CR chinook salmon was close to the highest (Kiefer and Forster 1991). If the availability of suitable overwinter habitat was the key, then we would have expected lower percentages because the parr populations in 1990 were much lower than the pervious 2 years. One possible explanation is the natural fish are more likely to emigrate in the fall, and with the cessation of fry supplementation for 1990 parr, the overall percentage of fall emigrants increased. Other possibilities are that the fish may be responding to environmental cues, or that the low parr populations result in relatively larger sampling errors.

Remote PIT Taq Monitors

Efficiency tests we conducted indicated that the irrigation diversion bypass pipe remote PIT tag monitors (monitors) are capable of detecting at least 60% of the PIT tagged fish passing through them. We do not know at this time if the remaining 40% were not detected, swam back out of the diversion, lost their tags, the tags failed, mortalities, or were lost to the diversion system.

Detections of previously PIT tagged fish show that at least some of the USR and East Fork Salmon River natural pre-smolts overwinter as far downstream as Challis. Incomplete data collected indicate that at least 27% of the fall 1991 emigrants passing through this section of the Salmon River passed through the S27 (south-side) diversion bypass pipe. This estimate was calculated as the percentage of PIT tagged parr detected in the upstream (S29) monitor and subsequently detected in the (S27) monitor, while both monitors were operating. We caution against using the estimates from this pilot study as hard data until further evaluation of these monitors is conducted.

The trial operation of the monitors on the Salmon River near Challis indicated that they could be a useful tool in determining where the fall emigrants from the USR overwinter, and evaluating factors affecting their survival. These monitors should also be useful in determining migration and survival rates for spring smolts from the USR.

Dam Detections

Detections of PIT-tagged smolts at Lower Granite dam allows us to determine migration characteristics of chinook salmon and steelhead trout smolts from both study areas. As in previous years at Lower Granite Dam the majority of the total chinook salmon run (predominately hatchery fish) arrived earlier than the natural fish from CR and USR (Figure 11).

As in previous years the natural steelhead trout smolts from CR and USR arrived at Lower Granite Dam within the last major peak of all wild/natural steelhead trout (Figure 12).

In all years studied, increases in flows at Lower Granite Dam corresponded with peaks of arrival at Lower Granite Dam for all PIT tagged smolt groups. This suggests to us that only at higher Snake River flows are velocities sufficient for smolt migration.

The Redfish Lake Creek sockeye/kokanee salmon smolts we PIT tagged and released were detected at a rate higher than USR chinook salmon. Although only 37 PIT tagged sockeye/kokanee smolts were released in Redfish Lake Creek, 10 were detected at Lower Granite dam, and 11 were detected at Little Goose Dam (57%). This relatively good detection of Redfish Lake sockeye/kokanee salmon smolts was associated with unusually heavy late spring rains increasing the flows, velocities, and turbidity through the lower Snake River reservoir system during the period when most sockeye/kokanee salmon smolts were emigrating (Marsh and Achord 1992). The chinook salmon smolts from USR and CR that emigrated from the study areas during the same period as the Redfish Lake sockeye/kokanee salmon smolts also had a high detection rate at the dams.

Survival Rates

Estimated overall egg-to-parr survival rate for chinook salmon in the USR averaged 5.2% for BYs 1984-90, and is about l/2 to l/3 of that observed from other Idaho streams (Scully et. al. 1990). At least part of the reason for the apparent low survival likely is that a large proportion of the chinook salmon fry emigrate from the study area during the spring. When we adjust the BY 1990 USR chinook salmon egg-to-parr survival for our estimate of 55% of the USR chinook salmon production that emigrated out of the study area as fry in 1991, the estimated USR chinook egg-to-parr survival for BY 1990 is 15.1%. If this 55% emigration of fry is accurate and has been consistent, then we can estimate the BY 1984-90 average egg-to-parr survival to be 11.6%, within the range observed by Scully et al. (1990).

Estimated egg-to-parr survival rates for BYs 1989 and 1990 chinook salmon in CR (15% and 9.4%, respectively) were similar to what Scully et. al (1990) observed in other Idaho streams. We have not observed significant chinook salmon fry emigrations from CR.

We have consistently estimated greater chinook salmon egg-to-parr survival from redds (natural and supplementation) constructed in the headwaters of USR than in the mainstem (Table 11 and 12). Two factors are probably contributing to this difference. First, the low gradient, meandering headwater streams are probably better juvenile chinook salmon rearing habitat than the predominately

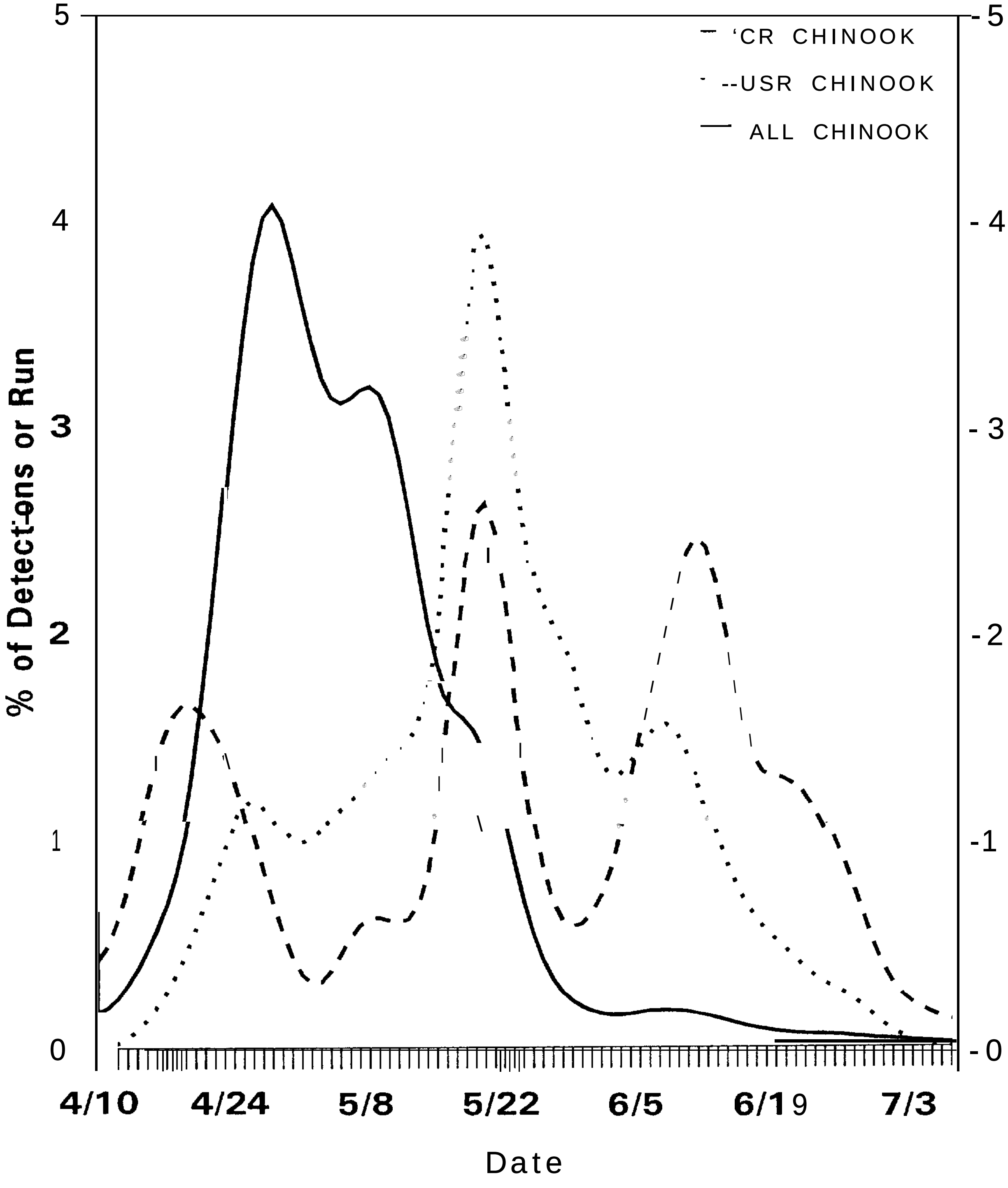

Figure 11. Arrival timing at Lower Granite Dam (3-day moving average) of all chinook salmon and PIT tagged chinook salmon from Crooked River and upper Salmon River 1991.

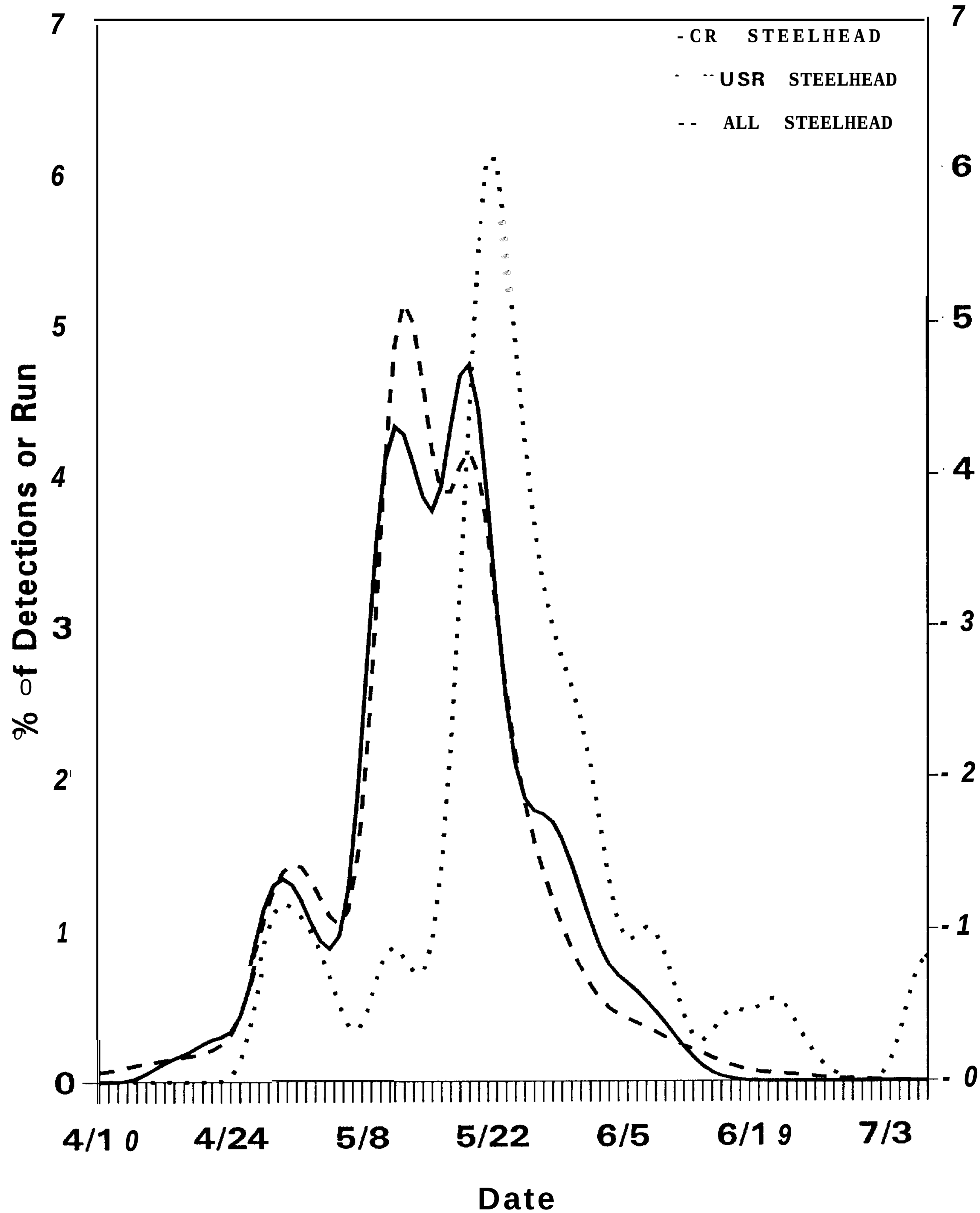

Figure 12. Arrival timing at Lower Granite Dam (3-day moving average) of all steelhead trout and PIT tagged steelhead trout from Crooked River and upper Salmon River 1991.

fast runs found in the mainstem. Second, based on 1991 studies, more than half of the fry produced in the mainstream emigrate out of the study area immediately after swim-up.

We calculated egg-to-age 1+ parr survival for steelhead trout that were much lower than we expected, 0.7% for CR and 0.1% for USR. Possible reasons for the lower than expected steelhead trout egg-to-parr survival are: 1) large numbers of steelhead trout fry may emigrate downstream out of our study areas and rear elsewhere; 2) undocumented steelhead trout parr rearing occurs in small tributaries of our study areas that we are not surveying; 3) many of the steelhead trout parr may have still been in the gravel when we conducted our snorkel counts in CR in 1991; 4) most of the USR adults released above the weir spawn in the lower two strata of our study area, and we believe the best steelhead spawning and rearing habitat is further up in the system; 5) and the Snake River A-run steelhead trout stock used to start the Sawtooth Fish Hatchery program may not have been a good habitat match for the USR.

Data we collected indicate that the adult steelhead trout outplants from Dworshak National Fish Hatchery in 1991 were not real successful at spawning in CR (23% female pre-spawning mortality and 21% egg retention on successful spawners) and are probably not representative of natural spawners. We believe there are two main reasons for this poor performance. First, we outplanted approximately twice as many adults as we estimate it would take to achieve full seeding. And second, mistakenly, most of the adults were outplanted into the lower meadow section instead of being released throughout the drainage as planned.

The method used to estimate parr-to-smolt survival from summer 1990 to spring 1991 uses PIT tags and comparative detections at Lower Snake and Columbia River dams from our study and traps at the head of Lower Granite pool (Buettner and Nelson 1991) to estimate survival to the head of Lower Granite pool. For this method, we must make two assumptions that may not be true: first, we assume that the smolts of unknown origin that they tag are representative of the natural smolts that we tag; and second, we assume equal detection rates at the dams even though the peak arrival timing for the smolts they tag occurs earlier than the peak arrival timing for the smolts we tag.

Our estimates of chinook salmon parr-to-smolt survival to the head of Lower Granite pool based on August 1990 PIT tagging were 6.9% for USR and 23.2% for CR. For August 1990 age 2+ and older steelhead trout, parr-to-smolt survival estimates to the head of Lower Granite pool were 3.7% for USR and 39.9% for CR.

For the three smolt migration years studied at both sites (1989-91), PIT tag detection rates for all steelhead trout groups have been consistently higher for CR than USR. In smolt migration year 1991, this difference in PIT tag detection rates for steelhead trout from our two study areas got much wider. We estimated very low survival to Lower Granite pool of USR age 2+ and older steelhead trout parr PIT tagged during summer and fall in 1989 (7.8% and 12.48, respectively) and 1990 (3.7% and 7.38, respectively). This raises doubts that the current stock of steelhead trout (lower Snake River A-run) can produce a self sustaining natural population in the USR with current poor mainstem survival conditions (IDFG 1990). For August 1987 and 1988 PIT tagged steelhead trout age 2+ and older parr from USR our estimated survival rates to the head of Lower Granite pool were 23.3% and 20.4% respectively. The majority of USR age 2+ and older steelhead trout parr we PIT tagged in August 1987 and 1988 were probably produced from Pahsimeroi Fish Hatchery fry outplants. It is possible that parr resulting from Pahsimeroi Fish Hatchery fry outplants survive to the head of Lower Granite pool at a higher rate than parr produced from Sawtooth Fish Hatchery adult steelhead trout returns released above the weir to spawn. However, the low number of unmarked adult steelhead trout returning to the USR the past few years indicates that even the fry outplants from Pahsimeroi Fish Hatchery did not return enough adults to produce a self sustaining population.

The estimated survival of CR age 2+ and older steelhead trout from August PIT tagging to the head of Lower Granite pool(39.9%) was the highest we have observed, but still fairly close to what we estimated in migratory year 1989 (33.5%). These data suggest that given adequate smolt-to-adult survival rates CR should be able to produce a viable naturally reproducing steelhead trout population.

Smolt Production

A major objective of this project is to develop adult escapement-to-smolt production curves for both chinook salmon and steelhead trout. Our study design breaks this objective down into two components; egg-to-parr survival and parr-to-smolt survival.

When we combine our estimates of chinook salmon egg-to-parr survival from USR and CR, we can calculate a mean of 11.7% ± 3.0% at alpha = 0.05. We believe this estimate is unreliable because of several factors. First, our estimate of 55% of the USR chinook salmon fry emigrating was calculated only in 1 year and has some tenuous assumptions. Second, estimates of parr abundance using the snorkel count method could be negatively biased if rearing is occurring in small side channels and tributaries that we do not sample. Finally, in no year do we have a direct estimate of chinook salmon egg-to-parr survival for CR; either the weir was not operated during the entire migration or we were not able to directly estimate the parr population with snorkel counts. However, we do have confidence in our estimates of chinook salmon egg-to-parr survival from the headwaters of the USR. These estimates have averaged 20.2% and have ranged to 32%.

The average chinook salmon parr-to-smolt survival rate for both USR and CR were fairly similar, 8.8% and 11.18, respectively. These estimates are for parr PIT tagged in August, and the survival is to the head of Lower Granite pool. For smolt migration year 1991, the CR chinook salmon parr-to-smolt estimate increased to 23.2%. We believe this increase occurred, because, in the previous 2 years in CR, we were primarily PIT tagging chinook salmon parr produced from hatchery fry outplants. The later migrating CR smolts benefited from the heavy late spring rains in 1991 like the USR sockeye/kokanee salmon did. Because of this, we believe that under good sub-basin flow conditions 23.2% is more representative of the true CR natural chinook salmon parr-to-smolt survival rate.

With this information, we estimate that an USR female chinook salmon spawner produced (during drought conditions) on average 94 smolts to the head of Lower Granite pool, and for CR the average is 118 smolts. These estimates are based on the following assumptions. The USR female chinook salmon have an average fecundity of 5,233. Our headwaters USR adult supplementation research gives us our best estimate of what the average egg-to-parr survival rate for the USR (20%). The average USR chinook salmon parr-to-smolt survival to the head of Lower Granite pool based on PIT tag detections (9%) is accurate. For CR chinook salmon the average fecundity has been 4,203. The average estimated egg-to-parr survival rate for CR chinook salmon has been 12% (this estimate is based on incomplete data). And our best estimate of CR natural chinook salmon parr-to-smolt survival based on PIT tag detections is the 23% we observed in 1991. This means that forthesetwo natural chinook salmon populations to replace themselves (if these survival estimates are correct) they need a smolt to adult survival rate of 2.1% for USR and 1.7% for CR.

At extremely high density levels, we believe there will be a reduction in parr body condition and a corresponding reduction in the parr-to-smolt survival rate.

If enough adult chinook salmon are available for supplementation at high densities we should be able within the next 3 years to develop adult-to-smolt production curves for chinook salmon at both study areas. However, we are not sure if the results from our two study areas will be applicable to the rest of the anadromous streams in Idaho.

For steelhead trout, we do not know at this time if we will be able to successfully use adult outplants to evaluate egg-to-parr survival at middle and high escapement levels. Within the next 3 years, we should be able to develop the low seeding level portion of the adult steelhead trout escapement-to-smolt production curve, and the middle to high portions are dependant upon our success with adult outplants.

RECOMMENDATIONS

1. Our survival estimates and adult returns at Sawtooth Fish Hatchery indicate that Sawtooth Fish Hatchery adult steelhead trout released above the weir are not producing a self sustaining natural population with current survival conditions. We recommend trying alternative brood stocks to supplement steelhead trout in the USR.

2. The NMFS and our PIT tag detection data from Lower Granite Dam indicates that Snake River stocks of wild/natural chinook smolts arrive at Lower Granite Dam over an extended period and that each stock appears to have its own unique arrival timing. We recommend that measures taken to improve smolt migration survival occur over the entire smolt migration period to rebuild all wild/natural Snake River chinook salmon stocks.

3. We recommend that further work be conducted to eliminate adult and juvenile passage problems associated with irrigation diversions in the upper Salmon

River. Complete dewatering of streams (Fourth of July, Champion, Williams, Fisher, and Beaver creeks) during summer and early fall prevents adult chinook salmon from reaching spawning areas where we have estimated better chinook salmon egg-to-parr survival rate than what we estimated for the mainstem upper Salmon River. U.S. Forest Service personnel have observed salmonids stranded in drying pools of Fourth of July and Champion creeks as they became dewatered in 1991 (Walter McClure personnel communication). In addition, all of these tributaries have unscreened diversions; and we have observed chinook salmon and steelhead trout parr in all of the streams listed above except Williams and Fisher creeks. In all probability, juvenile chinook salmon and steelhead trout are being lost down these diversions; especially in the fall as approximately 60% will attempt to emigrate downstream to overwinter.

4. Because of the uncertainties of Perry and Bjornn's (1992) estimate of the proportion of USR chinook salmon fry emigrating in the spring and the effect of this estimate on our stock/recruitment curves, we recommend refinement of these estimates.

5. We recommend that snorkel count surveys to estimate juvenile salmonid densities not be conducted when the daily water temperatures do not reach 10°C.

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Submitted by:

Russell B. Kiefer
Sr. Fishery Research Biologist

Jerald N. Lockhart
Sr. Fishery Technician

Approved by:

IDAHO DEPARTMENT OF FISH AND GAME

Steven M. Huffaker, Chief
Bureau of Fisheries

Virgil K. Moore
Fisheries Research Manager