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RECRUITMENT OF RAINBOW TROUT IN THE HENRYS FORK OF THE SNAKE RIVER, IDAHO

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BY:

Matthew G. Mitro, Graduate Student
Alexander V. Zale, Principal Investigator
Montana Cooperative Fishery Research Unit
Department of Biology, Montana State University
Bozeman, Montana 59717

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1996 Annual Report

Matthew G. Mitro
Graduate Student

Alexander V. Zale
Principal Investigator

Montana Cooperative Fishery Research Unit
Department of Biology, Montana State University
Bozeman, Montana 59717

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INTRODUCTION

The Henrys Fork of the Snake River has long been renowned as one of the world's best rainbow trout (Oncorhynchus mykiss) fly fishing rivers. Since 1978, the river section from Island Park Dam to Riverside Campground has been managed under special regulations to protect the fishery, including catch-and-release since 1988. However, there has been a steady decline in the fishery in this section of river during this time period according to Idaho Department of Fish and Game (IDFG) population estimates and angler surveys. An increase in numbers of rainbow trout occurred in 1993 following the 1992 drawdown of Island Park Reservoir, but the fishery began to decline again thereafter. The causes of these fluctuations in the rainbow trout fishery are not well understood. Recruitment may have been limited by the loss of concealment cover resulting from overgrazing of aquatic macrophytes and siltation and dewatering of interstitial spaces. Prior to the screening of most of the discharge from the dam beginning in 1993, recruitment may have been augmented by the input of rainbow trout from Island Park Reservoir.

Much of the biology of the rainbow trout in the Henrys Fork remains unknown. The temporal and spatial variation of spawning has not been determined. Optimal and marginal habitat for juvenile rainbow trout has not been identified, nor has seasonal use of and movement among these habitats. Answers to these questions are necessary to begin to understand the recruitment dynamics of rainbow trout in the Henrys Fork.

The overall goal of this study is to develop an understanding of the processes affecting rainbow trout recruitment rates in the Henrys Fork of the Snake River from Island Park Dam to Riverside campground. We are investigating spawning activity, quantifying immigration of

hatchery rainbow trout from Island Park Reservoir to the Henrys Fork, determining seasonal abundances and survival rates of juvenile rainbow trout in study sections, and quantifying movements of juvenile rainbow trout among these sections. With this information, we will evaluate the ability of the fishery to sustain itself.

STUDY SITE

The Henrys Fork of the Snake River from Island Park Dam to Riverside Campground was divided into the following five sections for sampling juvenile rainbow trout (Figure 1): 1. Box Canyon (mouth of Buffalo River to head of Box Canyon rapids; 4 km); 2. Last Chance (tail of Box Canyon rapids to Harriman north fence; 4 km); 3. Harriman State Park (Railroad Bridge to Osborne Bridge; 4.5 km); 4. Harriman East (Osborne Bridge to Pinehaven development; 6.1 km); and 5. Pinehaven-Riverside (Pinehaven development to Riverside Campground; 4.5 km). Box Canyon was further divided into the upper Box Canyon (1.5 km) and the lower Box Canyon (2.5 km). An additional section, extending from Island Park Dam to the United States Geological Survey (USGS) gauging station (0.25 km), was searched for spawning redds.

OBJECTIVES

1. To identify rainbow trout spawning areas in the Henrys Fork below Island Park Dam and quantify spawning activity therein.

2. To determine seasonal abundances and survival and mortality rates of juvenile rainbow trout in study sections of the Henrys Fork.

3. To quantify immigration of hatchery rainbow trout from Island Park Reservoir to the Henrys Fork below Island Park Dam.

4. To quantify movement of juvenile rainbow trout among study sections.

5. To develop a protocol of techniques used to accomplish the preceding objectives to facilitate their subsequent use by IDFG personnel for monitoring purposes. The protocol will detail the efficient and effective conduct of techniques and methods found to be useful during the course of the study; it will also describe methods that failed to produce useful data, and reasons for such failures.

This report describes progress on the first four objectives during calender year 1996. Objective 5 will be addressed upon completion of the study, after all techniques used have been fully evaluated.

METHODS

Estimates of Redd Abundance

Redd densities were estimated using distance sampling techniques (Buckland et al. 1993) and the computer program DISTANCE (Laake et al. 1994). Replicate transects perpendicular to flow were randomly selected within the study section from Island Park Dam to the USGS gauging station; other sections were not sampled in 1996 because of time constraints. Locations

of redds on either side of a transect of known length were recorded to estimate the effective area sampled and the density of redds. Locations were identified by perpendicular distance (m) from the transect to the redd center. An estimate of the total number of redds in a section was obtained by extrapolating the estimate of density across the total available spawning area within the section.

Seasonal Estimates of Juvenile Rainbow Trout Abundance and Survival and Mortality Rates

A robust design was used to estimate seasonal abundances and survival and mortality rates of juvenile (i.e., < 200 mm total length (TL)) rainbow trout. The population (in a statistical sense) was considered open between primary sampling periods, hereafter referred to as seasons, and closed between secondary sampling periods, hereafter referred to as within-season sampling periods (i.e., days). Sampling seasons in 1996 were spring (mid-May to mid-June), summer (August), and autumn (October) (Table 1). Within-season sampling periods ranged from two to five days and were usually interspersed with days on which sampling did not occur.

Marking

Visible implants of fluorescent elastomer (VIE) were used to identify capture seasons and capture sections of trout 60-200 mm TL. One color located in the right post-ocular area was used in all sections to indicate year of first capture for the year beginning in the summer sampling season. The year mark was red in spring 1996 (as well as summer and autumn 1995) and orange in summer and autumn 1996. An additional mark was used to denote the study section (using

different colors) and season (using different marking locations) of capture. Colors to denote study sections were as follows: Box Canyon, blue; Last Chance, red; Harriman State Park, green; Harriman East, yellow; and Pinehaven-Riverside, orange. These were injected in the left pelvic fin in spring 1996, the left post-ocular area in summer 1996, and the left pectoral fin in autumn 1996.

Within-season capture histories were indicated by a unique fin clip for each sampling date. Fin clips were minimized in size to allow mark recognition among within-season sampling periods and regeneration between seasons.

Age Analyses

Scales were collected from up to 10 juvenile rainbow trout in each 10-mm size class, ranging from 60 to 219 mm TL, in each section and in each season from spring 1995 to autumn 1996. Three scales from each fish were pressed onto cellulose acetate slides. Two individuals independently read each set of scales.

Abundance

Seasonal estimates of abundance were obtained using either mark-recapture or removal methods. Mark-recapture data were analyzed using the Lincoln-Petersen and the modified Schnabel estimators (Ricker 1975) and mark-recapture models in the computer program CAPTURE (Otis et al. 1978; White et al. 1982; Pollock et al. 1990; Rexstad and Burnham 1991). Removal data were analyzed using the removal estimator option in CAPTURE.

CAPTURE uses closed-population mark-recapture models that allow for unequal capture probabilities. The program considers a range of different models allowing for capture heterogeneity among individuals (model M(h)), variation in behavioral response to capture and recapture (model M(b)), temporal variation to capture (model M(t)), or some combination thereof (e.g., model M(tb)), and includes an objective method for selecting the most appropriate model for a given data set. A complex interaction of population size (N), capture probability (p), and number of sampling periods is required for reliable model selection by CAPTURE. N should be sufficiently large (e.g., 50), p should be greater than 0.1, and five or more sampling periods, among which sampling effort is equal, are optimal.

Individual capture histories are required to use CAPTURE or the modified Schnabel method. Alternatively, data from secondary periods can be pooled into early and late samples to use the Lincoln-Petersen method. The Lincoln-Petersen method may be preferable to CAPTURE in situations where model selection is poor (e.g., low capture probabilities) (Menkins and Anderson 1988). If CAPTURE results were unreliable (e.g., because of low capture probabilities), either a Lincoln-Petersen or a modified Schnabel estimate was chosen based on maximizing the number of recaptures used by the estimator.

Mark-Recapture. Abundance estimates were obtained for 100-m sample areas in lower Box Canyon, Last Chance, and Harriman State Park and extrapolated to estimate total abundances in these sections. Sample areas were defined as bank-to-bank areas about 100 m long. A greater proportion of juvenile rainbow trout could be marked, and thus recaptured, in sample areas as compared to entire study sections. A stratified random procedure was used to select the sample areas; sample areas were separated by at least 1 km to reduce the likelihood that

fish marked in one sample area would move to another sample area within a season. The same sample areas were used in each season in 1995 and 1996.

Juvenile rainbow trout were collected along eight transects perpendicular to the current in each 100-m sample area by wading with boat-mounted electrofishing gear (continuous DC, 175-250 V). One person operated the electrical on-off switch, held the bow of the drift boat, and waded across the river with the boat parallel to the current. An electrode ring was suspended port or starboard in the direction that the boat was moving. Another person, positioned downstream of the electrode ring, netted fish. The amount of effort in each sample area was equal among sampling dates. The channel location of each juvenile rainbow trout collected in the 100-m sample areas was recorded as follows: within 2 m of the west bank and associated woody debris, center channel, or within 2 m of the east bank and associated woody debris.

Abundances in two 100-m sample areas were assessed in the lower Box Canyon in summer and autumn (high discharges necessitated use of removal techniques in spring; see below). Sample areas 1 and 2 were located about 1.75 km and 2.75 km below the confluence of the Buffalo River. Area 1 was sampled 5 d in both summer and autumn, and area 2 was sampled 3 d in summer and 5 d in autumn.

Two 100-m sample areas in Last Chance were located about 1.5 km (area 1) and 3 km (area 2) downstream from the upper boundary of the section. Abundance estimates were obtained in both summer and autumn, but only in area 1 during spring; high discharges precluded sampling of area 2 then. Area 1 was sampled 3 d in spring and 5 d in both summer and autumn. Area 2 was sampled 4 d in summer and 5 d in autumn.

A single 100-m sample area, located about 0.7 km downstream from the upper boundary of the section, was assessed in Harriman State Park in each season. Sampling there occurred on 1 d in spring, 5 d in summer, and 2 d in autumn. Abundances in this area were extrapolated to estimate total abundances in the 1-km reach below the Railroad Bridge.

No 100-m sample areas were used in the upper Box Canyon, Harriman East, and Pinehaven-Riverside because it was not possible to wade across the river channel in these sections. Abundance estimates in Harriman East and Pinehaven-Riverside were obtained by mark-recapture of juvenile rainbow trout collected by drifting with electroshocking gear through the entire sections. Sampling in Harriman East occurred on 3 d in both spring and summer (1 run per day) and 2 d in autumn (2 runs per day). Five days of sampling (2 runs per day) were performed in Pinehaven-Riverside during spring and summer, and 2 d (2 runs per day) were completed in autumn.

Removal. Bank sections were sampled using removal methods in the upper Box Canyon and Pinehaven-Riverside because drifting with electroshocking gear was inefficient at sampling the complex bank habitats in these sections. Bank sections were also sampled in the lower Box Canyon in spring (in conjunction with upper Box Canyon) when discharge was too high to wade across the 100-m sample areas.

Bank samples were collected with a hand-held probe operated from the boat-mounted electrofishing gear. Samples consisted of one-pass removals, three-pass removals, or independent one-pass and three-pass removals of the same section along a known length of bank; sampling was generally within 2 m of the bank and associated woody debris.

Three-pass removal data were required for the use of the removal estimator in CAPTURE to estimate numbers of juvenile rainbow trout along sections of riverbank. Independent one-pass and three-pass removal estimates of the same section along a known length of bank were used to construct a regression model to predict three-pass removal estimates of abundance from one-pass removal data. Predicted three-pass removal estimates were obtained for one-pass removal data using the regression model.

Twenty 10.0- to 14.5-m bank sections (10 on each bank) were sampled throughout Box Canyon (i.e., both upper and lower reaches) during spring by one-pass removal, and 10 (5 per bank) of these were sampled independently by three-pass removal. Ten (5 per bank) 12.1- to 15.7-m sections were sampled in the upper Box Canyon during summer by one-pass (2 east bank, 5 west bank) or three-pass (3 east bank) removals. Nine (4 east bank, 5 west bank) 11.0- to 14.8-m sections were sampled there in autumn by three-pass removal and 5 of these (1 east bank, 4 west bank) were sampled independently by one-pass removal. Ten (5 per bank) 12.0- to 15.0-m sections were sampled in Pinehaven-Riverside by one-pass removal in spring; two of these were independently sampled by three-pass removal. Ten (5 per bank) 17.0- to 27.0-m Pinehaven-Riverside bank sections were sampled in summer by one-pass removal.

A mean of the bank-section estimates was extrapolated to provide an estimate of total abundance along each bank in a section. The spring 1995 estimate of abundance in Box Canyon was recalculated using the regression model to predict three-pass removal estimates from the one-pass removal data, and all confidence intervals for 1995 in Box Canyon were recalculated to include both the error term within bank sections and the error term among bank sections.

Survival and Mortality

Jolly-Seber models, available in the computer programs MARK and POPAN, will be used to obtain seasonal estimates of survival. A rough estimate of the overwinter mortality rate between autumn 1995 and spring 1996 was obtained by comparing the total estimates of abundance and 95% CI's for these seasons, but this estimate may include losses to emigration downstream.

Immigration of Hatchery Rainbow Trout

About 25% of 750,000 hatchery juvenile rainbow trout stocked in Island Park Reservoir (i.e., about 187,500) received an adipose clip to allow recognition of reservoir fish that migrated to the Henrys Fork. All rainbow trout captured in the Henrys Fork below Island Park Dam were inspected for an adipose clip.

Movement of Juvenile Rainbow Trout

Movement Among Study Sections

Movement, or lack thereof, was detected by recapturing trout marked with VIE. All trout collected were inspected for VIE. The same sample areas were resampled from season to season such that a high proportion of juvenile rainbow trout in these areas were marked, and restricted movement could be recognized by the recapture of trout originally marked in these areas. Long

range movement was detected by sampling many areas throughout the five study sections and by recapturing marked individuals in sections other than those in which they were marked.

Movement Within Study Sections

The closure assumption was tested for sample areas for within-season sampling periods. That is, we wanted to determine how much movement upstream or downstream out of a 100-m sample area occurred within a seasonal sampling period. Juvenile rainbow trout were marked and recaptured in 50-m areas upstream and downstream adjacent to sample area 1 in Last Chance in both summer and autumn. A unique fin clip was assigned to each adjacent area to identify movement into and out of the sample area.

Measurements of Habitat Variables

Cover and Substrate

Habitat measurements were taken at each of the 20 bank sections sampled in Box Canyon in spring. Measurements of cover consisted of the number of surfaces associated with woody debris, macrophytes, and boulders (Kinsolving and Bain 1990) and measurements of substrate were based on a modified Wentworth scale (Bain et al. 1985). Measurements were obtained at 0.2-m intervals along transects perpendicular to the current at 1-m intervals along the bank; a mean of 82 cover and substrate observations were obtained for each bank section. Habitat measurements were also obtained in Last Chance sample area 1 in spring. Cover and substrate were measured at 1-m intervals along three transects for a total of 270 observations.

Water Temperature

Hobo-Temp temperature loggers (Onset Computer Corporation) were used to record water temperatures. Temperature loggers were placed on the substrate along the east and west banks in Box Canyon about 2 km downstream from the upper boundary of the section, at the Railroad Bridge in Harriman State Park, and about 100 m upstream of Riverside Campground. Water temperature was recorded every 3 h beginning on 9 September 1995.

RESULTS

Estimates of Redd Abundance

The DISTANCE analysis of redd observations from Island Park Dam to the USGS gauging station on four dates from 30 March to 21 April 1996 showed an increasing trend in the total numbers of redds (Table 2). There was an insufficient number of redd observations on 30 March (N=2) for DISTANCE to estimate redd density. The maximum number estimated was 16 redds (95% CI, 6-42) on 21 April 1996. Visibility was reduced because of an increase in discharge by 21 April 1996. Thereafter, it was not feasible to wade or snorkel to sample redds because of an additional increase in discharge.

Seasonal Estimates of Juvenile Rainbow Trout Abundance and Survival and Mortality Rates

Age Analyses

Age data from 1995 and 1996 have not been analyzed yet. The estimates of abundance and survival and mortality rates were for juvenile rainbow trout < 200 mm TL and not for cohorts. A retroactive application of age analyses will partition 1995 and 1996 abundance estimates and survival and mortality rates into age cohorts.

Prediction of Three-Pass Removal Estimates from One-Pass Removal Data

Predicted estimates of abundance from one-pass removal data were obtained from the following regression model: predicted three-pass abundance = (0.643165) + (1.481706)one-pass abundance (r^2=0.75, P=0.0001, N=21) (Figure 2).

Spring

The estimated mean number of trout along a 10-m bank section in Box Canyon in spring 1996 was 13 for the east bank (95% CI, 2-26; N=10) and 8 for the west bank (95% CI, 0-19; N=10). A difference in the number of trout along each bank was detectable at the α=0.16 level (Wilcoxon rank sum test; P=0.16). Extrapolation of these estimates indicated a total abundance of 8,241 juvenile rainbow trout along the banks of Box Canyon (95% CI, 878-18,056) (Table 3).

Young-of-year (YOY) rainbow trout ranging from 27 to 34 mm TL were captured at 10 east bank sections and 2 west bank sections in Box Canyon, but were not included in the spring

abundance estimate for Box Canyon because the mesh of the sampling nets was not fine enough to efficiently capture fish < 40 mm TL.

The Lincoln-Petersen method was used to estimate abundance in sample area 1 in Last Chance because sample size was small and capture probabilities were low (Table 3). Extrapolation of this estimate indicated a total abundance of 2,008 juvenile rainbow trout in Last Chance (95% CI, 742-5,032). This estimate was extrapolated from sample area 1 only; sample area 2 could not be sampled because of high discharge.

Abundance was not estimated for the 100-m sample area in Harriman State Park because no trout were captured. Four adult and five juvenile rainbow trout were captured in Harriman State Park in five runs from the Railroad Bridge to the Osborne Bridge. A few YOY were seen above the Railroad Bridge on 19 June. We concluded that abundances in Harriman State Park were negligible.

Four adult and two juvenile rainbow trout were captured in Harriman East in five runs. Abundance was not estimated because no trout were recaptured. We concluded that abundances in Harriman East were negligible.

The Lincoln-Petersen method was used to estimate abundance in Pinehaven-Riverside because capture probabilities were low (Table 3). An estimated 666 juvenile rainbow trout were in Pinehaven-Riverside (95% CI, 202-1,211) (Table 3); 130 adults were also captured. Only four juvenile rainbow trout were captured in ten bank sections in Pinehaven-Riverside. A few YOY were also captured.

The estimate of total abundance of juvenile rainbow trout in the five study sections in spring was 10,915 (95% CI, 1,822-24,299) (Table 3). Most of these were located in Box Canyon.

Summer

The estimated mean number of juvenile rainbow trout along a 10-m bank section in Box Canyon was 22 for the east bank (95% CI, 2-51; N=5) and 9 for the west bank (95% CI, 2-19; N=5). A difference in the number of trout along each bank was detectable at the α=0.06 level (Wilcoxon rank sum test; P=0.06). Extrapolation of these estimates indicated a total abundance of 4,626 juvenile rainbow trout along the banks of the upper Box Canyon during summer (95% CI, 248-11,672) (Table 3).

The model M(b) in CAPTURE was used to estimate abundance in sample areas 1 and 2 in Box Canyon (Table 3). Extrapolation of these estimates indicated a total abundance of 17,732 juvenile rainbow trout in the lower Box Canyon (95% CI, 13,221-33,884).

The model M(h) in CAPTURE was used to estimate abundance in sample area 1 and the model M(o) was used for sample area 2 in Last Chance (Table 3). Extrapolation of these estimates indicated a total abundance of 57,135 juvenile rainbow trout in Last Chance (95% CI, 46,970-130,705) .

The Lincoln-Petersen method was used to estimate abundance in sample area 1 in Harriman State Park because sample size was small and capture probabilities were low (Table 3). Extrapolation of this estimate indicated a total abundance of 10,075 juvenile rainbow trout in Harriman State Park (95% CI, 3,692-25,194).

A total of 51 juvenile rainbow trout was captured in 3 runs in Harriman East; 46 were captured within the last 0.5 km of the section in a spring-fed area along the east bank (water temperature 7-7.5°C) and 5 were captured throughout the rest of Harriman East (water temperature 14-14.5°C). We concluded that abundances in Harriman East were negligible.

The Lincoln-Petersen method was used to estimate abundance in Pinehaven-Riverside because capture probabilities were low. An estimated 1,464 juvenile rainbow trout were in Pinehaven-Riverside (95% CI, 434-2,662) (Table 3). Only 22 juvenile rainbow trout were captured in 10 bank sections.

The estimate of total abundance of juvenile rainbow trout in the five study sections in summer was 91,032 (95% CI, 64,565-204,117) (Table 3). Over half of these were located in the Last Chance section.

Autumn

The estimated mean number of trout along a 10-m bank section in the upper Box Canyon was 65 for the east bank (95% CI, 0-161; N=4) and 13 for the west bank (95% CI, 0-31; N=5). A difference in the number of trout along each bank was detectable at the α=0.07 level (Wilcoxon rank sum test; P=0.07). Extrapolation of these estimates indicated a total abundance of 11,738 juvenile rainbow trout along the banks of the upper Box Canyon (95% CI, 0-28,867) (Table 3).

The model M(t) in CAPTURE was used to estimate abundance in sample area 1 and the model M(b) was used for sample area 2 in Box Canyon (Table 3). Extrapolation of these estimates indicated a total abundance of 40,202 juvenile rainbow trout in the lower Box Canyon (95% CI, 32,434-52,807).

The model M(t) in CAPTURE was used to estimate abundance in sample area 1 and the model M(o) was used for sample area 2 in Last Chance (Table 3). Extrapolation of these estimates indicated a total abundance of 94,162 juvenile rainbow trout in Last Chance (95% CI, 79,4262-143,394).

The Lincoln-Petersen method was used to estimate abundance in sample area 1 in Harriman State Park because there were only two capture occasions (Table 3). Extrapolation of this estimate indicated a total abundance of 16,380 juvenile rainbow trout in Harriman State Park (95% CI, 6,682-40,950).

The Lincoln-Petersen method was used to estimate abundance in Harriman East because there were only two capture occasions. Extrapolation of this estimate indicated a total abundance of 2,673 juvenile rainbow trout in Harriman East (95% CI, 1,193-6,682) (Table 3). Juvenile rainbow trout were not concentrated in the spring-fed area along the east bank in the last 0.5 km of Harriman East as they had been in summer.

Absence of recaptures in Pinehaven-Riverside precluded abundance estimation.

The estimate of total abundance of juvenile rainbow trout in the five study sections in autumn was 165,155 (95% CI, 119,735-272,700) (Table 3). A majority of these were present in Last Chance.

Recalculated 1995 Estimates

Extrapolation of recalculated estimates for bank sections in Box Canyon in spring 1995 indicated a total abundance of 14;719 juvenile rainbow trout along the banks (recalculated 95% CI, 4,873-28,388) (Table A1). The recalculated 95% CI for the summer estimate of abundance

along the banks in Box Canyon was 0-6,574 (mean, 2,389) and for autumn was 0-15,484 (mean, 6,707) (Table A1). The mean estimates of abundance in summer and autumn did not change.

Survival and Mortality

Comparisons of abundance estimates suggested a mean overwinter mortality rate (possibly including downstream emigration) of about 91% (95% CI, 68-99%).

Immigration of Hatchery Rainbow Trout

No juvenile rainbow trout we captured in 1996 had an adipose clip. Thus, there was no evidence that juvenile rainbow trout stocked in Island Park Reservoir had migrated into the Henrys Fork below the dam

Movement of Juvenile Rainbow Trout

Movement Among Study Sections

We recaptured 11 juvenile rainbow trout marked in 1995 in 1996; 4 were marked and recaptured in Box Canyon, 2 were marked in Box Canyon and recaptured in Pinehaven-Riverside, 1 marked in Last Chance and 1 marked in Harriman East were recaptured in Pinehaven-Riverside, and 3 were marked and recaptured in Pinehaven-Riverside (Table 4). No juvenile rainbow trout marked in 1995 was recaptured in 1996 in Last Chance, Harriman State Park, or Harriman East.

Most recaptured fish did not move. Two juvenile rainbow trout marked in Box Canyon and four marked in Pinehaven-Riverside in spring 1996 were recaptured in summer 1996 in the sections they were marked (Table 4). Thirty two (32) juvenile rainbow trout marked in Box Canyon, 31 marked in Last Chance, and 2 marked in Harriman State Park in summer 1996 were recaptured in autumn 1996 in the section they were marked (Table 4). All recaptured trout marked in Pinehaven-Riverside in 1995 and 1996 were there (Table 4).

Some movement was detected between summer and autumn 1996. One juvenile rainbow trout marked in Last Chance was recaptured in Pinehaven-Riverside and one marked in Harriman State Park was recaptured in Last Chance (Table 4). A fish marked in Box Canyon in summer 1995 had moved to Harriman East by autumn 1995.

Movements of two juvenile rainbow trout in 1995 were detected within seasons (Table 4). An individual captured in Last Chance in spring was recaptured in Pinehaven-Riverside, moving > 15 km in ≤ 24 d, and an individual captured in Last Chance in autumn was recaptured in Box Canyon, moving > 4 km in ≤ 14 d. However, there was also evidence that juvenile rainbow trout were not moving within seasons. Juvenile rainbow trout were consistently recaptured within the areas they were marked in all sample areas in Box Canyon, Last Chance, and Harriman State Park.

A total of 130 juvenile rainbow trout was recaptured in different seasons or in different sections within a season in 1995 and 1996. There was no movement between sections for 91% of these fish, 6% had moved downstream, and 3% had moved upstream (Table 4).

Movement Within Study Sections

Most juvenile rainbow trout that were recaptured in sample area 1 or in the areas upstream or downstream adjacent to sample area 1 in Last Chance were in the area they were marked (Table 5). However, there was some movement of marked fish outside of the area they were marked; most of the movement was downstream. There was a decreasing trend in the number of recaptured fish as the distance from the marking area increased, both upstream and downstream (Table 5).

Measurements of Habitat Variables

Cover and Substrate

The bank habitat in Box Canyon generally consisted of woody debris and rock substrate and the habitat in Last Chance generally consisted of macrophyte cover and rock substrate. Quantitative measurements of cover and substrate have not been analyzed.

Water Temperature

Water temperatures were about 0.5 °C higher on average along the east bank in Box Canyon (mean, 3.48 °C) than along the west bank (mean, 2.96 °C) during the winter months from November through February. There was greater variability in water temperature along the east bank (SD, 1.26) than along the west bank (SD, 0.59) (Figure 5). The minimum and maximum water temperatures were 0.6 °C and 6.6 °C along the east bank and 1.7 °C and 5.3 °C along the west bank during winter. Water temperatures were cooler and more variable in

Harriman State Park (mean, 1.79 °C; SD, 1.57) and Pinehaven-Riverside (mean, 1.72 °C; SD, 1.57) than in Box Canyon in winter (Figure 6). Summer water temperature data summer has not yet been retrieved.

Other Observations

A total of 119 YOY (i.e., age-0 rainbow trout) and 14 juvenile rainbow trout (i.e., age 1 or 2 in spring) were captured at six east bank sections and a total of 45 YOY, 2 juvenile rainbow trout, and 1 adult rainbow trout were captured at four west bank sections in Box Canyon on 18 and 19 June. The YOY ranged from 23 to 59 mm TL and most were in the 30-50 mm size class that was not well represented in Box Canyon in late May. Total discharge had decreased in the previous month and it appeared that the juvenile rainbow trout had moved away from the bank and were replaced by YOY. A section in which 60 juvenile rainbow trout were collected in late May yielded no juvenile rainbow trout in late June.

DISCUSSION

Estimates of Redd Abundance

Distance sampling techniques provided an unbiased sampling method to estimate the abundance of spawning redds. The method was particularly useful for sampling large-scale areas such as Box Canyon and Last Chance in 1995, where a traditional census was not feasible. The

1995 samples resulted in abundance estimates on single sampling dates in each section that described the spatial scale of spawning activity from Island Park Dam through Last Chance. Spawning activity was concentrated in the section between Island Park Dam and the USGS gauging station and was limited in other sections.

The 1996 samples resulted in abundance estimates for three dates in the section between Island Park Dam and the USGS gauging station that described the temporal scale of spawning activity. There was an increasing trend in the estimated number of redds in the sampling area from 30 March to 21 April. Spawning likely continued during the time of increased discharge after 21 April, but was impossible to estimate. The presence of YOY rainbow trout, about 25-35 mm TL, in samples collected from mid-May to mid-August was indirect evidence of spawning across a larger temporal scale than indicated by the sampling from 30 March to 21 April. Spawning may have continued into July.

Seasonal Estimates of Juvenile Rainbow Trout Abundance and Survival and Mortality Rates

Abundance in Study Sections

Samples collected in Box Canyon in 1996 showed the importance of bank habitat to juvenile rainbow trout. During spring, high discharge from runoff compromised the effectiveness of drifting with electrofishing gear to capture juvenile trout because they were holding tight to cover. Sampling bank sections with hand-held electrofishing gear facilitated their capture.

The difference in the number of trout per bank section on each side of the river in Box Canyon was not detectable at the α=0.05 level in 1996, but there did tend to be a greater abundance along the east bank. The failure to detect a difference at this significance level may have resulted from small sample size. Most of the variability in the bank estimates of abundance was attributable to the variability among bank sections rather than within sections. To increase our sample size in the future, we will use the relation between one-pass and three-pass removals to allow predictions of abundance from a single pass removal. If the time saved by not completing a second and third pass was used to sample more bank sections, the among-bank section variability could be reduced and any difference between banks may be detected at a lower significance level.

The greater abundance of juvenile rainbow trout along the east bank in Box Canyon may be related to the difference in water temperature between the banks. The spring-fed Buffalo River enters the east side of the Henrys Fork at the upper boundary of Box Canyon, merging with water released from Island Park Reservoir. The difference in temperature measured about 2 km downstream from the upper boundary of the section suggested that water did not mix from bank to bank in the upper half of the Box Canyon. This difference may be particularly important in winter. Previous studies have found higher overwinter mortality at colder temperatures (e.g., Hunt 1969; Smith and Griffith 1994).

Most of the juvenile rainbow trout captured in spring were in Box Canyon or Pinehaven-Riverside, suggesting that these sections provided the best overwinter habitat. Although Last Chance supported the greatest abundance of juvenile rainbow trout in summer and autumn, it provided inadequate overwinter habitat, as was evident by the substantial loss of trout to either

mortality or migration between autumn and spring. Harriman State Park and Harriman East failed to provide habitat for juvenile rainbow trout throughout most of the year. The absence of trout in Harriman State Park in spring and Harriman East in spring and summer suggested that trout did not overwinter in these areas.

1995 vs. 1996

Spring abundances of juvenile rainbow trout were highest in Box Canyon in both 1995 and 1996, but shifted to Last Chance in summer and autumn (Figure 3). Abundances increased greatly from spring to summer in these sections in both years, especially in Last Chance (Figure 4). Estimated abundances in these sections decreased from summer to autumn in 1995, but increased in 1996 (Figures 3 and 4). The greatest decrease in the estimated abundance of juvenile trout occurred between autumn 1995 and spring 1996. The seasonal changes in the estimated abundance of juvenile rainbow trout followed a similar trend in Box Canyon and Last Chance (Figure 4).

Very few trout were captured in Harriman State Park and Harriman East in spring 1995 and 1996. No estimate could be obtained and the abundances in these sections were considered negligible in both years (Figure 3). Abundances in Harriman State Park increased through summer and autumn in 1996; an insufficient number of samples were collected to obtain an estimate of abundance in summer 1995, but the abundance increased by autumn. Very few trout were captured in Harriman East in summer 1995 and 1996, so abundances were considered negligible (Figure 3). Abundances in Harriman East increased from summer to autumn in both years. Few juvenile rainbow trout were captured in Pinehaven-Riverside relative to other

sections where estimates were obtained, but the number of trout captured per day was relatively consistent from spring 1995 to autumn 1996. Estimates of abundance for Pinehaven-Riverside have been based on 1 or 2 recaptures; insufficient numbers of samples were collected at other times to obtain an estimate of abundance.

Abundance Estimation

The precision of estimates in mark-recapture sampling is strongly dependent on the number of captures and recaptures, both of which are influenced by capture probability, the number of capture periods, and the true abundance. Rather than sampling entire sections inadequately, smaller areas were sampled more intensively in wadeable sections. The abundance estimates for these smaller sample areas were large (>1,000). Consequently, capture probabilities were often < 0.10, even though there were five capture periods and smaller areas were sampled. The model selection procedure in CAPTURE may not be reliable with such data. There have been recent advances in the use of Akaike's Information Criterion (AIC) for data-based model selection in likelihood contexts (Burnham and Anderson 1992), but some closed population models, e.g., M(h), do not exist in likelihood form, thus negating the use of AIC. We will investigate the use of the bootstrap and Monte Carlo simulation methods to test the validity of different mark-recapture models for large populations (N>1,000) and low capture probabilities (p<0.10), possibly providing an objective method for selecting an appropriate model and determining the confidence with which a model is selected. Improvements in the model selection procedure will reduce the chance of bias in abundance estimates and improve the coverage of confidence intervals.

Variability in the behavior of juvenile rainbow trout or in the behavioral response to capture is suggested by the selection of models such as M(h), M(b), or M(t). Intraspecific variation in fish behavior such as dominance hierarchies, feeding behavior, predator avoidance, and habitat use is common (Magurran 1986; Elliott 1994). It is therefore not unlikely that juvenile rainbow trout may exhibit variation in capture probabilities, and it would be misleading to analyze these data sets assuming otherwise.

Survival and Mortality

The estimate of the mortality rate from autumn 1995 to spring 1996 was not based on an analysis of mark-recapture data. An extensive amount of work has been done on mark-recapture theory as it relates to estimating survival and mortality (e.g., Lebreton et al. 1992; Burnham et al. 1995). The mark-recapture data collected from spring 1995 to autumn 1996 will be analyzed using models for estimating survival and mortality available in the computer programs MARK and POPAN.

Movement of Juvenile Rainbow Trout

Movement Among Study Sections

Identifying the movement of stream salmonids over large spatial scales is inherently difficult (Gowan et al. 1994). By repeatedly sampling short sample areas in Box Canyon, Last Chance, and Harriman State Park, and sampling throughout Harriman East and Pinehaven-Riverside, we were able to detect the movement of juvenile rainbow trout. Other studies have

not been able to detect long range movements because sampling was confined to one area (see review in Gowan et al. 1994). If a high proportion of fish in a single area were marked, resampling in that area would show restricted movement if marked fish were recaptured. This was evident in Box Canyon, Last Chance, and Harriman State Park sample areas (Table 4). However, by sampling in more than one such area, long range movements of juvenile rainbow trout were detected by recaptures in sections other than those they were marked in. Juvenile rainbow trout were less likely to be recaptured in areas they were not originally marked in, but this likelihood of recapture could be increased by sampling more areas or by sampling more intensively in fewer areas. Sampling intensively in fewer areas (but more than one) was preferred because of the increased probability of capturing juvenile rainbow trout that did not move while still being able to detect long range movements.

Movement Within Study Sections

The assumption of closure is necessary to obtain unbiased estimates of abundance when using closed population models. The loss of marked fish or the addition of unmarked fish may result in the overestimation of abundance, the degree of which depends on the extent the assumption was violated. Movements of marked juvenile rainbow trout may not have been representative of unmarked trout. Trout that were captured were removed from their territory and released along the bank near the transect sampled. These fish were induced to move by the sampling process, unlike fish that were not disturbed. Therefore, the extent of the violation of the closure assumption may be limited to captured or disturbed fish and may not necessarily be

significant. Computer simulation and randomization techniques will be used to determine the effect of the closure violation on the estimation of abundance.

Conclusions

The abundance of juvenile rainbow trout in streams and rivers can be limited by a lack of suitable spawning habitat, summer growth habitat, or overwinter habitat (Waters 1995). Although the amount of spawning activity observed in the Henrys Fork was limited, the abundances of juvenile rainbow trout present during summer and autumn suggest that spawning is not a limiting factor. The abundance of juvenile trout observed through autumn also suggests that summer growth habitat is not a limiting factor. However, interstitial spaces necessary for overwinter habitat are largely confined to Box Canyon. Consequently, most overwinter survival has been in Box Canyon and most trout observed in other sections in autumn have not been found in those sections in the following spring.

LITERATURE CITED

Bain, M. B., J. T. Finn, and H. E. Booke. 1985. Quantifying stream substrate for habitat analysis studies. North American Journal of Fisheries Management 5:499-500.

Buckland, S. T., D. R. Anderson, K. P. Burnham, and J. L. Laake. 1993. Distance Sampling: Estimating Abundance of Biological Populations. Chapman and Hall, London.

Burnham, K. P., and D. R. Anderson. 1992. Data-based selection of an appropriate biological model: the key to modern data analysis. Pp. 16-30. In D. McCullough and R. Barret [ed.]. Wildlife 2001: populations. Elsevier, New York.

Burnham, K. P., G. C. White, and D. R. Anderson. 1995. Model selection strategy in the analysis of capture-recapture data. Biometrics 51:888-898.

Elliott, J. M. 1994. Quantitative ecology and the brown trout. Oxford University Press, New York.

Gowan, C., M. K. Young, K. D. Fausch, and S. C. Riley. 1994. Restricted movement in resident stream salmonids: a paradigm lost? Canadian Journal of Fisheries and Aquatic Sciences 51:2626-2637.

Hunt, R. L. 1969. Overwinter survival of wild fingerling brook trout in Lawrence Creek, Wisconsin. Journal of the Fisheries Research Board of Canada 26:1473-1483.

Kinsolving, A. D., and M. B. Bain. 1990. A new approach for measuring cover in fish habitat studies. Journal of Freshwater Ecology 5:373-378.

Laake, J. L., S. T. Buckland, D. R. Anderson, and K. P. Burnham. 1994. DISTANCE User's Guide V2.1. Colorado Fish and Wildlife Research Unit, Colorado State University, Fort Collins, CO.

Lebreton, J. D., K. P. Burnham, J. Colbert, and D. R. Anderson. 1992. Modeling survival and testing biological hypotheses using marked animals: case studies and recent advances. Ecological Monographs 62:67-118.

Magurran, A. E. 1986. Individual differences in fish behavior. Pp. 338-365. In T. J. Pitcher [ed.] The behavior of teleost fishes. Croom Helm, London.

Menkins, G. E., Jr., and S. H. Anderson. 1988. Estimation of small-mammal population size. Ecology 69:1952-1959.

Otis, D. L., K. P. Burnham, G. C. White, and D. R. Anderson. 1978. Statistical inference from capture data on closed animal populations. Wildlife Monographs 62.

Pollock, K. H., J. D. Nichols, C. Brownie, and J. E. Hines. 1990. Statistical inference for capture-recapture experiments. Wildlife Monographs 107.

Rexstad, E., and K. Burnham. 1991. User's guide for interactive program CAPTURE. Colorado Cooperative Fish and Wildlife Research Unit, Colorado State University, Fort Collins, CO.

Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish populations. Fisheries Research Board of Canada Bulletin 191.

Smith, R. W., and J. S. Griffith. 1994. Survival of Rainbow Trout during their first winter in the Henrys Fork of the Snake River, Idaho. Transactions of the American Fisheries Society 123:747-756.

Waters, T. F. 1995. Sediment in streams: sources, biological effects, and control. American Fisheries Society Monograph 7.

White, G. C., D. R. Anderson, K. P. Burnham, and D. L. Otis. 1982. Capture-recapture and removal methods for sampling closed populations. Los Alamos National Laboratory, LA 8787-NERP, Los Alamos, NM.

Table 1. Sampling dates for juvenile rainbow trout in spring, summer, and autumn, 1996, in study sections of the Henrys Fork.

Study section	Dates sampled	Total (d)
	Spring	
Box Canyon	20-23 May, 18, 19 Jun	6
Last Chance	1-4 Jun	3
Harriman State Park	3-10 Jun	3
Harriman East	3-10 Jun	3
Pinehaven-Riverside	11-18 Jun	5
Total	20 May-18 Jun	19
	Summer	
Box Canyon	16-29 Aug	7
Last Chance	13-30 Aug	8
Harriman State Park	6-14 Aug, 8 Sep	6
Harriman East	25-28 Aug	3
Pinehaven-Riverside	6-14, 28 Aug	6
Total	6 Aug-8 Sep	21
	Autumn	
Box Canyon	5-20 Oct	7
Last Chance	6-22 Oct	6
Harriman State Park	22, 24 Oct	2
Harriman East	2, 3 Nov	2
Pinehaven-Riverside	2, 3 Nov	2
Total	5 Oct-3 Nov	15[a]

[a] Two shocking crews used on eight of the fifteen dates for an equivalent of 23 sampling days.

Table 2. Estimates of redd abundance (N) and 95% confidence intervals (CI) in the Henrys Fork from Island Park Dam to the USGS gauging station (13,750 m^2) in 1995 and 1996. Estimates were obtained using the computer program DISTANCE; effort was the sum of transect lengths.

Date	Transects	Effort (m)	Observed redds	N	95% CI
			1995		
27 Apr	13	716.7	22	28	[12; 67]
			1996		
30 Mar	10	537.5	2	--	--
9 Apr	10	520.6	6	12	[3; 44]
14 Apr	10	551.0	11	11	[4; 30]
21 Apr	10	575.0	9	16	[6; 42]

Table 3. Seasonal estimates of juvenile rainbow trout (< 200 mm TL) abundance in study sections of the Henrys Fork in 1996; R denotes the number of recaptures used in estimates.

Section	Sample area abundance [95% confidence interval]	Total abundance [95% confidence interval]	R
	Spring		
Box Canyon	--	8,241 [878; 18,056][a]	--
Last Chance	73 [27; 183]	2,008 [742; 5,032][b,d]	2
Harriman State Park	--	--	--
Harriman East	--	--	--
Pinehaven-Riverside	--	666 [202; 1,211][b]	1
Total	--	10,915 [1,822; 24,299]	--
	Summer		
Box Canyon-upper section	--	4,626 [248; 11,672][a]	--
Box Canyon-lower section	1,012 [738; 2,025][c,d]		35
	417 [327; 708][c,e]	17,732 [13,221; 33,884]	7
Last Chance	1,488 [1,387; 1,600][c,d]		15
	2,078 [1,592; 6,035][c,e]	57,135 [46,970; 130,705]	11
Harriman State Park	775 [284; 1,938][b,d]	10,075 [3,692; 25,194]	3
Harriman East	--	--	--
Pinehaven-Riverside	--	1,464 [434; 2,662][b]	1
Total	--	91,032 [64,565; 204,117]	--

Table 3.-Continued.

Section	Sample area abundance [95% confidence interval]	Total abundance [95% confidence interval]	R
	Autumn		
Box Canyon-upper section	--	11,738 [0; 28,867][a]	--
Box Canyon-lower section	2,418 [1,936; 3,107][c,d]		56
	825 [680; 1,151][c,e]	40,202 [32,434; 52,807]	33
Last Chance	3,895 [3,172; 4,888][c,d]		69
	2,400 [2,105; 4,396][c,e]	94,162 [79,426; 143,394]	38
Harriman State Park	1,260 [514; 3,150][b,d]	16,380 [6,682; 40,950]	3
Harriman East	--	2,673 [1,193; 6,682][b]	4
Pinehaven-Riverside	--	--	--
Total	--	165,155 [119,735; 272,700]	--

[a] Bank removal extrapolation.
[b] Lincoln-Petersen estimate.
[c] Program CAPTURE.
[d] Sample area 1.
[e] Sample area 2.

Table 4. Movements of juvenile rainbow trout between seasons and between sections within a season (separated by a comma) in 1995 and 1996. R is the number of recaptures, the first number is the section in which fish were marked, and the second number is the section in which fish were recaptured. Sections are as follows: 1. Box Canyon, 2. Last Chance, 3. Harriman State Park, 4. Harriman East, and 5. Pinehaven-Riverside.

R	Spring 1995	Summer 1995	Autumn 1995	Spring 1996	Summer 1996	Autumn 1996
			Box Canyon			
3	1			1		
8		1	1			
2		1	4			
4			1	1		
1			1	5		
1			1		1	
2				1	1	
32					1	1
1		1				5
			Last Chance			
1	2,5					
15		2	2			
2		2	1			
1			2,1			
1			2	5		
31					2	2
1					2	5
			Harriman State Park			
8		3	3			
2					3	3
1					3	2
			Harriman East			
1			4		5	

Table 4.-Continued.

R	Spring 1995	Summer 1995	Autumn 1995	Spring 1996	Summer 1996	Autumn 1996
			Pinehaven-Riverside			
5	5	5				
3		5	5			
1		5		5		
2		5			5	
4				5	5	
1					5	5

Table 5. Total number of juvenile rainbow trout captured and the distribution of recaptures in Last Chance sample area 1 (100 m) and the adjacent areas upstream (50 m) and downstream (50 m) in summer and autumn 1996.

Capture area	Total captured	d	Recapture area		
			Upstream	Sample area 1	Downstream
			Summer		
Upstream	286	5	7	4	0
Sample area 1	528	5	3	15	3
Downstream	228	5	0	0	3
			Autumn		
Upstream	223	3	12	5	3
Sample area 1	850	5	0	69	6
Downstream	223	3	0	5	10

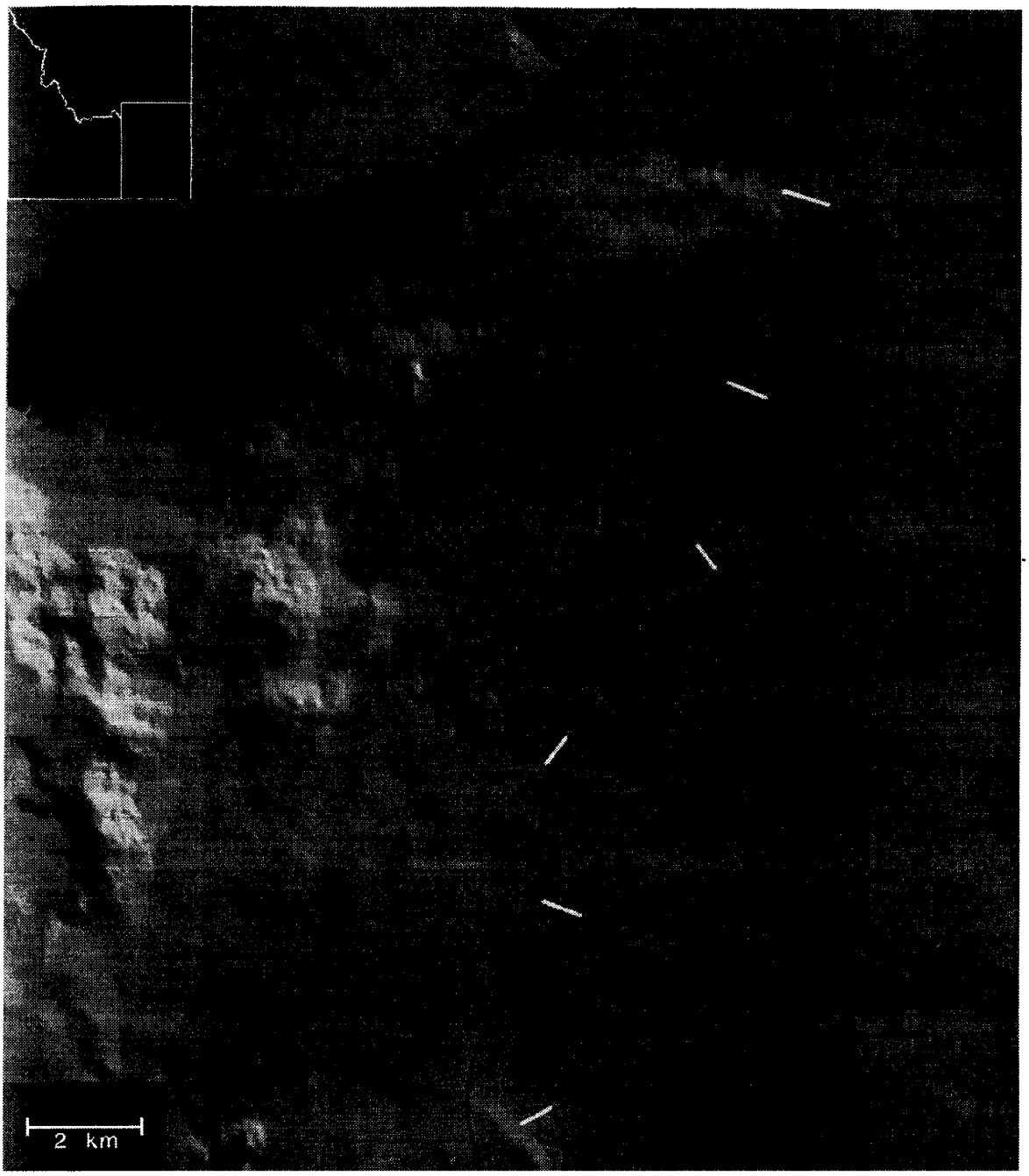

Figure 1. Study sections of the Henrys Fork below Island Park Reservoir: Box Canyon, Last Chance, Harriman State Park, Harriman East, and Pinehaven-Riverside.

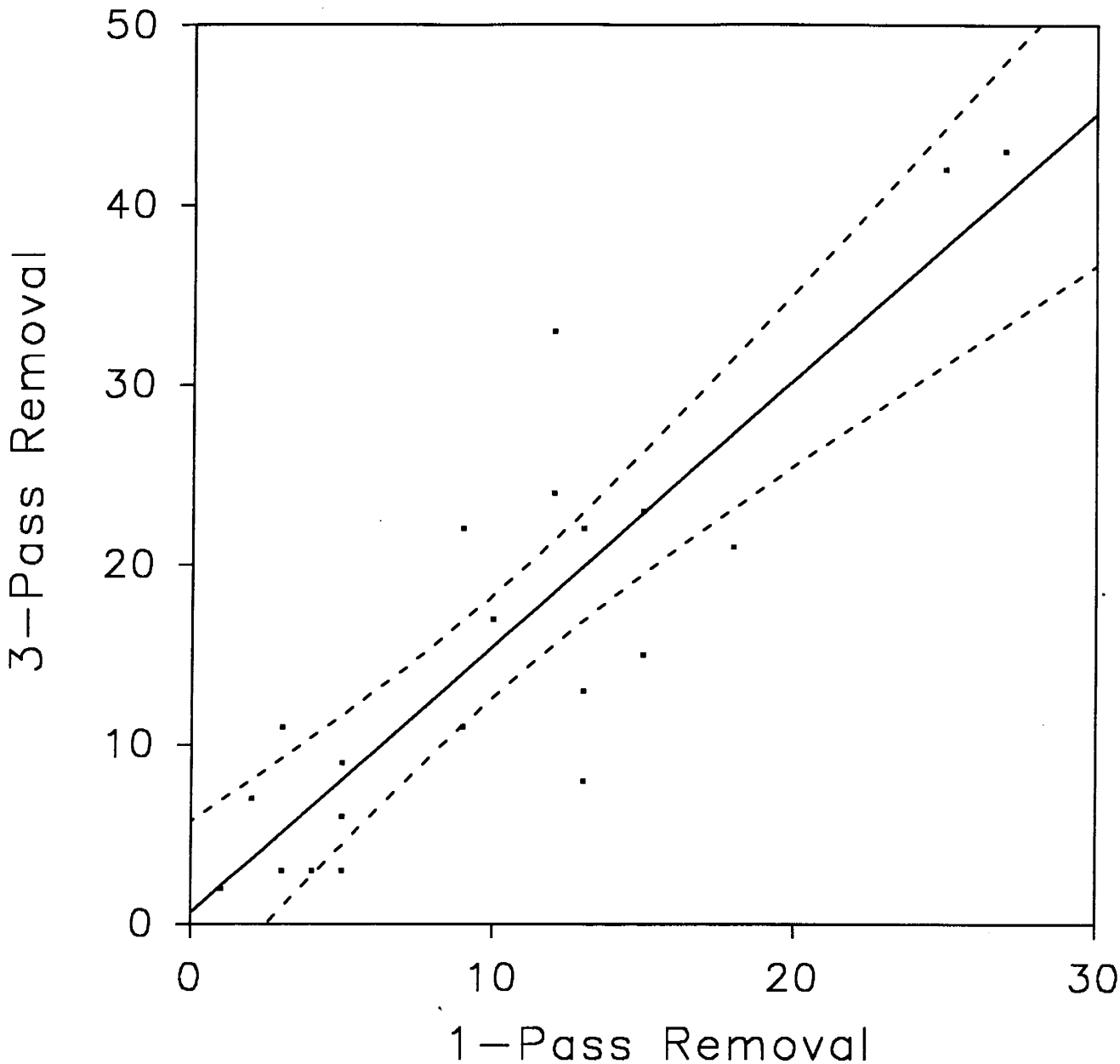

Figure 2. Paired one-pass and three-pass removal estimates from 19 bank sections in Box Canyon and 2 bank sections in Pinehaven-Riverside, from autumn 1995 to autumn 1996, with fitted linear regression model (solid line) and 95% confidence interval (dashed lines) (r^2=0.75, P=0.0001).

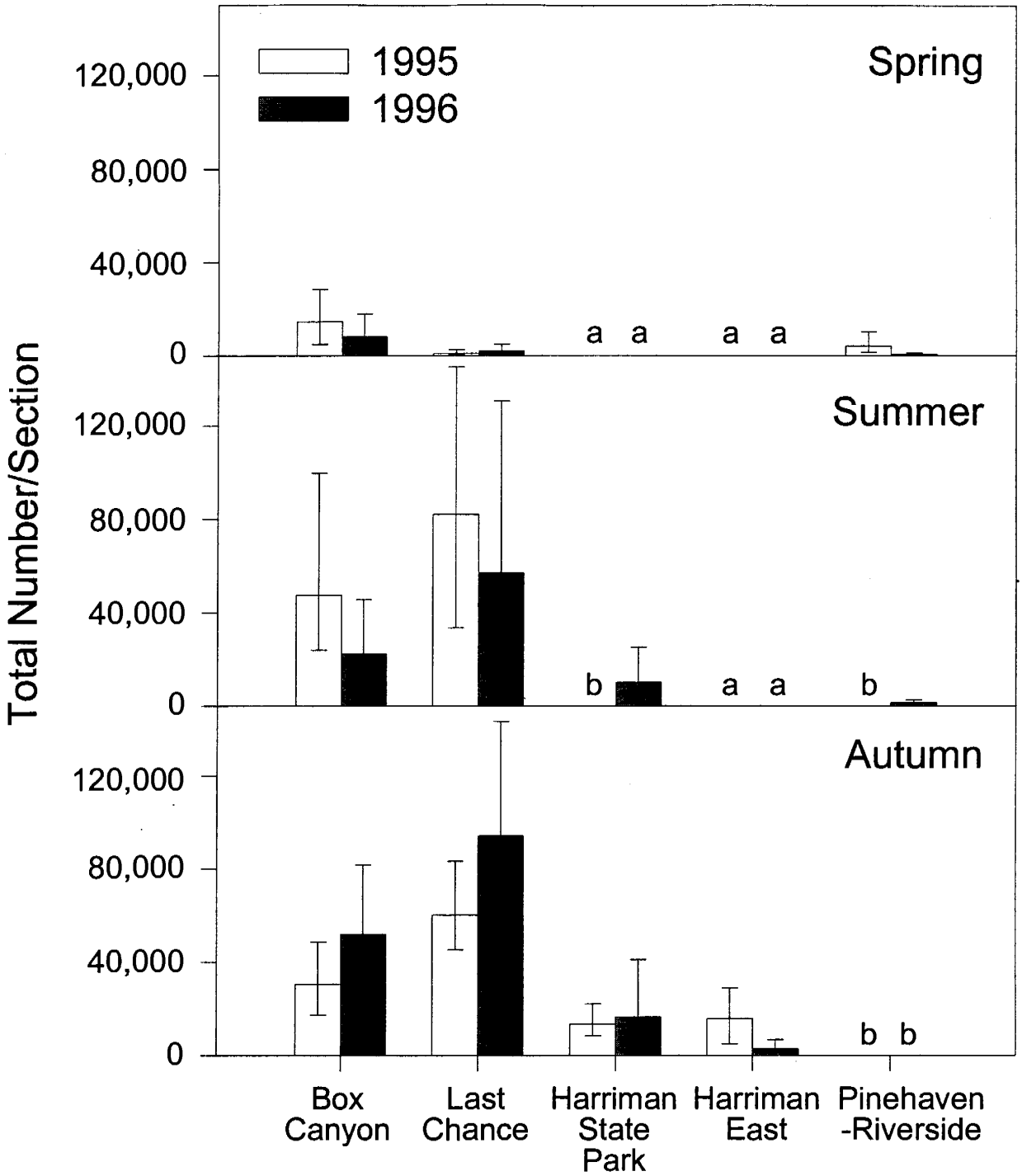

Figure 3. Total abundance of juvenile rainbow trout and 95% confidence interval for each study section by season in 1995 and 1996. a, few trout captured; total number considered negligible. b, insufficient number of capture periods and recaptures to calculate estimate.

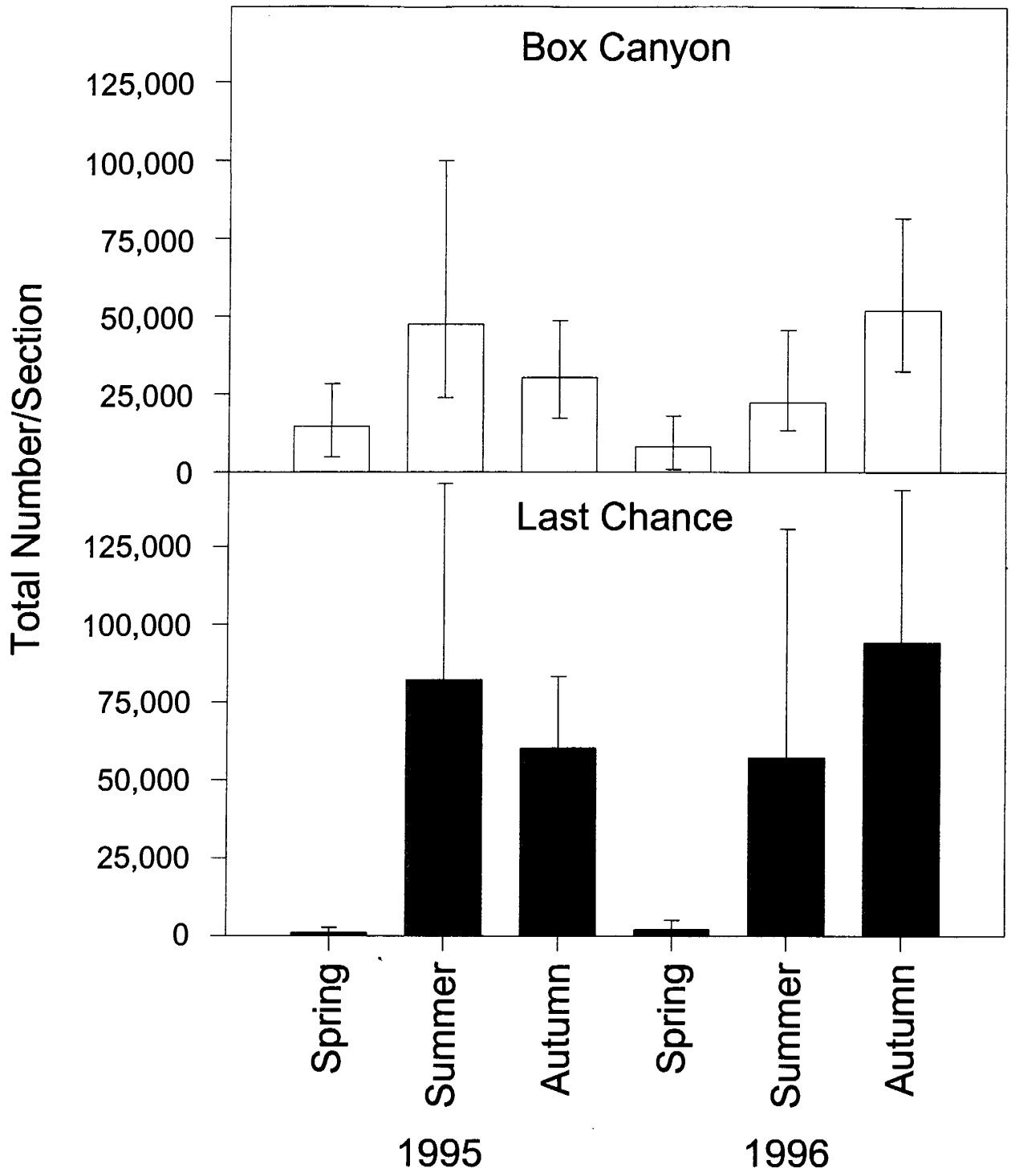

Figure 4. Total abundance of juvenile rainbow trout and 95% confidence interval for Box Canyon and Last Chance from spring 1995 to autumn 1996.

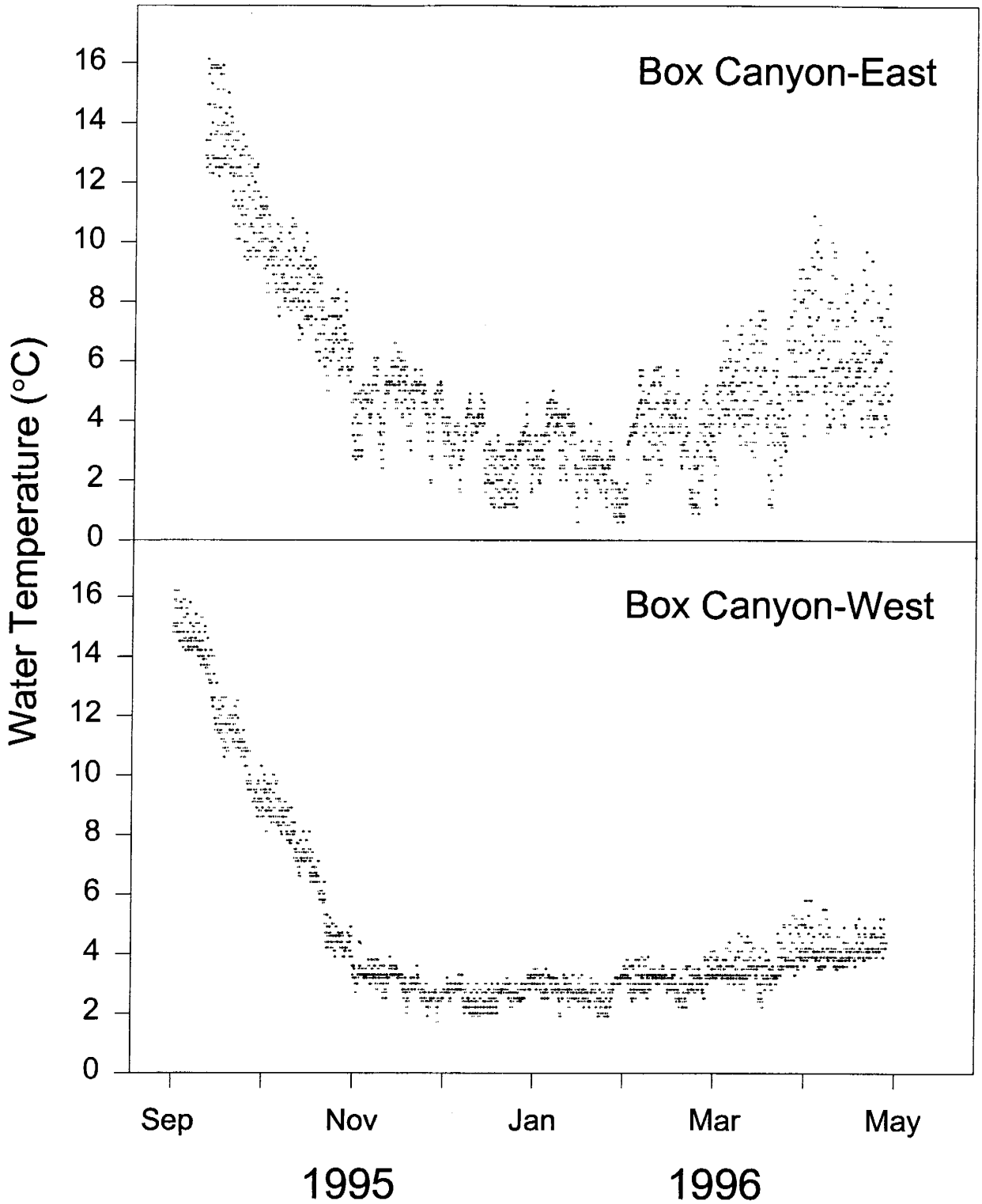

Figure 5. Water temperature (°C) along the east and west banks in Box Canyon from 11 Sep 1995 to 5 May 1996. Temperature was recorded every 3 h.

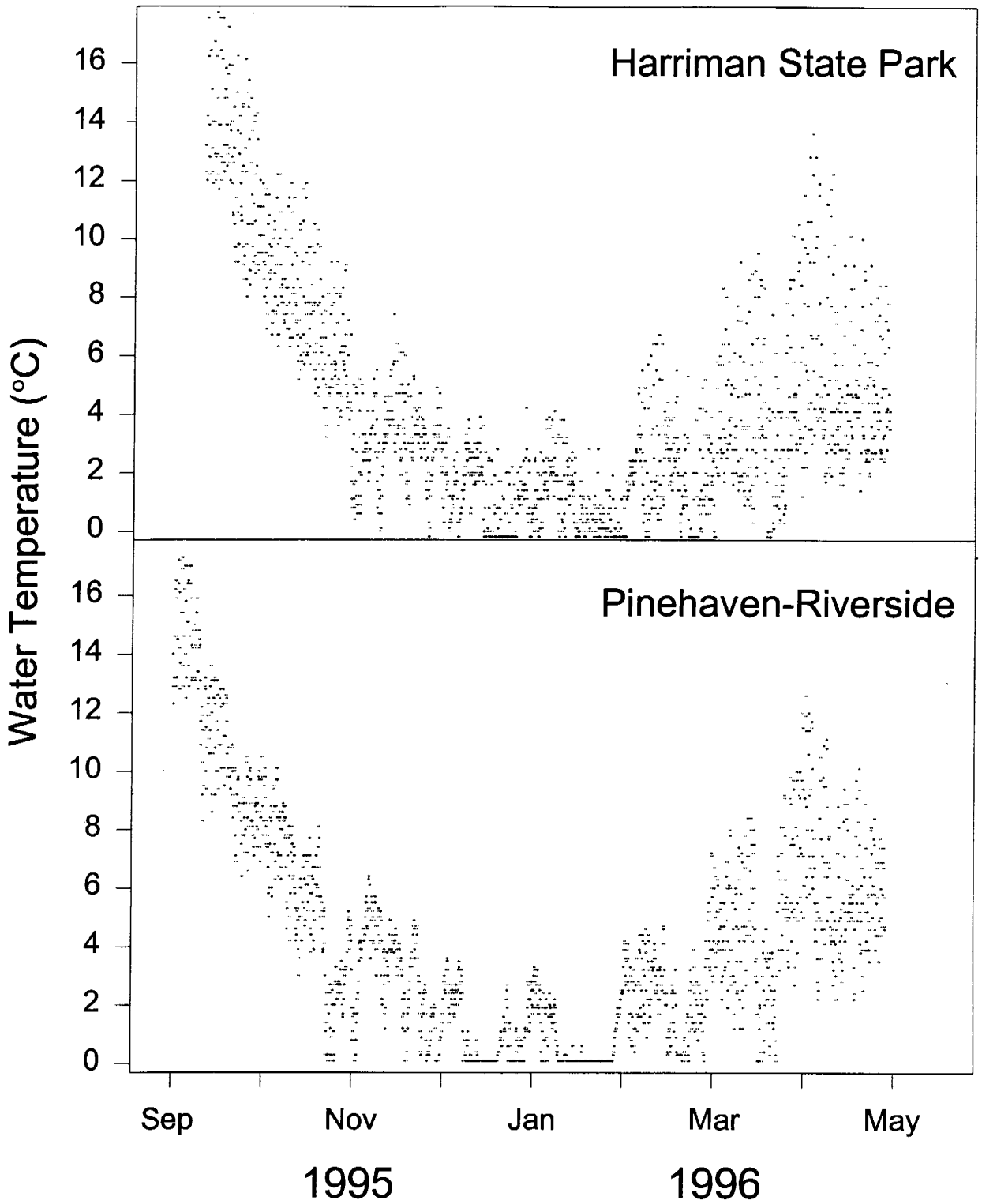

Figure 6. Water temperature (°C) in Harriman State Park and Pinehaven-Riverside from 11 Sep 1995 to 5 May 1996. Temperature was recorded every 3 h.

Appendix

Table A1. Seasonal estimates of juvenile rainbow trout (< 200 mm TL) abundance in study sections of the Henrys Fork in 1995 and 1996; R denotes the number of recaptures used in estimates.

Section	1995	R	1996	R
	Spring			
Box Canyon	14,719 [4,873; 28,388]	--	8,241 [878; 18,056]	--
Last Chance	1,074 [479; 2,684]	4	2,008 [742; 5,032]	2
Harriman State Park	--	--	--	--
Harriman East	--	--	--	--
Pinehaven-Riverside	4,169 [1,525; 10,422]	2	666 [202; 1,211]	1
Total	19,962 [6,877; 41,494]	6	10,915 [1,822; 24,299]	3
	Summer			
Box Canyon	47,461 [23,915; 99,854]	20	22,358 [13,469; 45,556]	42
Last Chance	82,129 [33,600; 145,282]	17	57,135 [46,970; 130,705]	26
Harriman State Park	--	--	10,075 [3,692; 25,194]	3
Harriman East	--	--	--	--
Pinehaven-Riverside	--	--	1,464 [434; 2,662]	1
Total	129,590 [57,515; 245,136]	37	84,805 [64,175; 183,473]	72
	Autumn			
Box Canyon	30,348 [17,318; 48,657]	38	51,940 [32,434; 81,674]	89
Last Chance	60,205 [45,167; 83,241]	96	94,162 [79,426; 143,394]	107
Harriman State Park	13,368 [8,418; 22,284]	16	16,380 [6,682; 40,950]	3

Table A1.-Continued.

Section	1995	R	1996	R
Harriman East	15,752 [4,773; 28,640]	1	2,673 [1,193; 6,682]	4
Pinehaven-Riverside	--	--	--	--
Total	119,673 [75,676; 182,822]	151	165,155 [119,735; 272,700]	203

Submitted by:

Matthew G. Mitro
Graduate Student

Alexander V. Zale
Principal Investigator

Approved by:

IDAHO DEPARTMENT OF FISH AND GAME

Steven M. Huffaker, Chief
Bureau of Fisheries

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Al Van Vooren
Fishery Research Manager