FISHERY MANAGEMENT INVESTIGATIONS

SOUTH FORK SNAKE RIVER INVESTIGATIONS

2006 Annual Report

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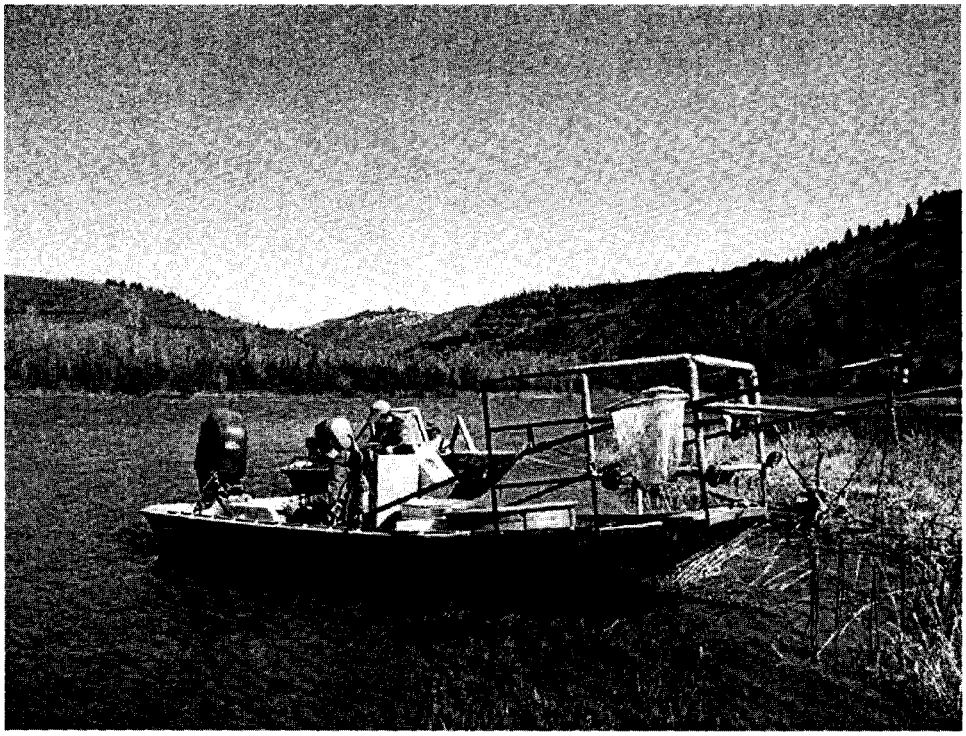

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ABSTRACT

At the Conant section in the upper South Fork Snake River, we captured a total of 1,805 trout during four days of electrofishing in October 2006. Relative abundance in the catch was 41.3% cutthroat trout *Oncorhynchus clarkii bouvieri,* 31.6% rainbow trout O. *mykiss* and hybrid rainbow x cutthroat trout O. *mykiss x O. clarkii* combined, and 27.1 % brown trout *Salmo trutta.* For age 1 and older fish, estimated densities were 749 cutthroat trout/km, 677 rainbow and hybrid trout/km, and 329 brown trout/km for a total of 1,755 fish/km. For age 1 (yearling) fish, estimated densities were 328 cutthroat trout/km, 411 rainbow and hybrid trout/km, and 219 brown trout/km for a total of 958 fish/km. Over all fish sizes, mean total length was 329 mm for cutthroat trout, 274 mm for rainbow and hybrid trout, 266 mm for brown trout, and 295 mm for all species combined. Quality stock density (QSD) was 17.6% for cutthroat trout, 15.4% for rainbow and hybrid trout, 17.4% for brown trout, and 16.8% for all species combined.

At the Lorenzo section in the lower river, we captured a total of 2,247 trout during four days of electrofishing in September 2006. Relative abundance in the catch was 7.7% cutthroat trout, 0.9% rainbow and hybrid trout, and 91.4% brown trout. For age 1 and older fish, estimated densities were 116 cutthroat trout/km and 1,761 brown trout/km for a total of 1,877 fish/km. For age 1 (yearling) fish, estimated densities were 37 cutthroat trout/km and 1,191 brown trout/km for a total of 1,228 fish/km. Rainbow and hybrid trout density estimates were not possible due to the small sample size. Over all fish sizes, mean total length was 310 mm for cutthroat trout, 284 mm for brown trout, and 286 mm for both species combined. Quality stock density (QSD) was 10.2% for cutthroat trout, 14.6% for brown trout, and 14.2% for both species combined.

A total of 114,157 trout >203 mm and 33,019 trout >406 mm were estimated to be in the upper river above Heise during April 2006. For fish >203 mm, 28% or 31,829 were cutthroat trout, 44% or 50,498 were rainbow and hybrid trout, and 28% or 31,830 were brown trout. For fish >406 mm, 15% or 4,849 were cutthroat trout, 32% or 10,480 were rainbow and hybrid trout, and 54% or 17,690 were brown trout. In general, spring-time densities of cutthroat trout >203 mm were slightly higher – and densities of cutthroat trout >406 mm were slightly lower – as we sampled from the dam downstream. Densities of both ≥203 mm and >406 mm rainbow and hybrid trout were highest upstream and gradually declined to near zero as we sampled downstream. Densities of both ≥203 mm and >406 mm brown trout were lowest upstream and gradually increased as we sampled downstream. Compared to the other trout taxa, cutthroat trout were more uniformly distributed throughout the upper river.

Estimated annual exploitation of rainbow and hybrid trout from April 26, 2006, to April 26, 2007, in the upper river above Heise was 24.4% for fish ≥203 mm and 29.5% for fish >406 mm. Estimates were derived using reward and non-reward Floy tag returns by anglers and were adjusted for angler compliance, natural tag loss, tag removal by anglers, and assumed tag-induced mortality rates. Unadjusted exploitation rates were 7.1% for fish ≥203 mm and 8.0% for fish >406 mm. Estimated harvest of rainbow and hybrid trout was 12,322 fish ≥203 mm and 3,092 fish ≥406 mm. Although rainbow and hybrid trout exploitation has roughly doubled since 2003, we hope to increase these rates further to around 40-60% by continuing our angler outreach and education campaign.

We used indices of hydrologic regime *(Hydro Index)* and trout recruitment *(YCT Index)* to partially evaluate Bureau of Reclamation's ecologically-based flow management objectives below Palisades Dam. The 2006 *Hydro Index was* 3.459 and was within the top three index

values over the last 20 years. The large value is primarily due to the relatively high peak flows delivered in 2005 and 2006, although maximum to minimum flow ratios both years were below the generally agreed upon goal of fifteen. As a result, the 2006 recruit class – i.e. yearlings measured in the fall 2006, but produced in the spring and summer 2005 – experienced very favorable hydrologic conditions in terms of the freshets but not in terms of the maximum to minimum flow ratios. Despite the large *Hydro Index,* the *YCT Index* was 0.677 and was within the bottom five index values over the last 20 years. The low *YCT Index* was due to below average cutthroat trout recruitment as well as very high rainbow trout recruitment – the fourth-highest recorded and exceeded only by recruitment years 1997, 2002, and 2003. Using the significant and positive linear relationship between the *Hydro Index* and the *YCT Index (P* = 0.0239, r^2 = 0.645, *n* **=** 17 years), a *YCT Index* value of 2.654 was predicted for 2006. The large deviation between the predicted and the observed value requires further investigation. The *Recruit Ratio,* or the ratio of estimated age 1 cutthroat to rainbow and hybrid trout at Conant, was 0.8 and was also within the bottom five values over the last 20 years.

Despite the most challenging runoff conditions since the inception of the tributary weir program in 2001, we trapped a total of 2,002 trout at Burns, Rainey, and Palisades creeks during 2006. Three rainbow and hybrid trout were caught at Burns Creek, three fish were caught at Rainey Creek, and 52 fish were caught at Palisades Creek. These rainbow and hybrid trout were relocated to family fishing waters. The remainder of fish trapped at the weirs was cutthroat trout – with 1,539 fish at Burns Creek, 69 fish at Rainey Creek, and 336 fish at Palisades Creek. Rainbow and hybrid trout were caught between April 14 and June 7 with run midpoints ranging from May 15 to May 31. Cutthroat trout were caught between April 22 and June 30 with run midpoints ranging from June 7 to June 10. At Palisades Creek, 44.2% of the rainbow and hybrid trout were females. At all weirs, from 51.7 to 62.3% of the cutthroat trout were females. The estimated efficiency of the refurbished Mitsubishi floating weir at Palisades Creek was 12.8%, and the estimated total cutthroat trout run size was 2,625 fish. We did not estimate efficiency at the Burns Creek Mitsubishi weir, but we believe it was low as well. Nor did we estimate efficiency at the Rainey Creek picket weir, which was off-line most of May. All the weirs were significantly damaged during high-water by debris and bedload movement. A portion of the Pine Creek Mitsubishi weir was destroyed shortly after installation.

We operated and maintained rotary-drum fish screens in Burns and Palisades creek irrigation diversions from early spring to late fall. Unknown numbers of outmigrating cutthroat trout fry and post-spawners have been prevented from being entrained since screen construction.

Our results are compared to previous years and are discussed in relation to our three-pronged, collaborative effort to restore and conserve the South Fork Snake River cutthroat trout population.

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INTRODUCTION

The South Fork Snake River supports an ecologically and economically important population of native Yellowstone cutthroat trout *Oncorhynchus clarkii bouvieri.* This population is one of the few remaining healthy fluvial populations within their historical range in Idaho (Thurow et al. 1988; Van Kirk and Benjamin 2001; Meyer et al., in review). The cutthroat trout fishery generated approximately $12 million in local income and supported 341 jobs in 2004 (Loomis 2005). Despite the overall health of cutthroat trout in the river, a population of non-native rainbow trout O. *mykiss* and rainbow x cutthroat hybrid trout O. *mykiss x O. clarkii* poses risks to future cutthroat trout productivity and stability. Perhaps the greatest risk is through hybridization. Genetic introgression from non-indigenous rainbow trout is well documented and can be serious (Behnke 1992; Leary et al. 1995). Hybrid trout, which are fertile, can also backcross with both cutthroat and rainbow trout in the South Fork Snake River (Henderson et al. 2000; Schrader et al. 2002). To date, rainbow and hybrid trout have increased only in the upper river above Heise and its associated tributaries, whereas few rainbow and hybrid trout occur in the lower river (Schrader and Fredericks 2006a, 2006b; Garren et al. 2006). Hereafter, unless stated otherwise, "rainbow trout" will refer to rainbow and hybrid trout combined.

From a fishery management perspective, relatively low densities of cutthroat trout in the lower river are also a concern. It is possible that these low densities reflect adverse environmental conditions such as unfavorable flow regimes, loss of fish to irrigation canals, or a decline in habitat quality. All three of these conditions are primarily a result of management of reservoirs and diversions in the Snake River system for storage and delivery of irrigation water. Van Kirk and Benjamin (2001) and Moller and Van Kirk (2003) found that the lower South Fork Snake River has a much greater degree of hydrologic alteration than does the upper river. However, this alteration is not believed to cause the low cutthroat trout densities observed there.

Because the hydrologic regime is the primary driver of ecological processes in large gravel-bed rivers such as the South Fork Snake River, and because this river is flow-regulated, the ecological effects of hydrologic regime and alteration have received increased attention in recent years. The two relatively recent drought periods – the first in 1987-1994 and the second in 2000-2005, perhaps the most severe on record – has only heightened that attention. Schrader and Griswold (1994) identified winter habitat preferences of juvenile salmonids and recommended a minimum winter flow of 42.5 m^3/s (1,500 ft^3/s) to sustain the fishery. Merigliano (1997) found that the decreased magnitude and frequency of spring flood events have limited cottonwood recruitment.

Moller and Van Kirk (2003) studied the effects of hydrologic alteration on trout recruitment in the South Fork Snake River. They found that flow characteristics during spawning and juvenile trout first-summer growth periods explained more variability in recruitment than did any other group of hydrologic variables, including winter flow. They observed sharp increases in rainbow trout recruitment following water years in which the maximum to minimum flow ratio was low and the hydrograph had a relatively low, flat, long-duration peak. In contrast, cutthroat trout recruitment was high following water years in which the maximum to minimum flow ratio was high, tributary discharge was high, and the peak was short in duration, high, and sharp. To increase cutthroat trout recruitment relative to rainbow trout recruitment, they recommended changing water management to provide higher, sharper, and shorter flood peaks and higher maximum to minimum flow ratios. Hauer et al. (2004) also studied channel morphology and stream ecology as it relates to flow regimes. The results of these two studies have been used by the U.S. Bureau of Reclamation (BOR) to develop ecologically-based flow management

objectives that were initiated in the winter and spring of 2003-2004. For example, one objective is to exceed a maximum to minimum flow ratio of 15. Within legally mandated and complex operational constraints, the overall goal was to enhance ecological processes in the river and floodplain downstream of Palisades Dam – with an emphasis on restoring and conserving cutthroat trout.

The mechanisms driving differential recruitment success described by Moller and Van Kirk (2003) are unknown. Rainbow trout spawn during April and May and it is possible that high flows after spawning scour redds – thereby reducing egg-to-fry survival. But it is also possible that higher maximum to minimum flow ratios cause other recruitment-related problems. These might include increased physiological stress prior to spawning, reduced available spawning habitat, or displacement of fry and decreased fry survival – all of which could contribute to lower rainbow trout recruitment relative to cutthroat trout. Higher flow ratios might also induce more cutthroat trout to migrate into tributaries to spawn.

South Fork Snake River fishing regulation decisions by the Idaho Fish and Game Commission are predicated on reliable and current estimates of fish population parameters – such as density and fish size – as well as fishing-related parameters – such as angler effort, catch rates, and exploitation developed by the Idaho Department of Fish and Game (IDFG). Fish populations have been monitored by IDFG electrofishing since 1986. Creel surveys have been used sporadically to collect data from anglers since the 1960s. Following creel surveys in 1979 (Moore 1980) and 1982 (Moore and Schill 1984), special regulations were implemented in 1984 to restrict cutthroat trout harvest to two fish, none between 10-16 inches, in a limited portion of the upper river (Appendix A). Based on the success of these special regulations, they were extended upstream to Palisades Dam in 1988 and throughout all eastern Idaho streams in 1990 – including the lower South Fork Snake River and all South Fork Snake River tributaries. In 1992, the rules were extended to all trout species – including rainbow trout – in the main river but not in tributaries. There were few rainbow trout *Salmo trutta* at the time, and the extension was intended to improve the brown trout fishery. However, the 1996 creel survey results (Schrader et al. 2003), combined with the 1998 petition to list Yellowstone cutthroat trout as a threatened species under the federal Endangered Species Act, led to emergency rule changes in 1999. This removed rainbow trout (and later hybrid trout) from all special regulations, returning them to the general six fish bag limit with no size restrictions. In 2000, the slot limit for cutthroat and brown trout was replaced by a minimum size restriction. In 2004, extensive rule changes were implemented in the main river and its tributaries following the 2003 creel survey (Schrader and Fredericks 2006a). All limits were removed for rainbow trout, only catch-andrelease was allowed for cutthroat trout, and the fishing season in the upper river was extended year round to allow harvest of rainbow trout spawners. Brown trout regulations remained the same. In addition, spawning closures on Palisades and Rainey creeks were added to those already in place on Pine and Burns creeks.

Both cutthroat and rainbow trout spawn in the spring in the main river as well as in the tributaries. However, research using radiotelemetry in 1996 and 1997 showed that most cutthroat trout spawn in the tributaries whereas most rainbow trout spawn in the main river (Henderson et al. 2000). Practically speaking, restricting spawning in the main river to limit hybridization is beyond the control of IDFG. However, by restricting spawning in the major tributaries – i.e. Palisades, Rainey, Pine, and Burns creeks – the genetic integrity of a large component of the South Fork Snake River cutthroat trout population can be insured. Fish trapping and collection facilities (weirs) are typically used to restrict fish spawning migrations. The first weir structure was built at Rainey Creek in 1996-1997, with weir panels installed in 2000. The next weir was built at Palisades Creek in 1998-1999, followed by Burns Creek in

2000 and Pine Creek in 2001. Host (2003) began trapping at all the weirs except Pine Creek in 2001. Trapping began at the Pine Creek weir in 2002.

All the structures that have been built, except Pine Creek, serve a dual purpose. Besides trapping adult spawners moving upstream, each weir also serves as an irrigation diversion dam. In addition, Palisades and Burns creeks have fish screens to pass juvenile fish and post-spawners moving downstream. The weir structures have allowed accurate measurement of decreed water and have prevented streambed alterations to obtain that water. The Pine Creek weir was constructed and is operated solely for capturing upstream migrating fish.

All the weirs are checkpoints that allow sorting and removal of rainbow trout. The weir program was not designed to eliminate rainbow trout from the South Fork Snake River but rather to maintain core, genetically pure populations of cutthroat trout. A key component to the program's success is the ability to accurately distinguish cutthroat from rainbow trout using visual or phenotypic characteristics — generally red throat markings, white fin tips, and spotting patterns. Genetic tissue samples taken and analyzed in 2000-2002 showed that with training, fisheries personnel could minimize the genetic contribution of rainbow trout to less than 1% of the upstream migrants (Host 2003).

This annual report summarizes South Fork Snake River fishery investigations conducted in 2006. BOR began Ecologically Based System Management (EBSM) operations on the South Fork Snake River in water year 2004 following flow-related research in 2002-2003 (Moller and Van Kirk 2003; Hauer et al. 2004; Schrader and Fredericks 2006a). IDFG also began flow evaluations and continued biological monitoring of cutthroat trout during water year 2004 (Garren et al. 2006), although fishery recruitment resulting from 2004 operations could not be measured until the following water year 2005 (Schrader and Fredericks 2006b). At the same time, a number of IDFG fishery objectives and programs were being implemented through the 2001-2006 Fisheries Management Plan (IDFG 2001). The current focus of both agencies is to preserve the unique native cutthroat trout fishery and to enhance the river ecosystem upon which it depends within BOR operational constraints. To this end, both agencies have cooperated since 2000 in running a three-pronged management program — flow management in the main river, harvest management in the main river and tributaries, and escapement management in selected tributaries. Our monitoring and research objectives were formulated with this emphasis in mind.

OBJECTIVES

1. Continue to monitor South Fork Snake River trout populations by electrofishing in the fall. Estimate relative abundance, density, and size and stock structures.
2. Assess total abundance of standard and quality trout stocks (fish >203 mm and >406 mm, respectively) in the upper river above Heise during spring. Describe spatial distribution patterns of trout density.
3. Estimate rainbow trout exploitation and harvest in the upper river above Heise over the fishing season. Coordinate with the statewide IDFG exploitation research project.
4. Evaluate age 1 cutthroat and rainbow trout recruitment following modified flow management by BOR in water years 2005 and 2006.
5. Operate fish weirs in Burns, Pine, Rainey, and Palisades creeks to maintain genetically pure spawning populations of cutthroat trout. Replace Burns Creek and Pine Creek weir

panels with floating Mitsubishi panels. Estimate weir efficiency at Palisades Creek. Monitor escapement, upstream migration timing, and sex ratios.

6. Operate rotary drum fish screens on irrigation diversions in Palisades and Burns creeks.
7. Evaluate the overall cutthroat trout conservation and management program, particularly as related to increasing rainbow trout.

METHODS AND STUDY AREA

Fall Population Monitoring

Trout populations in the South Fork Snake River have been monitored using electrofishing since 1986. Four river sections have been sampled (Figure 1): Palisades (5.0 km, 39.50 ha), Conant (4.9 km, 34.79 ha), Twin Bridges (2.9 km, 19.14 ha), and Lorenzo (4.8 km, 22.08 ha). However, only the Conant section has been sampled every year, a portion of which was sampled in 1982 as well (Moore and Schill 1984). During 2006, the Conant section was electrofished on October 3, 4, 11, and 12, and the Lorenzo section was electrofished on September 19, 21, 27, and 28. The upper or lower half of a section was sampled each day. At Conant, flows ranged from 88.4 to 89.0 m^3/s (3,120 to 3,140 ft^3/s) at the Irwin gage (USGS, provisional data; Appendix B). At Lorenzo, flows ranged from 24.2 to 49.9 m^3/s (855 to 1,760 ft^3/s) at the Lorenzo gage (USGS, provisional data; Appendix C). Roughly 70.8 m^3/s (2,500 ft^3/s) is needed at either section for safe boat operation and efficient sampling.

Fish were captured using direct-current (DC) electrofishing gear (Coffelt VVP-15 powered by a Honda 5000 W generator) mounted in a jet boat. We used pulsed DC current through two boom-and-dangler anodes fixed to the bow while driving downstream. The boat hull was the cathode. Similar to previous years, the WP settings were at 200-250 V, 5-6 A, 20% pulse width, and 90 Hz (pulses per second). Water conductivity was not measured.

We attempted to capture all species and sizes of trout. Fish were anesthetized and identified, and total length (TL) was measured to the nearest millimeter. Age 0 fish – which were cutthroat trout less than 102 mm, rainbow trout less than 152 mm, and brown trout less than 178 mm – were not marked as they are not efficiently recruited to the gear. Age 1 and older fish were marked with a caudal fin punch and released. Ages were approximated from overall length frequency distributions (Figure 2).

All electrofishing data were entered and analyzed using the computer program Mark Recapture 5.0 (MR5; Montana Department of Fish, Wildlife, and Parks 1997). Additional analysis was performed using Microsoft Excel. General statistical analysis was conducted according to Zar (1984).

We assumed capture probabilities did not vary with species, and relative abundance was estimated using the proportions of all trout captured. Although capture probabilities vary with fish length or size (Schill 1992), we assumed that variability was similar among sections. Population size structures (length frequency distributions) and average fish lengths were estimated using all sizes of fish captured. Quality stock density (QSD) was estimated by dividing the number of fish captured $\geq$406 mm by the number >203 mm, multiplied by 100. These statistics were calculated for each section and species after excluding recaptured fish.

Density was estimated using two methods in the MR5 computer program. Results from the log-likelihood method were used over the modified Petersen method if the modeled efficiency curves were acceptable (termcode = 1 and at least one of two chi-square pvalues>0.05). Following the nomenclature of Ricker (1975), sample efficiency, E, is defined as:

$$E = \frac{R}{C} \tag{1}$$

where C = number of fish sampled on recapture runs and examined for marks and R = number of recaptured marks in that sample. The log-likelihood method models sample efficiency (or capture probability) by fish length, thereby accounting for the size-selectivity of the electrofishing gear. The log-likelihood estimate of fish abundance, Ni , for each 25.4 mm size group, *i,* was:

$$= \frac{M}{Ei} \tag{2}$$

where, for each size group i, M; = number of fish marked on marking runs and E; _' modeled efficiency. The overall estimate of abundance was the sum of the individual estimates. The log-likelihood estimated variance for each 25.4 mm size group, i, was according to Seber (1973):

$$var[Ni = \frac{}{]} \frac{}{(Mi + 1XCi + 1XMi - RiXCi - Ri)(Ri+1)^2(Ri+2)} \tag{3}$$

where the terms are the same as before. The overall variance was the sum of the individual estimates. We used Chapman's modification of the Petersen method if the log-likelihood model was rejected. The overall estimate of abundance, N , was estimated as:

$$1V - \frac{(m+l)(C+1)-1}{(R+1)} \tag{4}$$

where the terms are the same as before. The overall variance was also according to Seber (1973):

$$var[N \sim _ \frac{(M+1)(C + 1XM - RXC - R)}{(R+1)2(R+2)} \tag{5}$$

where the terms are the same as before. For either method, the 95% confidence interval for the overall abundance estimate was calculated as:

$$N \pm 1.96 \text{ V var } N \qquad (6)$$

We estimated fish density by dividing the abundance estimate by the electrofishing section length to calculate fish per kilometer. The density variance estimate was calculated similarly.

Following Ricker (1975), we made five general assumptions needed for valid mark-recapture estimates. First, we assumed the population was closed, i.e. no mortality, recruitment, immigration, or emigration. Though electrofishing sections were not blocked at each end, we assumed fish did not move beyond natural habitat boundaries between marking and recapture runs. Second, we assumed that marked fish were as vulnerable to subsequent electrofishing as unmarked fish, i.e. capturing and marking them did not affect their catchability. Third, the marked fish did not lose their mark. Fourth, the marked fish became randomly mixed with the unmarked fish. And fifth, all marks were recognized and recorded correctly.

Spring Stock Assessment and Distribution

We repeated methods used in 2003 and 2005 to estimate or extrapolate total stock abundance and distribution in the upper 64 km of the South Fork Snake River from Heise to Palisades Dam (Schrader and Fredericks 2006a, 2006b). Like past years, two stocks of cutthroat, rainbow, and brown trout are defined: fish >203 mm are the standard stock and fish ≥406 mm are the quality stock. These are the same lengths used to define quality stock density. Nine sites were sampled using standard boat electrofishing gear on April 25-26, 2006 (Figure 3). A second boat was used for processing fish. The sites were spaced at eight river kilometer intervals and were at the same locations sampled in 2003 and 2005. Flows were 424.9 m^3/s (15,000 ft^3/s) as measured at the Irwin gage (USGS provisional data). Captured fish were anesthetized, identified, and measured to the nearest millimeter (TL). Linear regression models developed in 2003 were used to predict fish densities at each site using recorded CPUE. Predicted densities were averaged between sites, multiplied by the distance between sites, and summed to calculate total stock abundance in the upper river.

Rainbow Trout Exploitation and Harvest

As part of a statewide IDFG exploitation research project (Butts and Kennedy, in press), we estimated annual rainbow trout exploitation in the upper river above Heise from April 26, 2006, to April 26, 2007. Rates of exploitation, angler compliance, and tag loss were estimated using a combination of reward and non-reward tag returns. Fish were tagged during our stock assessment electrofishing in April, 2006, as described above, except that two additional sites – one at Sheep Creek and one at Indian Creek – were electrofished exclusively to tag fish. From 8 to 47 rainbow trout ≥203 mm were tagged at each site for a total of 321 fish. These included from 2 to 24 rainbow trout >406 mm at each site, for a total of 112 fish of this size. Over all sites, the smallest fish tagged was 230 mm and the largest was 567 mm. Ripe and spent rainbow trout were observed on redds, particularly just below the dam.

Roy T-bar external anchor tags were inserted into the fish at the base of the dorsal fin. Tags were fluorescent orange, 70 mm in total length with 51 mm of tubing, and were treated with algaecide. Each tag was labeled on two sides with one side stating the IDFG toll-free automated hotline number and the other side with a unique tag number and reward amount if applicable. To assess tag loss, a sub-sample of non-reward-tagged fish and all reward-tagged fish were double-tagged with an additional non-reward tag. We assumed tagged fish did not move into the lower river below Heise and that catchability was equal for tagged and untagged fish. Butts and Kennedy (in press) provide a detailed description of the program and how it was publicized to anglers.

The unadjusted exploitation rate, u , is calculated according to Ricker (1975):

$$u = \frac{R,}{M_S} \qquad (7)$$

where R_S is the number of standard tags recovered from fish that are harvested, and M_S is the number of fish tagged with standard tags. For this study, "standard" tags are defined as non-reward tags or reward tags with values of $10 or $50. We assumed that angler compliance, i.e. their willingness to report the tag, would be equal for these various values.

The high-reward method is used to calculate the tag reporting rate, A , or angler compliance (Pollock et al. 2001, with slightly different notation):

$$A, = \frac{R`Mh}{MR_{Sh}} \qquad (8)$$

where R_S and M_S are as before, M_h is the number of fish tagged with high-reward tags, and R_h is the number of high-reward tags reported from fish that are harvested. For this study, "high-reward" tags had values of $100 or $200. We assumed that angler compliance would be equal and 100% for each of these values, i.e. all anglers catching and keeping high-reward tagged fish would report the tag. Dividing *u by A* gives the exploitation rate adjusted for angler compliance.

Additional adjustments can be incorporated to account for tag loss. For this study, we differentiate between "natural" tag loss, in which case tags do not hold and become unattached from the fish by natural processes, and "angler-induced" tag loss, in which case anglers remove the tags, generally by clipping them off, before releasing the fish. The rate of natural tag loss, Tag„ , is estimated by double-tagging and can be expressed as:

$$Tag_{n„} = \frac{R}{R_d} \qquad (9)$$

where R_d' is the number of double-tagged fish for which a single tag was recovered, whether harvested or not — i.e. one tag was lost — and R_d is the total number of double-tagged fish reported, whether by one or both tags. Note that both R_d' and R_d can include high-reward tagged fish and angler compliance is not an issue. The rate of tag removal by anglers, Tag, , can be expressed as:

$$Tag,. = \frac{(R_r / 2)}{.r} \qquad (10)$$

where R,' is the number of released fish that had standard tags removed by anglers, i.e. the fish was released untagged, and M_S and A are as before. Note that because anglers report the tags that are removed, their recoveries are adjusted for compliance. We assume compliance is equal for anglers harvesting or releasing fish.

A final adjustment can be incorporated to account for the tag-induced mortality rate, *Tagm.* We assumed 25% tagging mortality for T-bar external anchor tags.

Taken together, the adjusted exploitation rate, u' , can be expressed as (adapted from Slipke and Maceina 2000):

$$u \quad 2\,(1 - Tag_{m}) \frac{u}{(1 - Tag\ r)\ (1 - Tag,,,)} \qquad (11)$$

where the terms are defined previously.

Unlike 2003 and 2005, we could not estimate exploitation rates for cutthroat, rainbow, or brown trout in 2006 by dividing total harvest, as determined from a creel survey, by total stock abundance. This is because we did not conduct a creel survey in 2006. However, total harvest of rainbow trout was estimated by multiplying the exploitation rate, which was derived from tagging, by total stock abundance, which was derived from CPUE models.

Modified Flows and Recruitment

Two mathematical indices were developed by Dr. Rob Van Kirk, Idaho State University, to evaluate South Fork Snake River flow management in terms of annual cutthroat trout recruitment relative to rainbow trout recruitment (Schrader and Fredericks 2006b). Both indices are based on empirical data and are a distillation and simplification of previous analytical work conducted by Moller and Van Kirk (2003). The Yellowstone cutthroat trout index, YCT_{Index} – developed using cutthroat and rainbow trout recruitment parameters measured at the Conant electrofishing section – is expressed as:

$$YCT\ Index = 3.083 \times 10^{-4}\ (YCT) - 2.359 \times 10^{-4}\ (RBT) + 2.559(\%YCT) + 0.1 \qquad (12)$$

where *YCT* is the age 1 (or yearling) cutthroat trout abundance estimate for the entire section, RBT is the age 1 rainbow trout abundance estimate, and *%YCT* is the percent age 1 cutthroat trout in the electrofishing catch out of all age 1 trout. The variable *%YCT* is expressed as a fraction rather than as a percent, e.g. 0.1 instead of 10%.

The hydrologic index, $Hydro\ Index,$ was developed from a set of five variables describing hydrologic conditions as measured at the USGS Heise gage. It is expressed as:

$$Hydro\ Index = -5.051(\text{Spawn } alt) + 0.1818(\text{Spawn } max/min) - 1.742(1\ st\ growth\ alt) + 0.1363(2\text{nd } spring\ max/min) - 3.183(2\text{nd } spring\ alt) + 4 \quad (13)$$

where *Spawn alt is* the mean daily absolute hydrologic alteration over the spawning period, *Spawn max/min is* the ratio of maximum flow during spawning to previous winter minimum flow, *1st growth alt is* the mean daily absolute hydrologic alteration over the first summer, *2nd spring max/min is* the same as *Spawn max/min* but calculated over the fish's second spring, and *2nd spring alt is* the same as *Spawn alt* but calculated over the spring of the fish's second year.

The two indices are significantly and positively correlated ($P = 0.0239$, $r^2 = 0.645$, $n = 17$) for recruitment years 1986 through 2003, excluding 1987 (Schrader and Fredericks 2006b). Our flow management goal, in cooperation with BOR, is to increase the *Hydro Index* which should result in an improved *YCT Index.*

We introduce a third simple metric to evaluate recruitment in relation to modified flow management. The cutthroat to rainbow trout recruitment ratio, *Recruit Ratio, is* expressed as:

$$Recruit\ Ratio = \frac{YCT}{RBT} \quad (14)$$

where *YCT* and *RBT* are as before. Our fishery management goal is for the ratio to be greater than one, i.e. more cutthroat than rainbow trout recruits.

Tributary Weirs

We operated, or attempted to operate, all four of the tributary fish weirs during 2006. Going upstream in the drainage, they include facilities at Burns, Pine, Rainey, and Palisades creeks — each located near the confluence with the South Fork Snake River (Figure 1). Host (2003) describes each weir and trap facility, but the old floating weir panels were replaced beginning in 2004 after poor weir efficiency and high cutthroat trout mortality were observed in 2003 (Schrader and Fredericks 2006a, 2006b; Garren et al. 2006). In 2006, we used Mitsubishi floating weir panels at Burns, Pine, and Palisades creeks (Figure 4). These panels were salvaged and refurbished from the Blackfoot River weir. Also at Pine Creek, we installed a temporary picket weir in a small side channel that carries water around the main weir during high runoff. At Rainey Creek, we used "hard" weir panels constructed with aluminum frames and 1.27 cm diameter electrical conduit pickets.

The Burns Creek weir was installed on April 14 and removed on June 30. The Pine Creek weir was installed on April 14 but had two panels wash out on April 18. Weir operation was discontinued because we could not replace the panels during extended high water. The Rainey Creek weir was installed on April 5 and removed on June 30. Pickets were pulled and the weir was off-line April 18 and April 30 to May 27 because of high water. High water on April 18 also eroded the embankments on both sides of the weir but did not affect the integrity of weir operation. The Palisades Creek weir was installed on April 4 and removed on June 30. All weirs were generally checked on a daily basis. Captured fish were identified and squeezed for gender determination. Cutthroat trout were released above the weir to spawn. Rainbow trout were loaded into an aerated fish tank, hauled to a holding pen at the Palisades Canal screen, and eventually stocked at kids fishing ponds. Captured fish were not anesthetized or measured.

We did not estimate weir or trap efficiency at Burns or Rainey creeks. Similar to past years, we estimated weir efficiency at Palisades Creek by marking all cutthroat trout released above the weir with a temporary upper caudal fin punch. We trapped a sample of post-spawning fish — defined as fish larger than 279 mm (Schrader and Fredericks 2006a) — returning downstream in the Palisades Canal screen bypass. The bypass trap was operated from May 2 to July 29 and checked on a daily basis. The proportion of marked to all cutthroat trout trapped was the weir efficiency. We assumed all the unmarked fish larger than 279 mm caught in the bypass were fluvial, had migrated upstream, spawned, and were returning downstream. As the Palisades Canal entrains some but not all post-spawning fish, we further assumed that the trapped fish were a random sample of all returning fish. Statistically, this implies that the proportion of marked fish in our sample was a valid estimate of the proportion in the total population. Unlike Host (2003) who evaluated the genetics of outmigrating fry, our goal was to evaluate the physical effectiveness of the refurbished Mitsubishi weir to block and trap upstream migrating fish.

Streamflows are not currently measured at any South Fork Snake River tributary. However, we used the difference between main river discharge measured at the USGS Heise and Irwin gages as a surrogate for discharge in the tributaries (Moller and Van Kirk 2003). This provided a single hydrograph to compare with our fish trapping results. Water temperature was also measured with a hand-held thermometer when we checked each weir.

Fish Screens

We operated and maintained rotary-drum fish screens in Burns and Palisades creek irrigation diversions from early spring to late fall. The small, single screen in Fullmer's ditch near Burns Creek was constructed in 1979. The large, four rotary-drum complex in the Palisades Canal was constructed by BOR in 1994. Unknown numbers of outmigrating cutthroat trout fry and post-spawners have been prevented from being entrained at the diversions since construction.

RESULTS

Fall Population Monitoring

Conant

We captured a total of 1,805 trout during four days of electrofishing. Relative abundance in the catch was 41.3% cutthroat trout, 31.6% rainbow trout, and 27.1% brown trout (Figure 5, Appendix B). No lake trout *Salvelinus namaycush* or kokanee *Oncorhynchus nerka* were captured, and less than 1% of the cutthroat trout was of hatchery origin from Palisades Reservoir.

Length frequency distributions show a relatively strong group of age 1 cutthroat trout (about 100 to 250 mm) but not as strong as age 1 rainbow trout (about 150 to 280 mm) or

brown trout (about 180 to 280 mm; Figure 6). However, this may be due to the size-selectivity of the sample gear. Strong groups of age 0 rainbow trout (<150 mm) and brown trout (<180 mm) are also evident.

Mean total length was 329 mm for cutthroat trout, 274 mm for rainbow trout, 266 mm for brown trout, and 295 mm for all trout species combined (Figure 6; Appendix B). Quality stock density was 17.6% for cutthroat trout, 15.4% for rainbow trout, 17.4% for brown trout, and 16.8% for all trout species combined.

Estimated densities of age 1 and older fish were 749 cutthroat trout/km, 677 rainbow trout/km, and 329 brown trout/km for a combined total of 1,755 fish/km (Figure 7; Appendix B). Cutthroat trout sample efficiency (R/C) over all sizes was 14.8%. This was within the range of previous years, as was rainbow trout efficiency at 9.2% and brown trout efficiency at 13.9%.

Estimated densities of age 1 fish, our measure of recruitment, were 328 cutthroat trout/km, 411 rainbow trout/km, and 219 brown trout/km for a combined total of 958 fish/km (Figure 8; Appendix B). The cutthroat to rainbow trout recruitment ratio was 0.8, i.e. about eight cutthroat trout were recruited for every ten rainbow trout (Figure 9). The cutthroat to brown trout recruitment ratio was 1.5. Yearling relative abundance in the catch was 21.7% cutthroat trout, 42.7% rainbow trout, and 35.6% brown trout.

Lorenzo

We captured a total of 2,247 trout during four days of electrofishing. Relative abundance in the catch was 7.7% cutthroat trout, 0.9% rainbow trout, and 91.4% brown trout (Figure 5, Appendix C). No lake trout or kokanee were captured, and none of the cutthroat trout was of hatchery origin from Palisades Reservoir.

The cutthroat trout length frequency distribution shows a relatively strong group of age 1 fish (about 100 to 250 mm) but sample size was small (Figure 10). Similarly, a very strong group of age 1 brown trout (about 180 to 280 mm) is evident. Only twenty-one rainbow trout were captured and they were not analyzed.

Mean total length was 310 mm for cutthroat trout, 284 mm for brown trout, and 286 mm for both trout species combined (Figure 10; Appendix C). Quality stock density was 10.2% for cutthroat trout, 14.6% for brown trout, and 14.2% for both trout species combined.

Estimated densities of age 1 and older fish were 116 cutthroat trout/km and 1,761 brown trout/km for a combined total of 1,877 fish/km (Figure 11; Appendix C). Cutthroat trout sample efficiency (WC) over all sizes was 19.7% and was the highest on record. Brown trout efficiency was 15.0% and was within the range of previous years. Similar to previous years, a density estimate was not possible for rainbow trout due to the small sample size.

Estimated densities of age 1 fish, our measure of recruitment, were 37 cutthroat trout/km and 1,191 brown trout/km for a combined total of 1,228 fish/km (Figure 12; Appendix C). The cutthroat to brown trout recruitment ratio was less than 0.1 (Figure 9). Yearling relative abundance in the catch was 4.1% cutthroat trout, 0.7% rainbow trout, and 95.2% brown trout.

Spring Stock Assessment and Distribution

For fish ≥203 mm, a total of 114,157 trout were estimated to be in the upper river above Heise on April 25-26, 2006 (Table 1). Of these, 28% or 31,829 fish were cutthroat trout, 44% or 50,498 fish were rainbow trout, and 28% or 31,830 fish were brown trout.

For fish ≥406 mm, a total of 33,019 trout were estimated to be in the upper river above Heise on April 25-26, 2006 (Table 2). Of these, 15% or 4,849 fish were cutthroat trout, 32% or 10,480 fish were rainbow trout, and 54% or 17,690 fish were brown trout.

In general, spring-time densities of cutthroat trout >203 mm were slightly higher – and densities of cutthroat trout ≥406 mm were slightly lower – as we sampled downstream (Figure 13). Spring-time densities of both >203 mm and >406 mm rainbow trout were highest upstream and gradually declined to near zero as we sampled downstream (Figure 14). In contrast, spring-time densities of both ≥203 mm and >406 mm brown trout were lowest upstream and gradually increased as we sampled downstream (Figure 15). Compared to the other trout taxa, cutthroat trout were more uniformly distributed throughout the upper river.

Rainbow Trout Exploitation and Harvest

Exploitation

The unadjusted exploitation rate for rainbow trout ≥203 mm, u_{203}, was estimated to be 7.1%. This is based on twenty-one fish with standard tags that were reported harvested, $Rs203$, from 296 fish at large, $Ms203$. The recoveries included sixteen fish with non-reward tags, two fish with $10 reward tags, and three fish with $50 reward tags. Initially, 296 rainbow trout ≥203 mm had standard tags – 243 with non-reward tags, 26 with $10 reward tags, and 27 with $50 reward tags.

The unadjusted exploitation rate for rainbow trout ≥406 mm, u_{406}, was estimated to be 8.0%. This is based on eight fish with standard tags that were reported harvested, $Rs406$, from 100 fish at large, $Ms406$. The recoveries included six fish with non-reward tags, one fish with a $10 reward tag, and one fish with a $50 reward tag. Initially, 100 rainbow trout >406 mm had standard tags – 86 with non-reward tags, 8 with $10 reward tags, and 6 with $50 reward tags.

The tag return rate, A, or angler compliance was estimated to be 186%, which is larger than 100% and theoretically impossible. The large value is based on one fish with a $200 high-reward tag, R_h, that was harvested from 25 fish at large, M_h. Originally, twelve fish had $100 reward tags and thirteen had $200 reward tags. Until a more accurate rate can be determined for the South Fork Snake River, we will use the median value of 60% from the statewide results for wild rainbow trout (n = 3 waters, range 40-80%; Butts and Kennedy, in press). We assumed angler compliance was equal for fish >203 mm and fish >406 mm.

The rate of natural tag loss, Tag, , was 29.0% based on nine single tags recovered, R_d', from thirty-one known double-tagged fish that were reported, R_d. Due to the small sample size, we assumed the rate of natural tag loss was equal for fish >203 mm and fish >406 mm.

For fish >203 mm, the rate of tag removal by anglers, $Tag_{,203}$, was estimated to be 9.0%. This is based on anglers removing sixteen standard tags without killing the fish, $R1_{203}'$, from 296 fish at large, Ms_{203} , and adjusting for angler compliance, A, at 60%. Another six fish were caught and released without removing the tag, but this did not affect the affect the exploitation rate.

For fish >406 mm, the rate of tag removal by anglers, $Tagr_{406}$, was estimated to be 15.0%. This is based on anglers removing nine standard tags without killing the fish, R_{r406}' , from 100 fish at large, Ms_{406} , and adjusting for angler compliance, A, at 60%. Another four fish were caught and released without removing the tag, but this did not affect the affect the exploitation rate.

The tagging mortality rate, *Tag,n ,* was assumed to be 25% for both fish >203 mm and fish >406 mm.

Using the above values, the adjusted exploitation rate for rainbow trout >203 mm, u_{203}' , was estimated to be 24.4% and for rainbow trout >406 mm, u_{406}' , was 29.5%.

These annual exploitation rates, and the harvest estimates below, reported for 2006 apply to the majority of the 2006 fishing season (April 26 to December 31) combined with the winter portion of the 2007 fishing season (January 1 to April 26). The values are applicable to the upper river above Heise (64 km). A total of $610 was paid in rewards for South Fork Snake River tag returns over this time period.

Harvest

Estimated harvest of rainbow trout <u>≥203</u> mm was 12,322 fish using the total stock abundance estimate of 50,498 fish (Table 1) and the adjusted exploitation rate of 24.4%. Estimated harvest was 3,585 fish using the unadjusted exploitation rate of 7.1%.

Estimated harvest of rainbow trout <u>≥406</u> mm was 3,092 fish using the total stock abundance estimate of 10,480 fish (Table 2) and the adjusted exploitation rate of 29.5%. Estimated harvest was 838 fish using the unadjusted exploitation rate of 8.0%.

<u>Modified Flows and Recruitment</u>

During 2006, a peak flow of 552.4 m^3/s or 19,500 ft^3/s was recorded on June 16 at the USGS Irwin gage (Figure 16). The maximum to minimum flow ratio was 6.4, as measured at the USGS Heise gage from March 23 to July 6.

The 2006 *Hydro Index,* calculated from the 2005 and 2006 flow regimes, was 3.459 (Figure 17). Despite the large *Hydro Index,* the *YCT Index* was 0.677 (Figure 18). Using the significant and positive linear relationship between the *Hydro Index* and the *YCT Index (P* = 0.0239, r^2 = 0.645, *n* **=** 17 years), a *YCT Index* value of 2.654 was predicted for recruitment year 2006 (Figure 19). As reported above, the *Recruit Ratio* was 0.8 (Figure 9).

Tributary Weirs

We removed 58 rainbow trout and passed 1,944 cutthroat trout upstream to spawn, for a combined total of 2,002 fish trapped, at the three South Fork Snake River tributary weirs (Table 3). Of the rainbow trout, 5.2% were caught each at Burns and Rainey creeks, and 89.6% were caught at Palisades Creek. Of the cutthroat trout, 79.2% were caught at Burns Creek, 3.5% at Rainey Creek, and 17.3% at Palisades Creek.

Burns Creek

From April **14** to June 30, 2006, we trapped a total of 1,542 trout at the Burns Creek weir, of which 3 fish or 0.2% were rainbow trout and 1,539 fish or 99.8% were cutthroat trout (Table 3).

The one male and two female rainbow trout were caught between May 15-25, and the midpoint was May 25 (Table 4; Figure 20). Too few rainbow trout were caught for a reliable estimate of sex ratio (n=3 fish).

The 744 male and 795 female cutthroat trout were caught between April 22 and June 27, and the midpoint was June 10 (Table 5: Figure 20). The observed sex ratio was 1.0 male to 1.1 females, or 51.7% females (n=1,539 fish).

We did not estimate the efficiency of the Mitsubishi weir during 2006.

Pine Creek

The Pine Creek Mitsubishi weir was destroyed during high water on April 18 – shortly after installation on April 14 – and no fish were trapped (Table 3; Figure 21).

Rainey Creek

From April 5 to June 30, 2006, we trapped a total of 72 trout at the Rainey Creek weir, of which 3 fish or **4.2%** were rainbow trout and 69 fish or 95.8% were cutthroat trout (Table **3).** It is likely additional fish were missed when the weir was off-line April 18 and most of the month of May, i.e. April 30 to May 27. One juvenile brown trout was also caught.

The one male and two female rainbow trout were caught between May 28-31, and the midpoint was May 31 (Table 4; Figure 22). Too few rainbow trout were caught for a reliable estimate of sex ratio (n=3 fish).

The 26 male and **43** female cutthroat trout were caught between May 28 and June 21, and the midpoint was June 7 (Table 5: Figure 22). The observed sex ratio was 1.0 male to 1.7 females, or 62.3% females (n=69 fish).

We did not estimate the efficiency of the "hard" picket weir during 2006.

Palisades Creek

From April **4** to June 30, 2006, we trapped a total of 388 trout at the Palisades Creek weir, of which 52 fish or 13.4% were rainbow trout and 336 fish or 86.6% were cutthroat trout (Table 3).

The 29 male and 23 female rainbow trout were caught between April 14 and June 7, and the midpoint was May 15 (Table 4; Figure 23). The observed sex ratio was 1.0 male to 0.8 females, or 44.2% females (n=52 fish).

The 140 male and 196 female cutthroat trout were caught between April 22 and June 30, and the midpoint was June 10 (Table 5: Figure 23). The observed sex ratio was 1.0 male to 1.4 females, or 58.3% females (n=336 fish).

The estimated efficiency of the refurbished Mitsubishi floating weir was 12.8% (Table 3). This is based on 117 post-spawning cutthroat trout caught in the Palisades Canal screen bypass trap, of which 15 fish were marked and 102 fish were unmarked. The total cutthroat trout run size was estimated to be 2,625 fish based on the number of marked fish released above the weir (M=336 fish) divided by the weir efficiency (R/C=12.8%).

Twenty rainbow trout of all sizes were also caught in the bypass trap, but only nine fish were >279 mm and initially considered post-spawners. These post-spawners were caught between May 18 and July 14. Dissection in the laboratory indicated that four females and two males were spent, whereas one female and one male were ripe and may not have spawned. Another female was immature at 390 mm, but the egg sacks were in an advanced stage of development. In addition, we caught two small precocious males that measured about 250 mm on May 11 and 13. Their testes were well-developed, but whether they had spawned is unknown.

DISCUSSION

Fall Population Monitoring

Compared to 2005 (Schrader and Fredericks 2006b), age 1 and older cutthroat trout increased 14% at Conant and 53% at Lorenzo (Figures 7 and 11). However, 95% confidence intervals overlapped and the increases from 2005 to 2006 were not statistically significant at either section. Unfortunately, the 2006 density estimates of **749** fish/km at Conant and 116 fish/km at Lorenzo remain at about one-third to one-half of their long-term averages – 1,388 fish/km at Conant (n=16 years) and 306 fish/km at Lorenzo (n=12 years). Age 1 and older cutthroat trout have not exceeded these averages at either section since 1999, partly due to the extended drought. We expect the recent but small upward trend to continue following the above normal precipitation observed in 2006.

Age 1 and older rainbow trout also increased at Conant by 61% (Figure 7), but we presume they did not increase much at Lorenzo for reasons discussed by Schrader and Fredericks (2006b). However, the electrofishing catch of 21 fish was the highest on record at Lorenzo. The increase at Conant from 2005 to 2006 was not statistically significant. In contrast to cutthroat trout, the 2006 rainbow trout density estimate of 677 fish/km at Conant is considerably higher than their long-term average of 460 fish/km (n=14 years). This is an unfortunate reversal of the decreasing trend that began in 2004 and extended to 2005.

Age 1 and older brown trout increased 60% at Conant and 128% at Lorenzo (Figures 7 and 11). The increase from 2005 to 2006 was not statistically significant at Conant but was at Lorenzo. The estimate of 1,761 fish/km at Lorenzo was also the highest on record. For the first time, total trout density was higher at Lorenzo than at Conant in 2006 – but this was more a result of a strong brown trout year class at Lorenzo rather than fewer cutthroat trout at Conant. The 2006 brown trout density estimate of 329 fish/km at Conant was near their long-term average of 316 fish/km (n=16 years), and their trend has been stable.

All the age 1 and older 2005 density estimates referred to above, except brown trout at Lorenzo, were derived using a modified Petersen estimator (Schrader and Fredericks 2006b). These estimates are typically biased downward due to the size-selectivity of the sample gear. Had the log likelihood estimator been used in 2005, the increases reported above would have been less. Another major consequence of using the modified Petersen estimator was the inability to estimate age 1 (yearling) density directly. By using cohort analysis and observed survival rates over the years, Schrader and Fredericks (2006b) estimated age 1 density indirectly. As a result, statistical comparisons between 2005 and 2006 are not possible because of the inability to calculate 95% confidence intervals around most of the 2005 yearling estimates.

Compared to 2005 (Schrader and Fredericks 2006b), yearling cutthroat trout at Conant decreased 5% but yearling rainbow trout increased 97% and yearling brown trout increased 548% – almost seven-fold (Figure 8). Further, the cutthroat trout estimate of 328 fish/km was below their long-term average of 434 fish/km (n=20 years including cohort analysis) – as has been the case since 2000. The rainbow trout estimate of 411 fish/km was not only higher than cutthroat trout – resulting in a recruitment ratio less than one – but was also above their long-term average of 274 fish/km (n=19 years). This is an unfortunate reversal of the decreasing trend that began in 2004 and extended to 2005. The brown trout estimate of 219 fish/km was near their long-term average of 158 fish/km (n=20 years), and their trend has been stable. The large increase in 2006 was the result of a very low estimate in 2005.

At Lorenzo, yearling brown trout increased 210% compared to 2005 (Schrader and Fredericks 2006b), but yearling cutthroat trout decreased 46% compared to 2003 (Schrader and Fredericks 2006a; Figure 12). A yearling cutthroat trout density estimate was not possible in 2005 due to the small sample size. The brown trout increase from 2005 to 2006 was statistically significant but the cutthroat trout decrease was not. The 2006 brown trout estimate of 1,191 fish/km – the highest on record – was three-fold higher than their long-term average of 396 fish/km (n=12 years), reflecting a very strong year class produced in 2005. The 2006 cutthroat trout estimate of 37 fish/km – the second lowest on record, surpassed only in 1988 – was lower than their long-term average of 88 fish/km (n=11 years), reflecting a very weak year class produced in 2005. Possible reasons for high brown trout but low cutthroat trout recruitment at Lorenzo are discussed in Schrader and Fredericks (2006b). In general, more than twice as many yearling brown trout, on average, are produced at Lorenzo than at Conant. In contrast, about five times as many yearling cutthroat trout are produced at Conant than at Lorenzo.

Spring Stock Assessment and Distribution

For fish ≥203 mm, the 114,157 trout estimated to be in the upper river above Heise on April 25-26, 2006, compares to about 69,000 trout on May 4-6, 2005 (Schrader and Fredericks 2006b) and 106,000 trout on April 22-May 17, 2003 (Schrader and Fredericks 2006a). For cutthroat trout, the 31,829 fish in 2006 compares to about 21,000 fish in 2005 and 42,000 fish in 2003. For rainbow trout, the 50,498 fish in 2006 compares to about 31,000 fish in 2005 and 39,000 fish in 2003. For brown trout, the 31,830 fish in 2006 compares to about 17,000 fish in 2005 and 25,000 fish in 2003.

For fish >406 mm, the 33,019 trout estimated to be in the upper river above Heise in 2006 compares to about 21,000 trout in 2005 (Schrader and Fredericks 2006b) and 34,000 trout in 2003 (Schrader and Fredericks 2006a). For cutthroat trout, the 4,849 fish in 2006 compares to about 3,400 fish in 2005 and 5,400 fish in 2003. For rainbow trout, the 10,480 fish in 2006 compares to about 6,600 fish in 2005 and 12,400 fish in 2003. For brown trout, the 17,690 fish in 2006 compares to about 11,200 fish in 2005 and 16,600 fish in 2003.

Rainbow Trout Exploitation and Harvest

The adjusted exploitation rate for rainbow trout ≥203 mm, u_{203}', was estimated to be 24.4% in 2006, which is slightly higher than the 20.6% reported for 2005 (Schrader and Fredericks 2006b) and double the 12.1% reported for 2003 (Schrader and Fredericks 2006a). The 2006 harvest estimate of 12,322 fish is almost double the 6,441 fish harvested in 2005 and almost triple the 4,703 fish harvested in 2003.

The adjusted exploitation rate for rainbow trout ≥406 mm, u_{406}', was estimated to be 29.5% in 2006, which is lower than the 43.3% reported for 2005 (Schrader and Fredericks 2006b) but higher than the 18.9% reported for 2003 (Schrader and Fredericks 2006a). The 2006 harvest estimate of 3,092 fish is higher than the 2,868 fish harvested in 2005 and the 2,352 fish harvested in 2003.

Note that exploitation in 2006 was estimated using a different method than was used in 2005 (Schrader and Fredericks 2006b) and 2003 (Schrader and Fredericks 2006a), when harvest estimates from creel surveys were combined with pre-season stock abundance estimates from a CPUE model.

Modified Flows and Recruitment

Three freshets have been provided by BOR since the need for modified flow management was recognized by Moller and Van Kirk (2003) and Hauer et al. (2004). A peak flow of 552.4 m^3/s (19,500 ft^3/s) was recorded on June 16, 2006 – compared to a peak flow of 422.1 m^3/s (14,900 ft^3/s) on June 15, 2005, and 538.2 m^3/s (19,000 ft^3/s) on May 23, 2004 – at the USGS Irwin gage (Figure 16). Maximum to minimum flow ratios, measured at the USGS Heise gage from March 23 to July 6, were 6.4 in 2006 – compared to 11.4 in 2005 and 14.3 in 2004. None of these flow ratios were fifteen or greater, the generally agreed upon goal (Rob Van Kirk, personal communication).

The 2006 *Hydro Index,* calculated from the 2005 and 2006 flow regimes, was 3.459 – which is higher than the 2005 index and is within the top three index values over the last 20 years (Figure 17). The large value in 2006 is primarily due to the relatively high peak flows delivered in 2005 and 2006, although maximum to minimum flow ratios both years were below fifteen. As a result, the 2006 recruit class – i.e. yearlings measured in the fall 2006, but produced in the spring and summer 2005 – experienced very favorable hydrologic conditions in terms of the freshets but not in terms of the maximum to minimum flow ratios.

Despite the large *Hydro Index,* the 2006 *YCT Index* was 0.677 – down from the 2005 index and within the bottom five index values over the last 20 years (Figure 18). The bottom five index values have all occurred since 2001, although 2005 is an exception. However, the 2005 value was measured using cohort analysis, as was six other years in the 20 year data set. The low *YCT Index* for 2006 is because cutthroat trout recruitment was below average and rainbow trout recruitment was very high – the fourth-highest recorded, exceeded only by recruitment years 1997, 2002, and 2003.

Using the significant and positive linear relationship between the *Hydro Index* and the *YCT Index (P* = 0.0239, r^2 = 0.645, *n* **=** 17 years), a *YCT Index* value of 2.654 was predicted for 2006 (Figure 19). The observed value of 0.677 was considerably lower than this predicted value for unknown reasons. A large deviation between the predicted and the observed value was also noted in recruitment year 2004 but not in 2005.

The *Recruit Ratio* at Conant was 0.8 in 2006 – down from 1.7 in 2005 and within the bottom five values over the last 20 years (Figure 9). Similar to the *YCT Index,* the bottom six *Recruit Ratio* values have all occurred since 2000, although 2005 is an exception. The general pattern of the *Recruit Ratio is* similar to the general pattern of the *YCT Index* over the last 20 years (Figure 18). This would be expected as the underlying data to calculate either. metric is fundamentally the same.

Tributary Weirs

The tributary weir program was not very effective at removing rainbow trout during 2006 due to the high runoff conditions – particularly bedload and debris movement that wreaked havoc with the weir panels. These conditions were a result of normal to slightly above normal snowpack, precipitation, and runoff in the basin during 2006. Because of the extreme drought – punctuated by above normal spring-time precipitation in 2004 and 2005 – we had not experienced similar conditions since the inception of the tributary weir program in 2001. Major repair work will be needed at all the weir sites before operating the weirs again in 2007.

Burns Creek

The 1,542 trout trapped at the Burns Creek weir during 2006 were within the range of previous years ($n^{=}3$) when a different type of weir was used under more moderate runoff conditions (Table 3). Few rainbow trout have ever been caught at Burns Creek – from one to sixteen fish – and their proportion has always been less than one percent of the total. In contrast, the number of cutthroat trout trapped at Burns Creek has always been large – from 1,300 to over 3,000 fish – and has only been surpassed by Pine Creek.

During 2006, rainbow trout were caught between May 15-25 with the midpoint on May 25 (n=3 fish; Table **4;** Figure 20). These dates fell within the range of previous years at Burns Creek (April 15 to June 16, n=3) and within the overall range of rainbow trout arrival dates into all tributaries over all years (March 22 to July 9, n=17). During 2006, cutthroat trout were caught between April 22 and June 27 with the midpoint on June 10 (n=1,539 fish; Table 5: Figure 20). These dates also fell within the range of previous years at Burns Creek (March 31 to July 9, n= 3) and within the overall range of cutthroat trout arrival dates into all tributaries over all years (March 28 to July 13, n=17).

Rainey Creek

Despite the extended down time in 2006 due to high runoff, the 72 trout trapped at the Rainey Creek weir were the highest on record (n=4 years), although a different type of weir was used the first two years (Table 3). Further, rainbow and brown trout were caught for the first time in 2006. The number of rainbow and cutthroat trout caught at Rainey Creek – and presumably their total run size – has always been and continues to be the lowest of the four tributaries monitored. This is primarily due to dewatering of the stream channel at several irrigation diversions below the weir site (Moore and Schill 1984)

During 2006, rainbow trout were caught between May 28-31 with the midpoint on May 31 (n=3 fish; Table **4;** Figure 22). Although no rainbow trout had been trapped prior to 2006 at Rainey Creek, these dates fell within the overall range of rainbow trout arrival dates into all tributaries over all years (March **22** to July 9, n=17). During 2006, cutthroat trout were caught between May 28 and June 21 with the midpoint on June 7 (n=69 fish; Table 5: Figure 22). Although few cutthroat trout had been trapped prior to 2006 at Rainey Creek, these dates also fell within the overall range of cutthroat trout arrival dates into all tributaries over all years (March 28 to July 13, n=17).

Palisades Creek

The 388 trout trapped at the Palisades Creek weir during 2006 were the lowest on record (n=5 years), although a different type of weir was used the first three years (Table 3). However, the estimated efficiency of the refurbished Mitsubishi floating weir was only 12.8% – the second lowest on record. Only during 2001 was efficiency estimated to be lower – about 10% using a different method and with a different type of floating weir (Host 2003). Of the four tributaries that have weirs, most rainbow trout are caught at Palisades Creek, sometimes numbering over 300 fish. For this reason, operating the Palisades Creek weir has been our highest priority. We believe we are seeing some success – about 25% of the fish caught were rainbow trout in 2001 through 2003, which declined to 22% in 2005 and 13% in 2006. Further, the total cutthroat trout run size in 2006 was estimated to be 2,625 fish – roughly double the 1,183 fish in 2005 or the 1,418 fish in 2003 using the same bypass mark-recapture method. The number of cutthroat trout caught in Palisades Creek has always been moderately large – from 300 to over 1,000 fish – but not as large as Burns or Pine creeks.

During 2006, rainbow trout were caught between April 14 and June 7 with the midpoint on May 15 (n=52 fish; Table 4; Figure 23). These dates fell within the range of previous years at Palisades Creek (March 22 to July 9, n=4) and within the overall range of rainbow trout arrival

dates into all tributaries over all years (March 22 to July 9, n=17). During 2006, and similar to Burns Creek, cutthroat trout were caught between April 22 and June 30 with the midpoint on June 10 (n=336 fish; Table 5: Figure 23). These dates also fell within the range of previous years at Palisades Creek (April 10 to July 13, n=4 years) and within the overall range of cutthroat trout arrival dates into all tributaries over all years (March 28 to July 13, n=17).

RECOMMENDATIONS

1. Continue to implement flow management objectives recommended by EBSM (Hauer et al. 2004) and by Moller and Van Kirk (2003). For 2007, encourage BOR to provide a higher spring flushing flow — greater than 566.6 m^3/s (20,000 ft^3/s) — and a higher maximum to minimum flow ratio — greater than 15.0 — even if the tradeoff is slightly lower winter flows.
2. Continue to monitor South Fork Snake River trout populations by electrofishing in 2007. Estimate pre-season stock abundance in the spring and sample the Conant and Lorenzo sections in the fall.
3. Continue to estimate rainbow trout exploitation using reward tags in 2007.
4. Continue to inform and educate anglers regarding benefits to cutthroat trout by harvesting rainbow trout.
5. Continue to operate all fish weirs except Burns Creek in 2007. Modify all tributary fish weirs to improve weir efficiency and develop evaluation objectives.
6. Continue to operate and maintain rotary drum fish screens on irrigation diversions in Palisades and Burns creeks.
7. Initiate population dynamics modeling with Rob Van Kirk (Idaho State University) and Laurie Battle (Montana Tech).

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TABLES

Table 1. Predicted stock density (N/km, from CPUE model) and total abundance (N) of trout >203 mm in the upper South Fork Snake River, Idaho, April 25-26, 2006. Sites were spaced at 8 km intervals beginning at Palisades Dam (site 1) and ending at the Heise cable (site 9).

Site	VVP shock time (min	Cutthroat trout[a]					Rainbow trout					Brown					Total N
		Catch	%	CPUE (fish/ min)	N/km	N	Catch	%	CPUE (fish/ min)	N/km	N	Catch	%	CPUE (fish/ min)	N/km	N	
1	34.92	18	22.2	0.52	197		42	51.9	1.20	661		21	25.9	0.60	215		
2	27.97	27	20.5	0.97	370	2,268	97	73.5	3.47	1,905	10,263	8	6.1	0.29	102	1,267	13,798
3	39.52	25	26.6	0.63	242	2,448	51	54.3	1.29	709	10,456	18	19.1	0.46	163	1,059	13,962
4	31.03	39	27.1	1.26	481	2,894	67	**46.5**	2.16	1,186	7,579	38	26.4	1.22	437	2,399	12,871
5	34.82	35	42.2	1.01	385	3,464	13	15.7	0.37	205	5,564	35	42.2	1.01	359	3,183	12,212
6	40.03	96	47.1	2.40	918	5,212	45	22.1	1.12	617	3,290	63	30.9	1.57	562	3,682	12,184
7	32.55		46_31	1.41	541	5,837	51	34.5	1.57	861	5,912	51	34.5	1.57	559	4,484	16,233
8	33.18	43	25.7	1.30	496	4,149	24	14.4	0.72	397	5,031	100	59.9	3.01	1,076	6,540	15,720
9	27.02	63	38.0	2.33	893	5,556	10	6.0	0.37	203	2,402	93	56.0	3.44	1,229	9,217	17,176
Total	301.03	392				31,829	400				50,498	427				31,830	114,157

[a] Includes hatchery cutthroat trout.

Table 2. Predicted stock density (N/km, from CPUE model) and total abundance (N) of trout >406 mm in the upper South Fork Snake River, Idaho, April 25-26, 2006. Sites were spaced at 8 km intervals beginning at Palisades Dam (site 1) and ending at the Heise cable (site 9).

Site	VVP shock time) (min	Cutthroat trout[a]					Rainbow trout					Brown					Total N
		Catch	%	CPUE (fish/ min)	N/km	N	Catch	%	CPUE (fish/ min)	N/km	N	Catch	%	CPUE (fish/ min)	N/km	N	
1	34.92	7	16.3	0.20	62		25	58.1	0.72	278		11	25.6	0.32	128		
2	27.97	14	31.8	0.50	155	868	22	50.0	0.79	306	2,335	8	18.2	0.29	116	974	4,177
3	39.52	8	17.0	0.20	63	871	23	48.9	0.58	226	2,127	16	34.0	0.40	164	1,120	4,117
4	31.03	8	22.2	0.26	80	570	15	41.7	0.48	188	1,656	13	36.1	0.42	170	1,335	3,561
5	34.82	10	25.0	0.29	89	675	8	20.0	0.23	89	1,108	22	**55.0**	0.63	256	1,703	3,486
6	40.03	11	16.2	0.27	85	696	18	26.5	**0.45**	175	1,056	39	57.4	0.97	395	2,603	4,355
7	32.55	2	5.1	0.06	19	416	9	23.1	0.28	107	1,128	28	71.8	0.86	349	2,973	4,518
8	33.18	6	11.8	0.18	56	300	5	9.8	0.15	59	664	40	78.4	1.21	488	3,348	4,312
9	27.02	5	13.9	0.19	57	453	3	8.3	0.11	43	407	28	77.8	1.04	420	3,634	4,493
Total	301.03	71				4,849	128				10,480	205				17,690	33,019

[a] Includes hatchery cutthroat trout.

Table 3. Summary of fish weirs operated in tributaries of the South Fork Snake River, Idaho, 2001-2006. Streams are listed going up the drainage.

Year	Estimated weir efficiency	Catch: Rainbow trout	Catch: Cutthroat trout	Catch: Total
	Burns Creek			
2001[b]		3	3,156	3,159
2002[d]		16	1,898	1,914
2003[d]		1	1,350	1,351
2004		ND	ND	ND
2005		ND	ND	ND
2006		3	1,539	1,542
	Pine Creek			
2001[b]		ND	ND	ND
2002[d]			14	
2003[f]			7	
2004			27	
2005			40	
2006[g]			ND	
	Rainey Creek			
2001[b]		0	0	0
2002[b]		0	1	1
2003		ND	ND	ND
2004		ND	ND	ND
2005		0	25	25
2006		3	69	72
	Palisades Creek			
2001[b]		160	491	651
2002[b]		310	967	1,277
2003		181	529	710
2004		ND	ND	ND
2005		301	1,071	1,372
2006		52	336	388
Total by year:				
2001		163	3,647	3,810
2002[b]		340	3,068	3,408
2003		189	2,207	2,396
2004		27	2,143	2,170
2005		341	3,913	4,254
2006[b]		58	1,944	2,002
Grand total:		1,118	16,922	18,040

[a] Weir efficiency was estimated using several different methods.
[b] From Host (2003).
NE = no estimate.
[d] Weir was shut down on June 10, but the trap was operated until June 23.
[e] ND = no data; weir either not built or not operated.

[f] Weir was shut down early due to high cutthroat trout mortality.
[g] Weir was destroyed during high runoff.

Table 4. Rainbow trout timing of arrival at fish weirs operated in the South Fork Snake River, Idaho, 2001-2006. Streams are listed going up the drainage.

Year	Weir type	Operation dates	Date first fish caught	Median date (50% caught)	Date last fish caught	Total fish caught
			Burns Creek			
2001[a]	Floating panel	Mar 7 - Jul 20	May 27	May 28	May 28	3
2002[a]	Floating panel	Mar 23 - Jul 5	Apr 15	Apr 30	May 27	16
2003[b]	Floating panel	Mar 28 - Jun 23	Jun 16	Jun 16	Jun 16	1
2004	ND°	ND	ND	ND	ND	ND
2005	ND	ND	ND	ND	ND	ND
2006	Mitsubishi	Apr 14 - Jun 30	May 15	May 25	May 25	3
Over all years:		Mar 7 - Jul 20	Apr 15	May **3**	Jun 16	23
			Pine Creek			
2001[a]	ND	ND	ND	ND	ND	ND
2002[a]	Floating panel	Apr 2 - Jul 5	May 12	May 12	Jun 13	14
2003[d]	Floating panel	Mar 27 - Jun 12	Apr 21	Jun **4**	Jun 8	7
2004	Hard picket	Mar 25 - Jun 28	Apr 22	May 17	Jun 22	27
2005	Hard picket	Apr 6 - Jun 30	Apr 26	May 31	Jun 20	40
2006[e]	Mitsubishi	Apr 14 - Apr 18	ND	ND	ND	ND
Over all years:		Mar 25 - Jul **5**	Apr 21	May 26	Jun 22	88
			Rainey Creek			
2001[a]	Floating panel	Mar 7 - Jul 6	ND	ND	ND	0
2002[a]	Floating panel	Mar 26 - Jun 27	ND	ND	ND	0
2003	ND	ND	ND	ND	ND	ND
2004	ND	ND	ND	ND	ND	ND
2005	Hard picket	Apr 7 - Jun 29	ND	ND	ND	0
2006	Hard picket	Apr **5 -** Jun 30	May 28	May 31	May 31	3
Over all years:		Mar 7 - Jul 6	May 28	May 31	May 31	3
			Palisades Creek			
2001[a]	Floating panel	Mar 7 - Jul 20	Mar 27	May 8	Jul 9	160
2002[a]	Floating panel	Mar 22 - Jul 7	Mar 26	May 18	Jun 16	310
2003	Floating panel	Mar 24 - Jun 24	Mar 31	Apr 25	Jun 11	181
2004	ND	ND	ND	ND	ND	ND
2005	Mitsubishi	Mar 18 - Jun 30	Mar 22	May 19	Jun 22	301
2006	Mitsubishi	Apr **4 -** Jun 30	Apr 14	May 15	Jun 7	52
Over all years:		Mar 7 - Jul 20	Mar 22	May 14	Jul 9	1,004
Overall:		Mar 7 - Jul 20	Mar 22	May 15	Jul 9	1,118

[a] From Host (2003).
[b] Weir was shut down on June 10, but the trap was operated until June 23.
ND = no data; well either not built or not operated, or no fish captured. [d] Weir was shut down early due to high cutthroat trout mortality. [a] Weir was destroyed during high runoff.

Table 5. Cutthroat trout timing of arrival at fish weirs operated in the South Fork Snake River, Idaho, 2001-2006. Streams are listed going up the drainage.

Year	Weir type	Operation dates	Date first fish caught	Median date (50% caught)	Date last fish caught	Total fish caught
			Burns Creek			
2001[a]	Floating panel	Mar 7 - Jul 20	May 13	Jun 9	Jul 9	3,156
2002[a]	Floating panel	Mar 23 - Jul 5	Apr 29	Jun 12	Jul 5	1,898
2003[b]	Floating panel	Mar 28 - Jun 23	Mar 31	Jun 14	Jun 22	1,350
2004	ND°	ND	ND	ND	ND	ND
2005	ND	ND	ND	ND	ND	ND
2006	Mitsubishi	Apr 14 - Jun 30	Apr 22	Jun 10	Jun 27	1,539
Over all years:		Mar 7 - Jul 20	Mar 31	Jun 11	Jul 9	7,943
			Pine Creek			
2001[a]	ND	ND	ND	ND	ND	ND
2002[a]	Floating panel	Apr 2 - Jul 5	May 12	Jun 17	Jul 5	202
2003[d]	Floating panel	Mar 27 - Jun 12	Mar 28	Jun 8	Jun 11	328
2004	Hard picket	Mar 25 - Jun 28	Apr 14	Jun 3	Jun 25	2,143
2005	Hard picket	Apr 6 - Jun 30	Apr 19	Jun 9	Jun 24	2,817
2006[e]	Mitsubishi	Apr 14 - Apr 18	ND	ND	ND	ND
Over all years:		Mar 25 - Jul 5	Mar 28	Jun 6	Jul 5	5,490
			Rainey Creek			
2001[a]	Floating panel	Mar 7 - Jul 6	ND	ND	ND	0
2002[a]	Floating panel	Mar 26 - Jun 27	ND	ND	ND	1
2003	ND	ND	ND	ND	ND	ND
2004	ND	ND	ND	ND	ND	ND
2005	Hard picket	Apr 7 - Jun 29	May 11	May 23	Jun 17	25
2006	Hard picket	Apr 5 - Jun 30	May 28	Jun 7	Jun 21	69
Over all years:		Mar 7 - Jul 6	May 11	Jun 7	Jun 21	95
			Palisades Creek			
2001[a]	Floating panel	Mar 7 - Jul 20	Apr 27	Jun 17	Jul 13	491
2002[a]	Floating panel	Mar 22 - Jul 7	May 11	Jun 15	Jul 7	967
2003	Floating panel	Mar 24 - Jun 24	Apr 10	Jun 9	Jun 21	529
2004	ND	ND	ND	ND	ND	ND
2005	Mitsubishi	Mar 18 - Jun 30	Apr 15	Jun 13	Jun 30	1,071
2006	Mitsubishi	Apr 4 - Jun 30	Apr 22	Jun 10	Jun 30	336
Over all years:		Mar 7 - Jul 20	Apr 10	Jun 13	Jul 13	3,394
Overall:		Mar 7 - Jul 20	Mar 28	Jun 10	Jul 13	16,922

[a] From Host (2003).
[b] Weir was shut down on June 10, but the trap was operated until June 23.
ND = no data; weir either not built or not operated, or no fish captured.
[d] Weir was shut down early due to high cutthroat trout mortality.
[e] Weir was destroyed during high runoff.

FIGURES

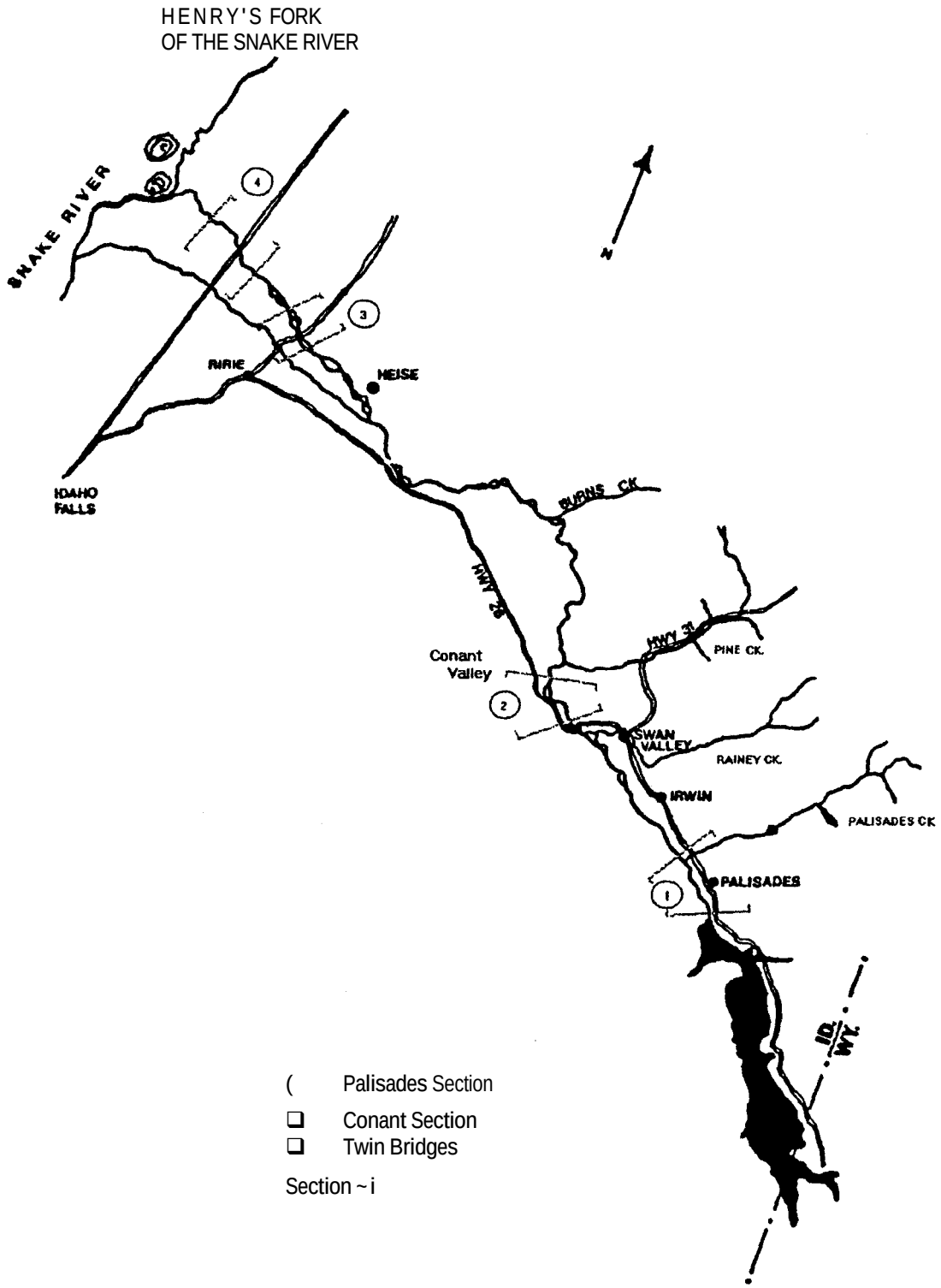


Figure 1. Map of South Fork Snake River, Idaho, showing standard electrofishing sections and the four major spawning tributaries.

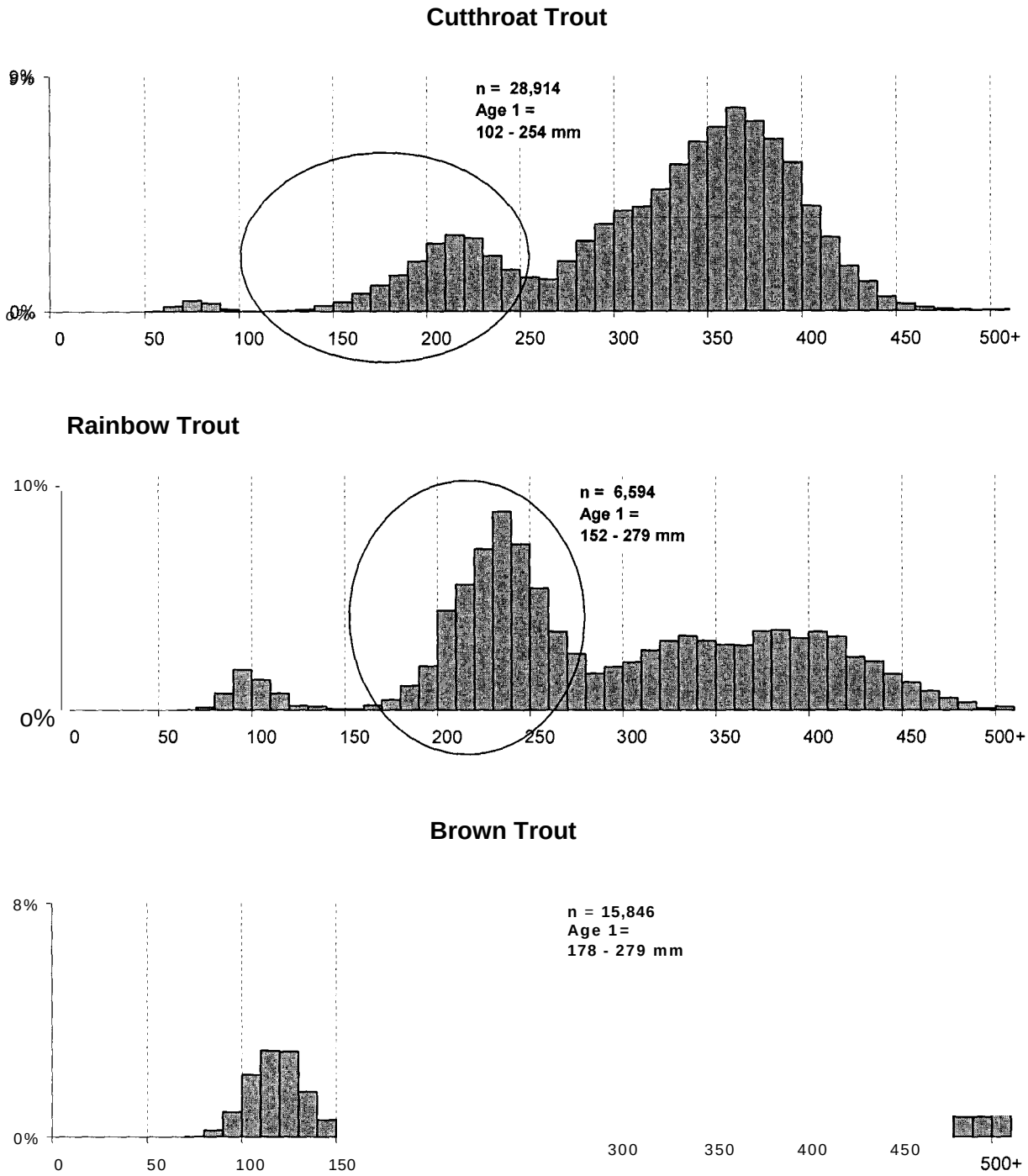


Figure 2. Overall length frequency distributions (IL, mm) of cutthroat (top), rainbow (middle), and brown trout (bottom) showing approximated age 1 fish, South Fork Snake River, Idaho, September-November 1986-2006. Fish from the Conant and Lorenzo electrofishing sections were combined. Total individual fish captured during electrofishing equals n.

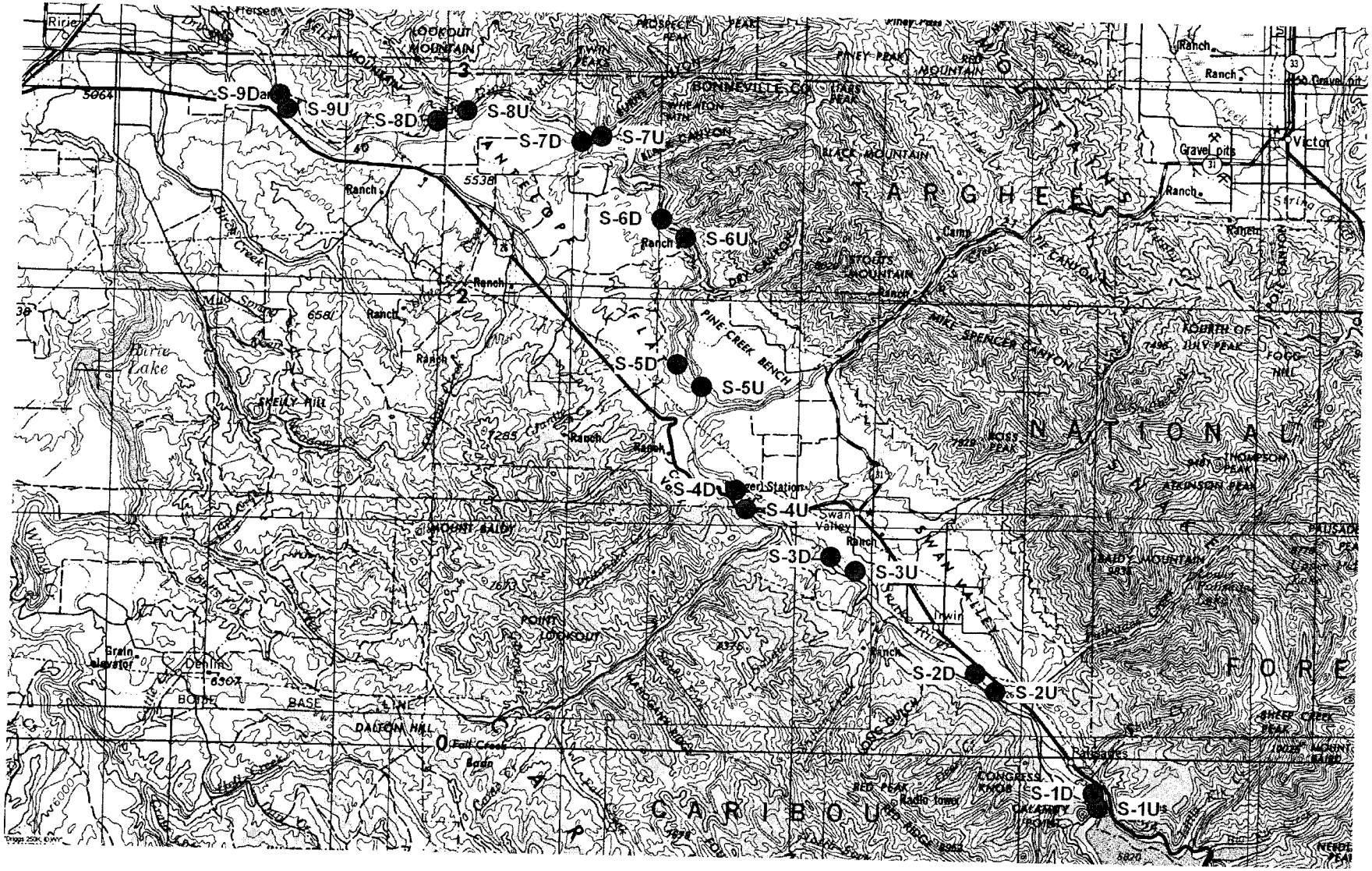


Figure 3. Location of the nine sites sampled for total stock abundance in the upper South Fork Snake River, Idaho, April 25-26, 2006. Sites were spaced at 8 km intervals beginning at Palisades Dam (S-1) and ending at the Heise cable (S-9). U = upstream starting point; D = downstream ending point.

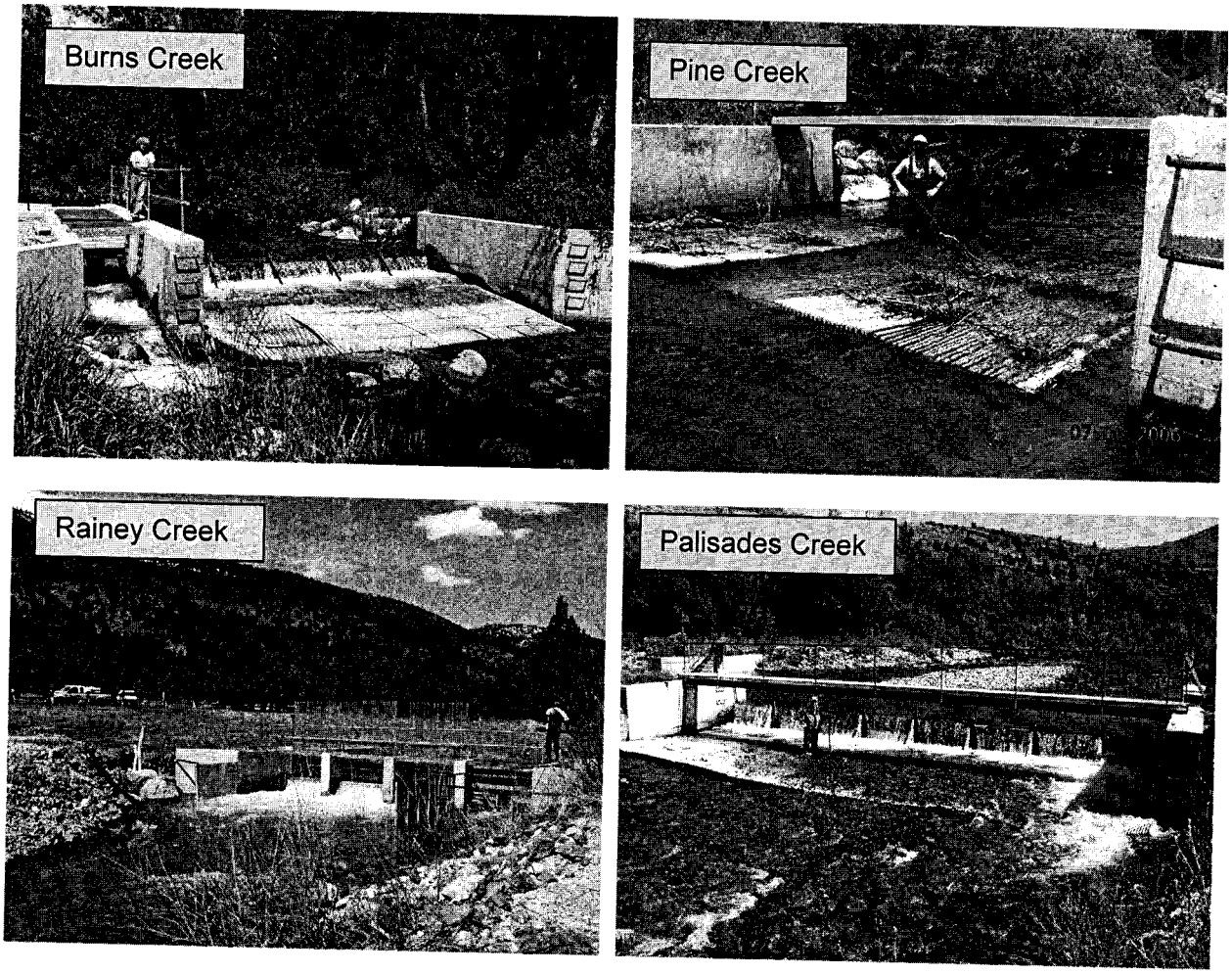
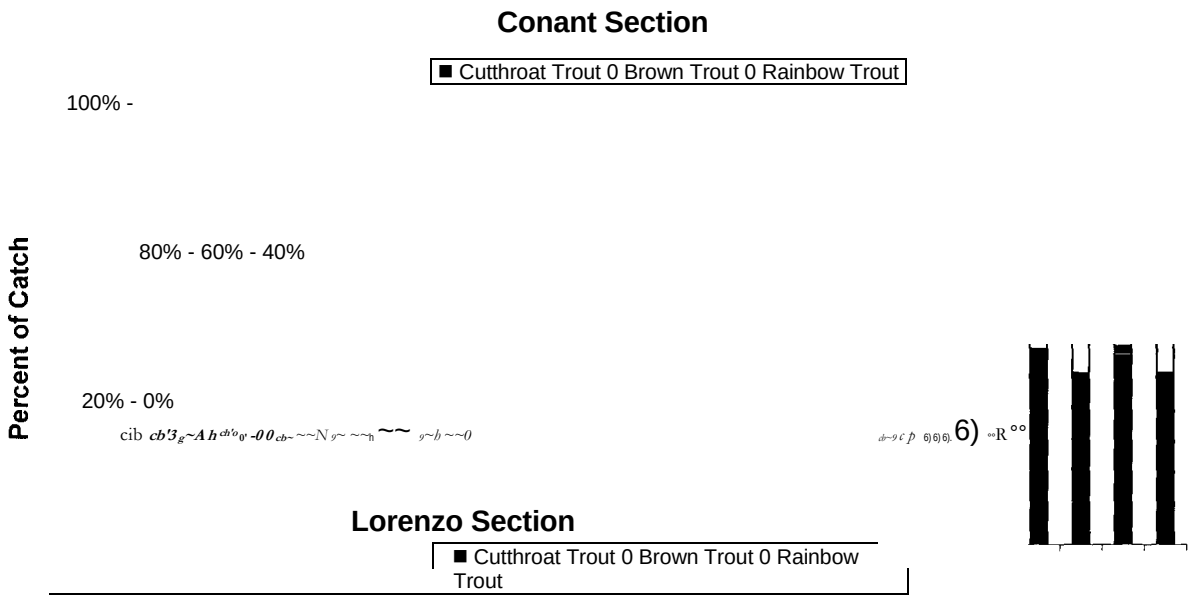


Figure 4. Photos of the four fish weirs used in spawning tributaries of the South Fork Snake River, Idaho, 2006. Photos were taken at Burns Creek on June 28, Pine Creek on July 6, Rainey Creek on April 22, and Palisades Creek on July 5. The Pine Creek weir was damaged beyond repair shortly after installation.



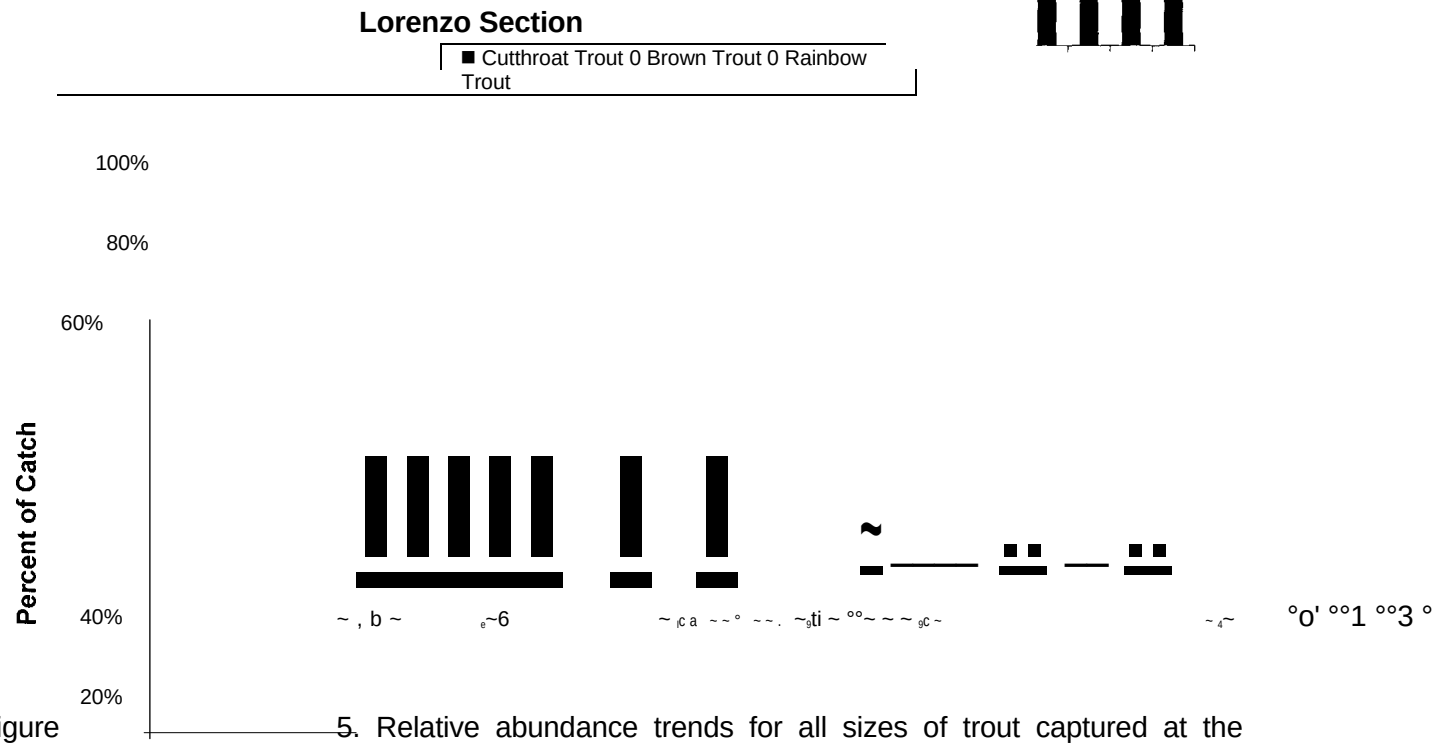


Figure 5. Relative abundance trends for all sizes of trout captured at the Conant (top) and Lorenzo (bottom) electrofishing sections, South Fork Snake River, Idaho, 1982 to 2006. Data for 1982 are from Moore and Schill (1984).

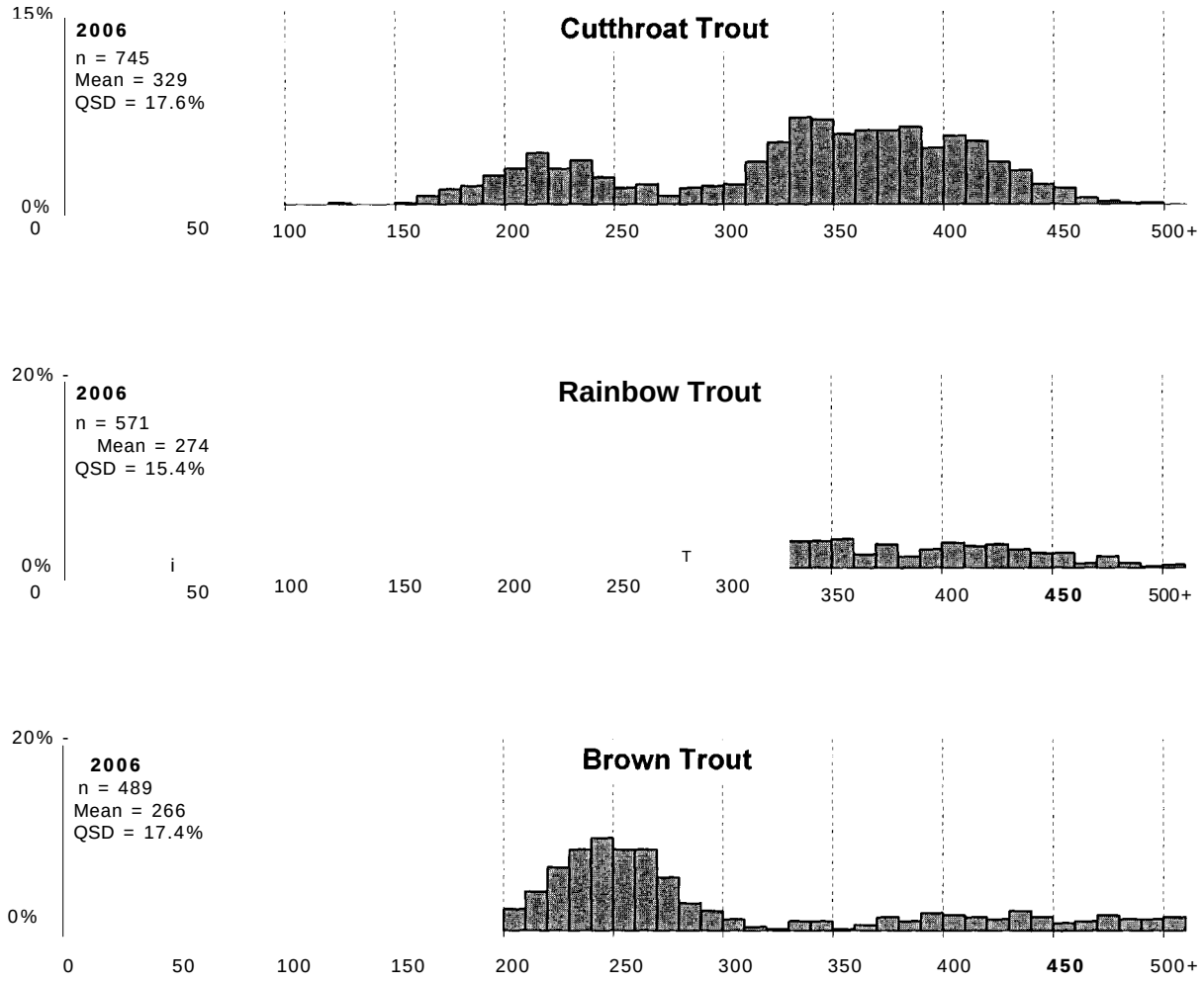


Figure 6. Length frequency distributions (TL, mm) of cutthroat (top), rainbow (middle), and brown trout (bottom) captured at the Conant electrofishing section, South Fork Snake River, Idaho, October 2006. Total individual fish captured during electrofishing equals n.

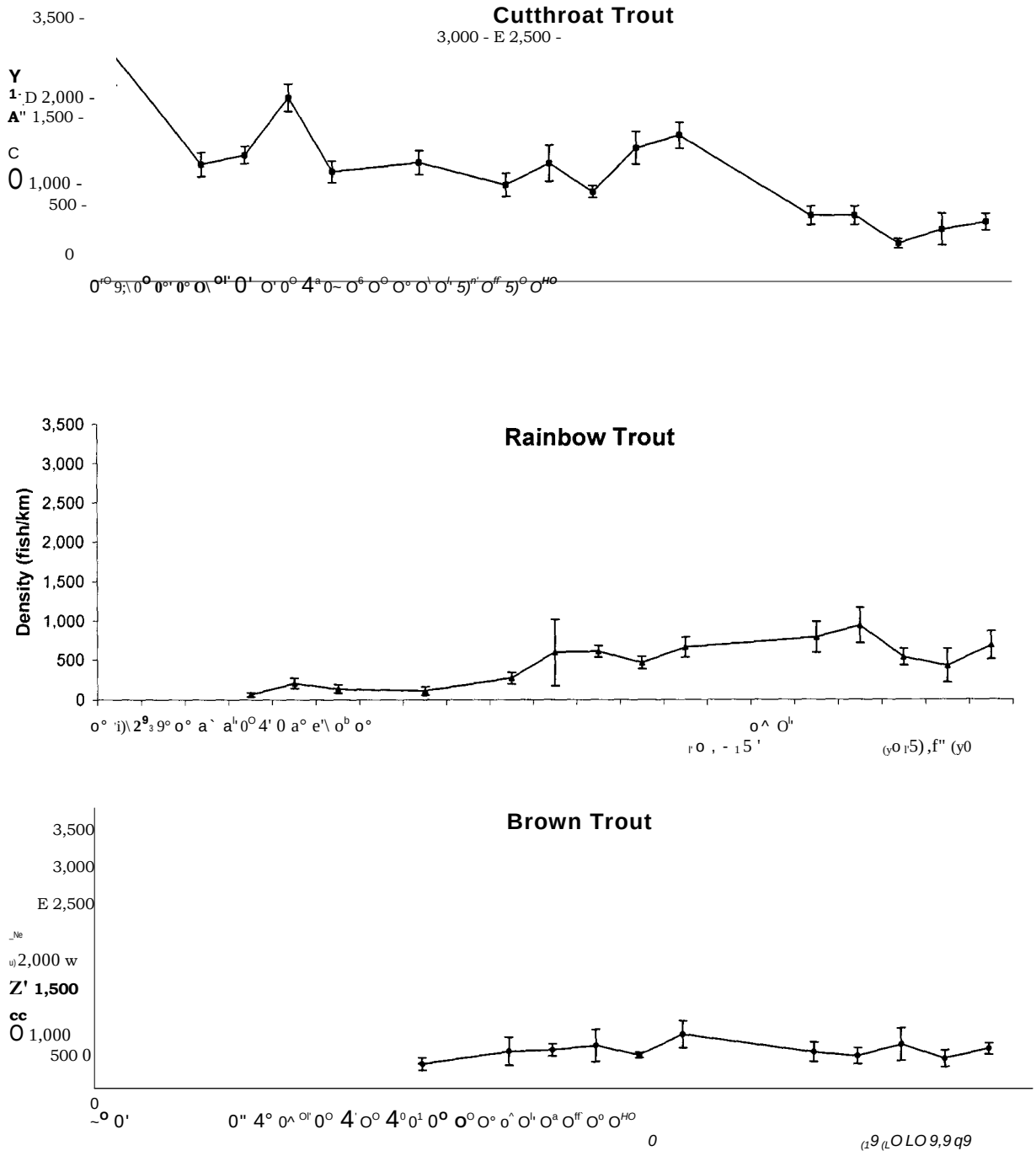


Figure 7. Density trends for age 1 and older cutthroat (>102 mm, top), rainbow (>152 mm, middle), and brown trout (>178 mm, bottom) at the Conant electrofishing section, South Fork Snake River, Idaho, October-November 1986-2006. Confidence intervals are at 95%.

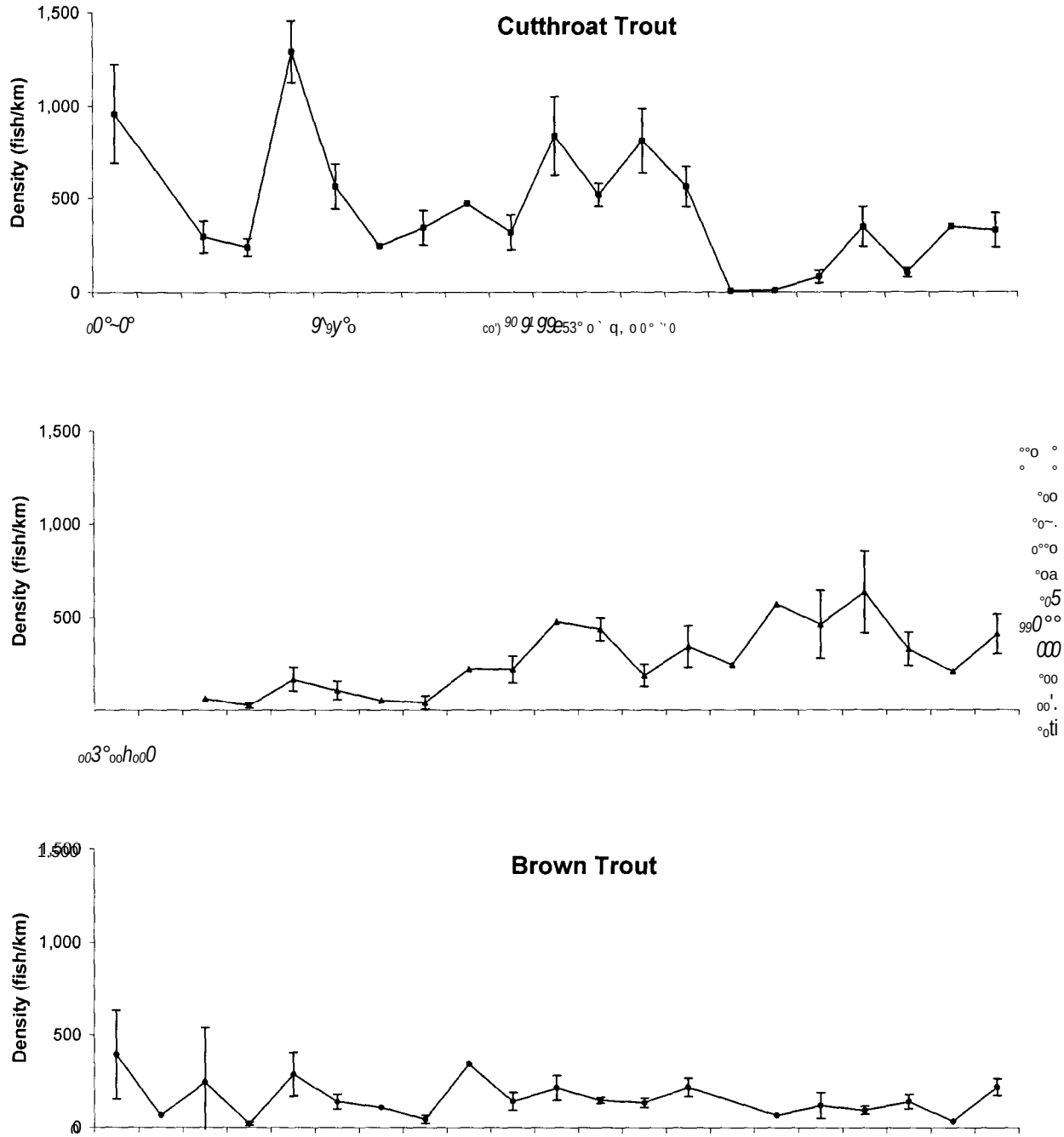


Figure 8. Density trends for age 1 cutthroat (102-254 mm, top), rainbow (152-279 mm, middle), and brown trout (178-279 mm, bottom) at the Conant electrofishing section, South Fork Snake River, Idaho, October-November 1986-2006. Points lacking 95% confidence intervals were estimated using cohort analysis (Moller and Van Kirk 2003).

Rainbow Trout

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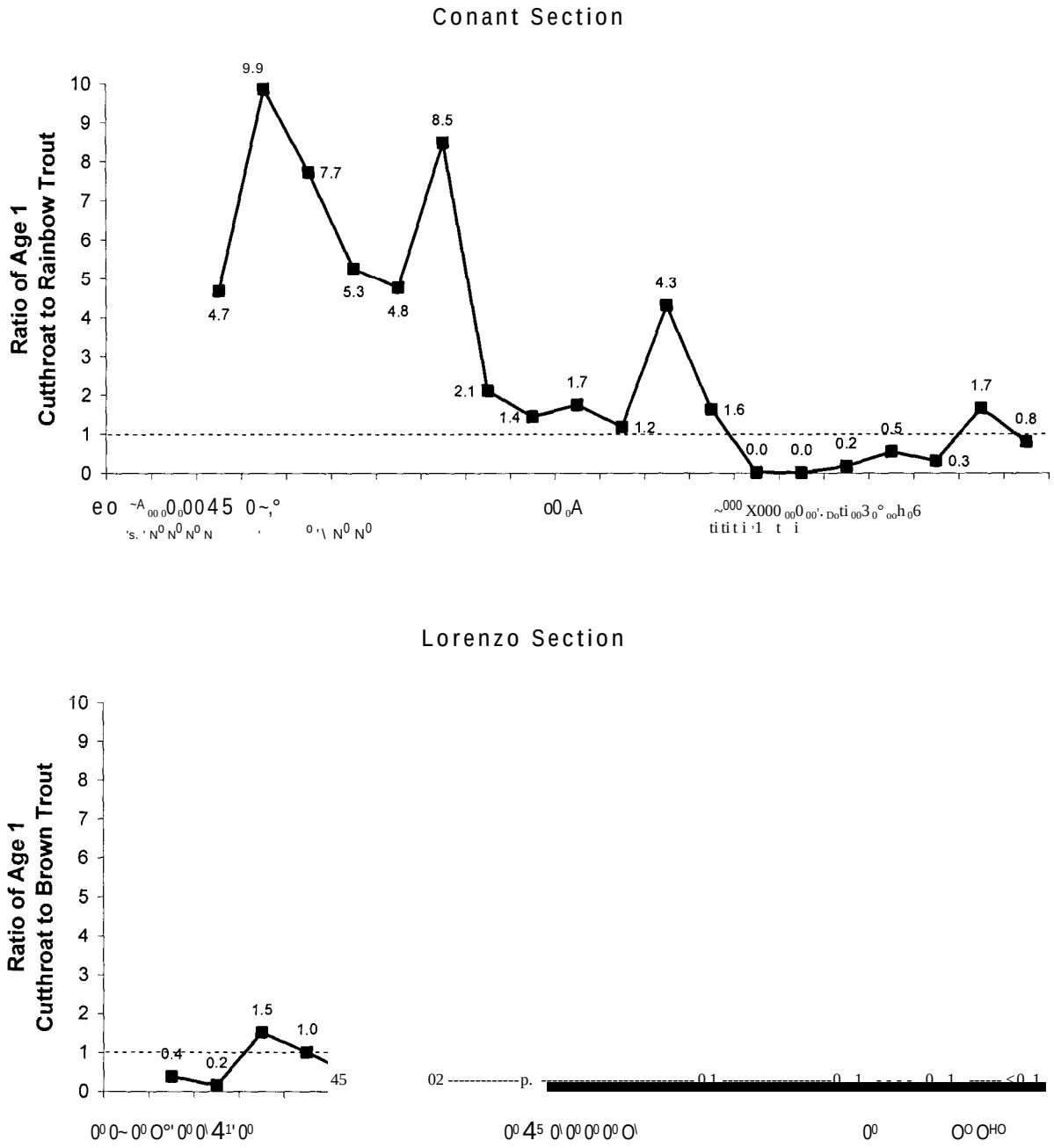


Figure 9. Trends in the ratio of age 1 cutthroat (102-254 mm) to rainbow trout (152-279 mm) at the Conant electrofishing section (top), and in the ratio of age 1 cutthroat to brown trout (178-279 mm) at the Lorenzo electrofishing section (bottom), South Fork Snake River, Idaho, September-November 1986-2006. Ratios are based on estimated densities. Dashed line indicates equal number of recruits with the management goal to be above the line.

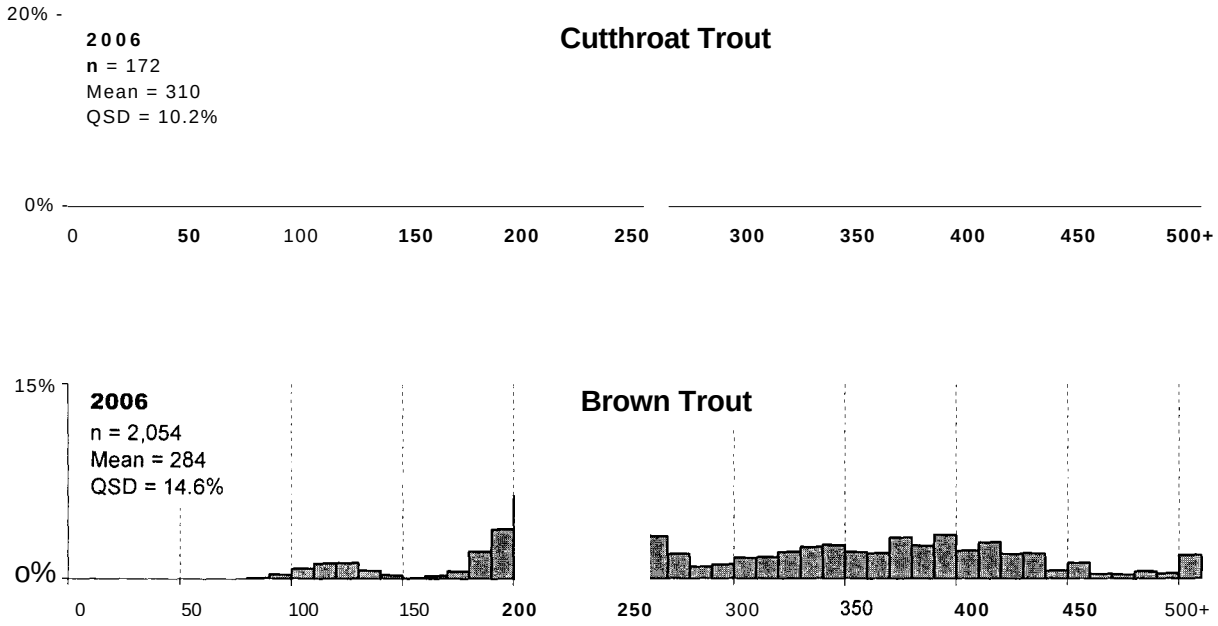


Figure 10. Length frequency distributions (TL, mm) of cutthroat (top) and brown trout (bottom) captured at the Lorenzo electrofishing section, South Fork Snake River, Idaho, September 2006. Total individual fish captured during electrofishing equals n.

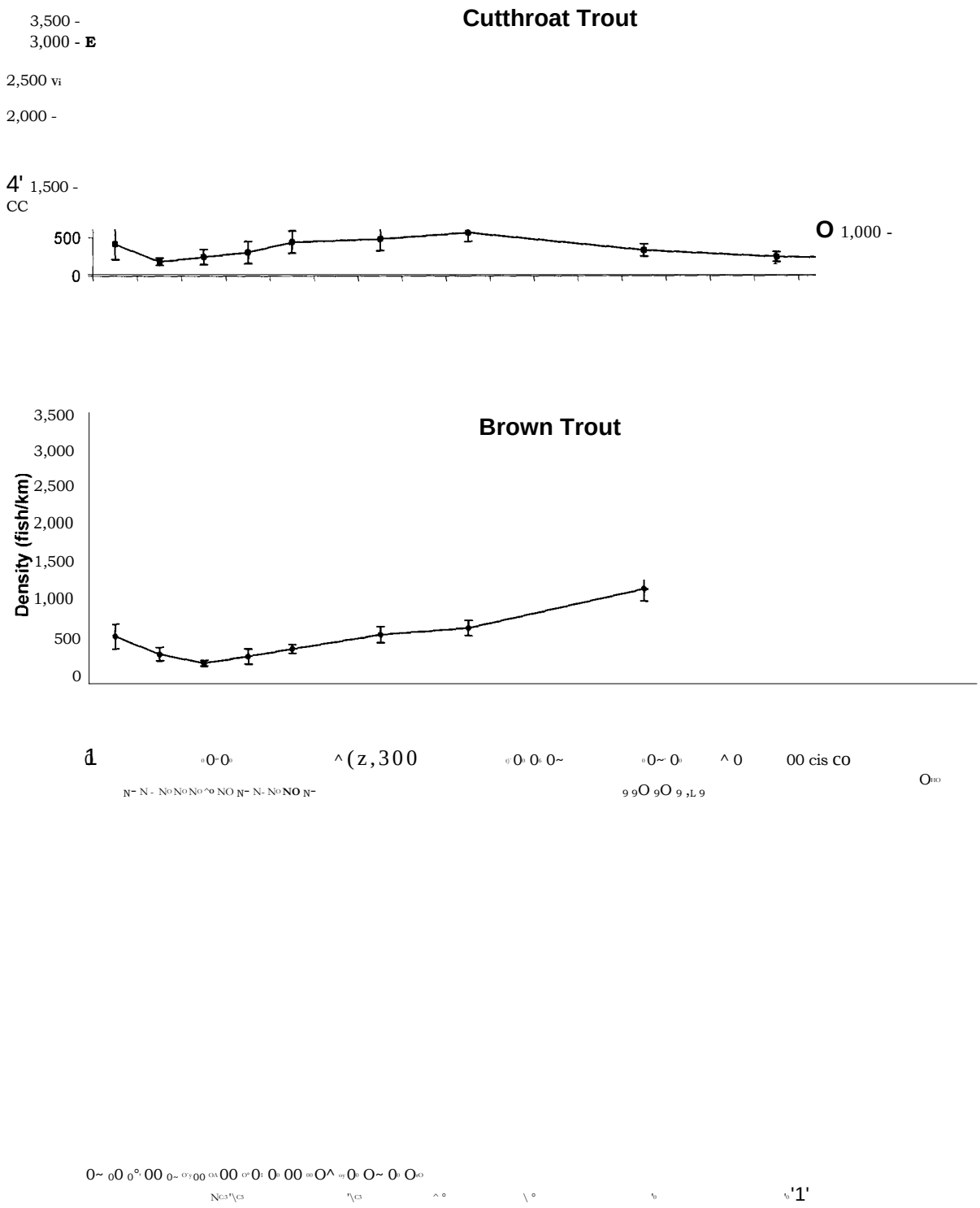


Figure 11. Density trends for age 1 and older cutthroat >102 mm, top) and brown trout (>178 mm, bottom) at the Lorenzo electrofishing section, South Fork Snake River, Idaho,

September-October 1987-2006. Confidence intervals are at 95%.

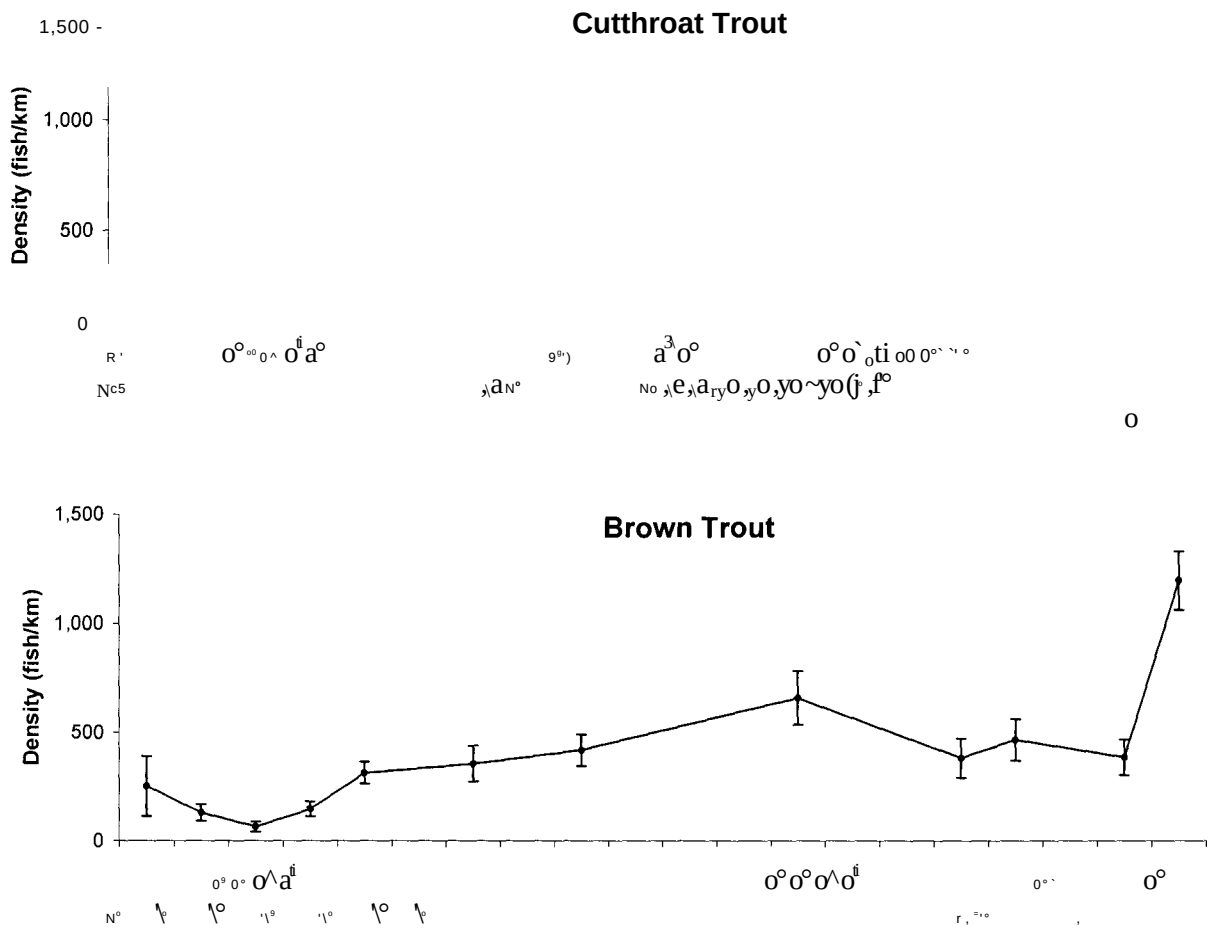


Figure 12. Density trends for age 1 cutthroat (102-254 mm, top) and brown trout (178-279 mm, bottom) at the Lorenzo electrofishing section, South Fork Snake River, Idaho, September-October 1987-2006. Points lacking 95% confidence intervals were estimated using cohort analysis (Moller and Van Kirk 2003).

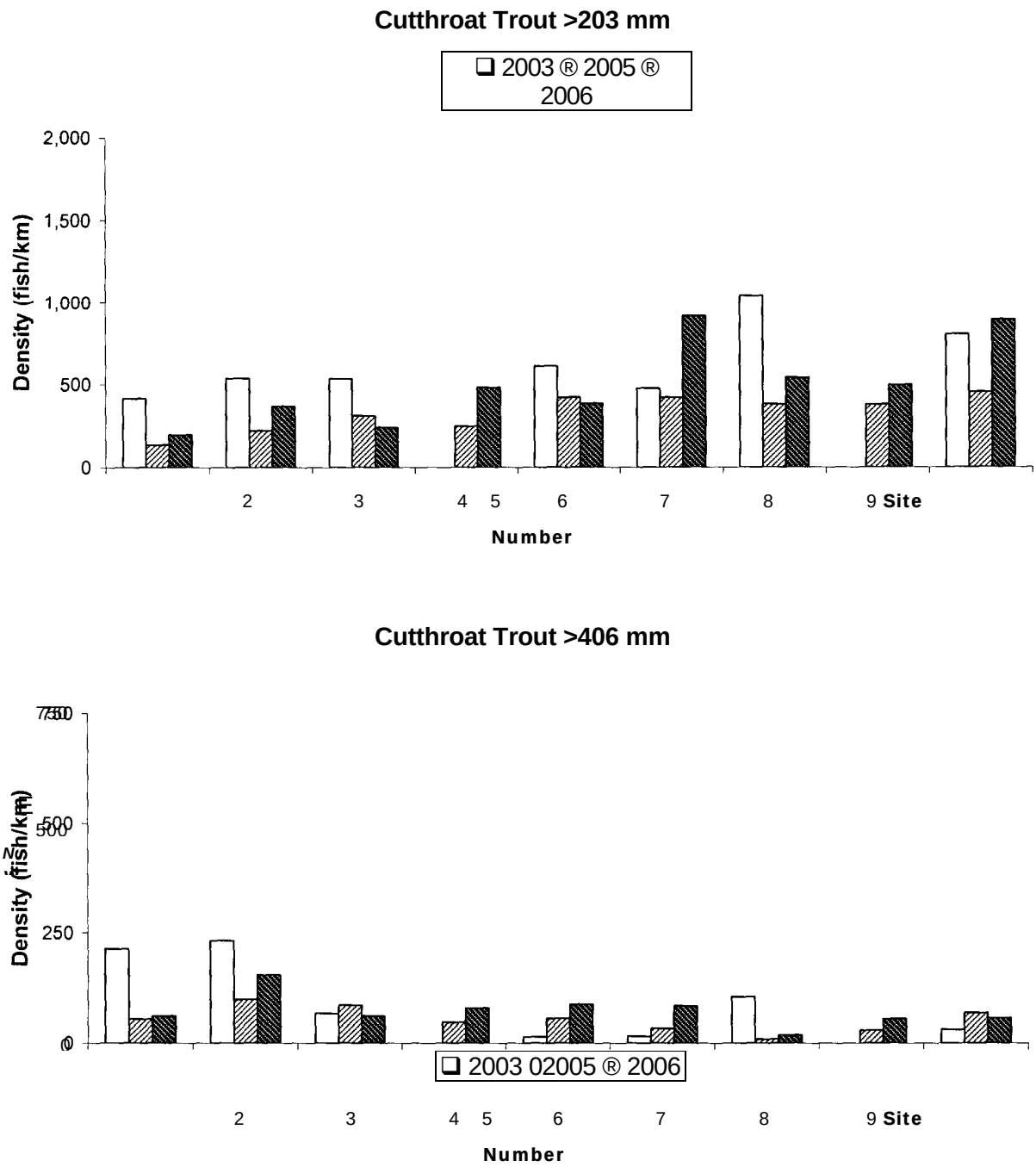


Figure 13. Estimated spring-time densities of cutthroat trout ≥203 mm (top) and >406 mm (bottom) in the upper South Fork Snake River, Idaho, 2003-2006. Estimates are from CPUE models for which confidence intervals are unavailable. Site 1 is at Palisades Dam,

site 9 is near the Heise cable. Note difference in scale.

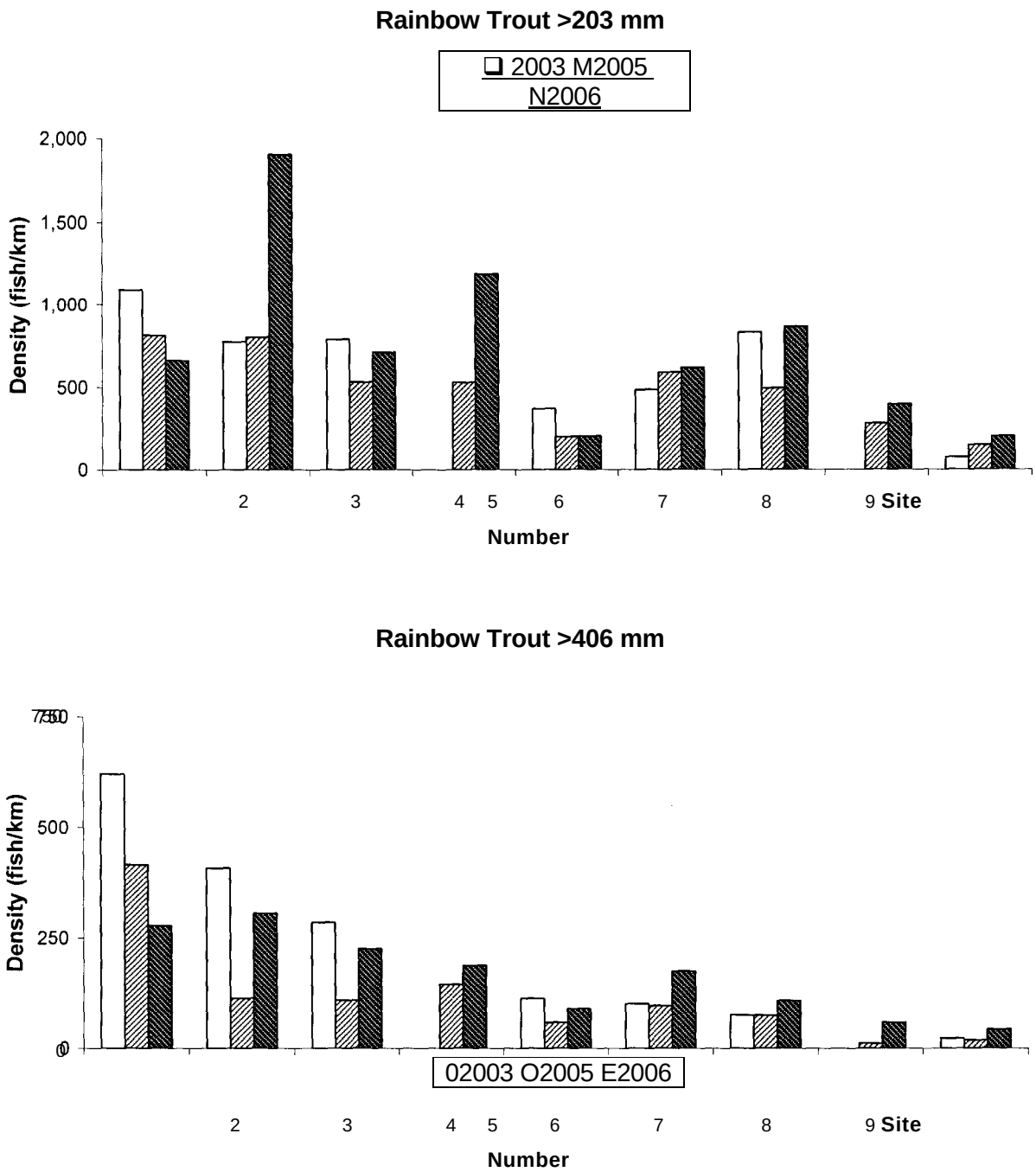


Figure 14. Estimated spring-time densities of rainbow trout >203 mm (top) and >406 mm (bottom) in the upper South Fork Snake River, Idaho, 2003-2006. Estimates are from CPUE models for which confidence intervals are unavailable. Site 1 is at Palisades Dam,

site 9 is near the Heise cable. Note difference in scale.

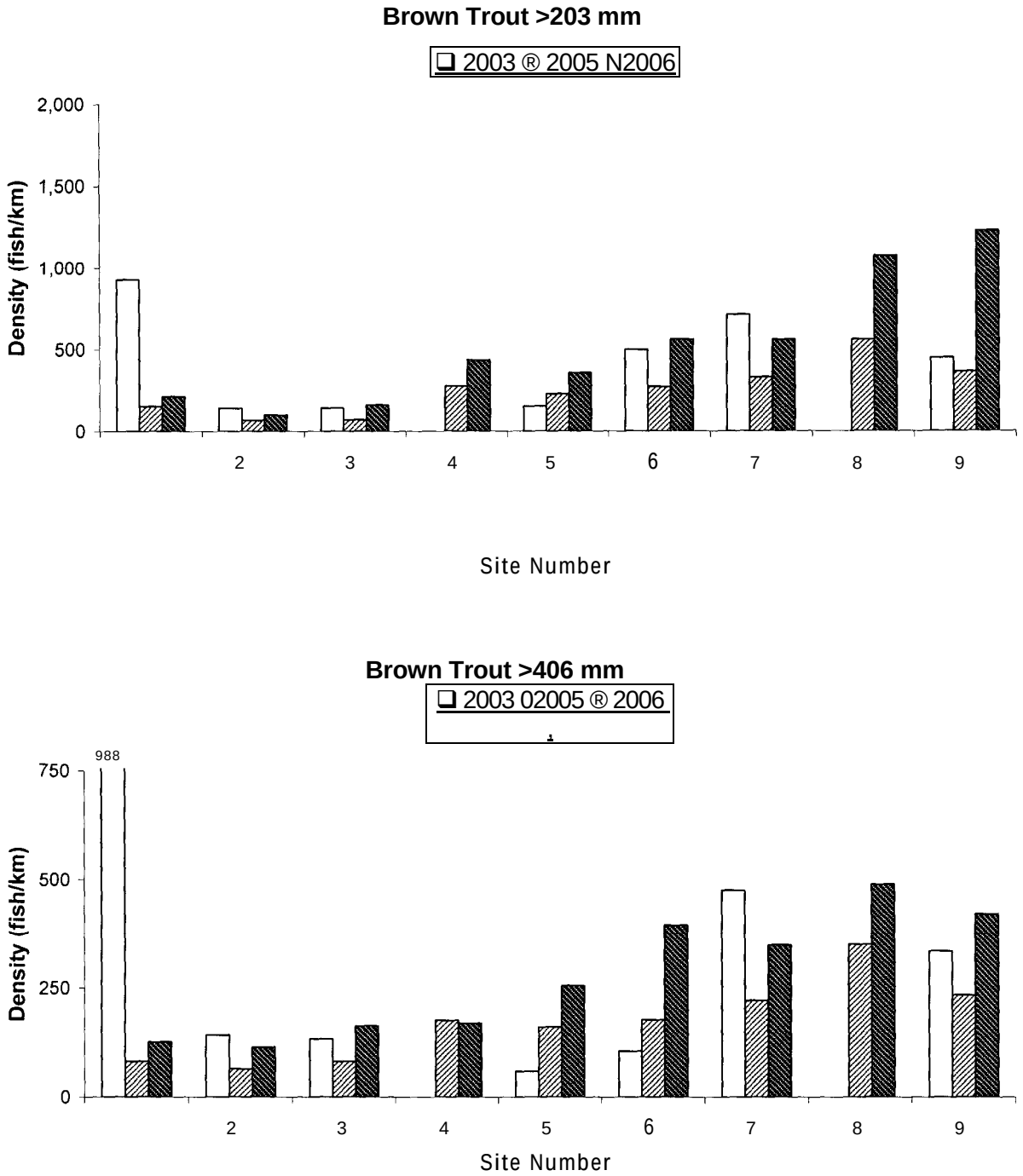
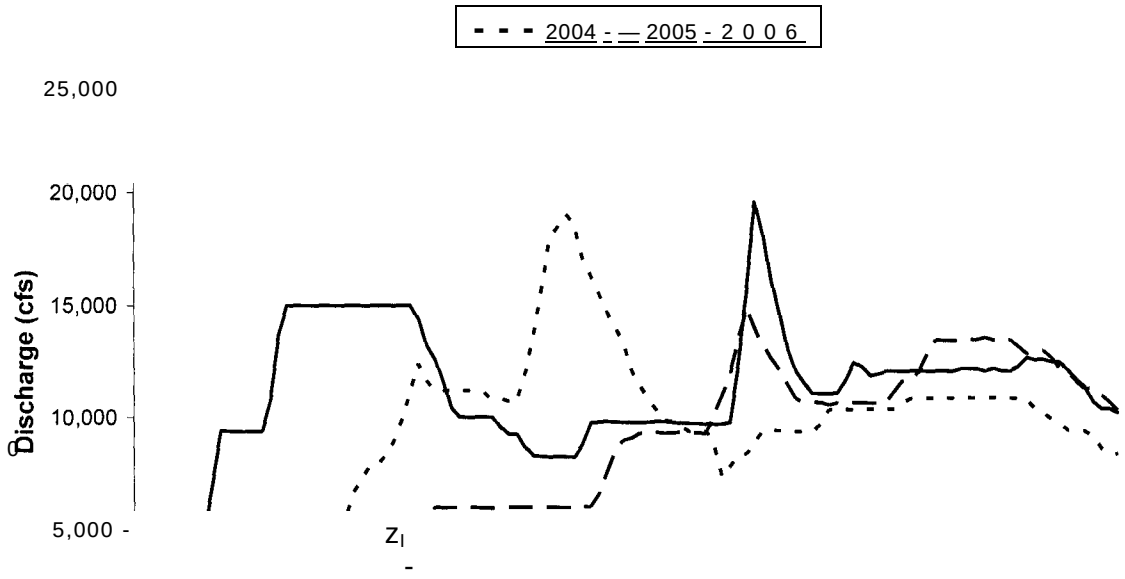


Figure 15. Estimated spring-time densities of brown trout >203 mm (top) and >406 mm (bottom) in the upper South Fork Snake River, Idaho, 2003-2006. Estimates are from CPUE models for which confidence intervals are unavailable. Site 1 is at Palisades Dam,

site 9 is near the Heise cable. Note difference in scale.


2004
2005
2006
25,000
20,000
15,000
10,000
5,000
Discharge (cfs)

ti

__ter--

May 1 Jun 1 Jul 1 Aug 1

Figure 16. Hydrographs at the USGS Irwin gage depicting managed flow regimes in the South Fork Snake River, Idaho, 2004-2006.

0 Apr 1

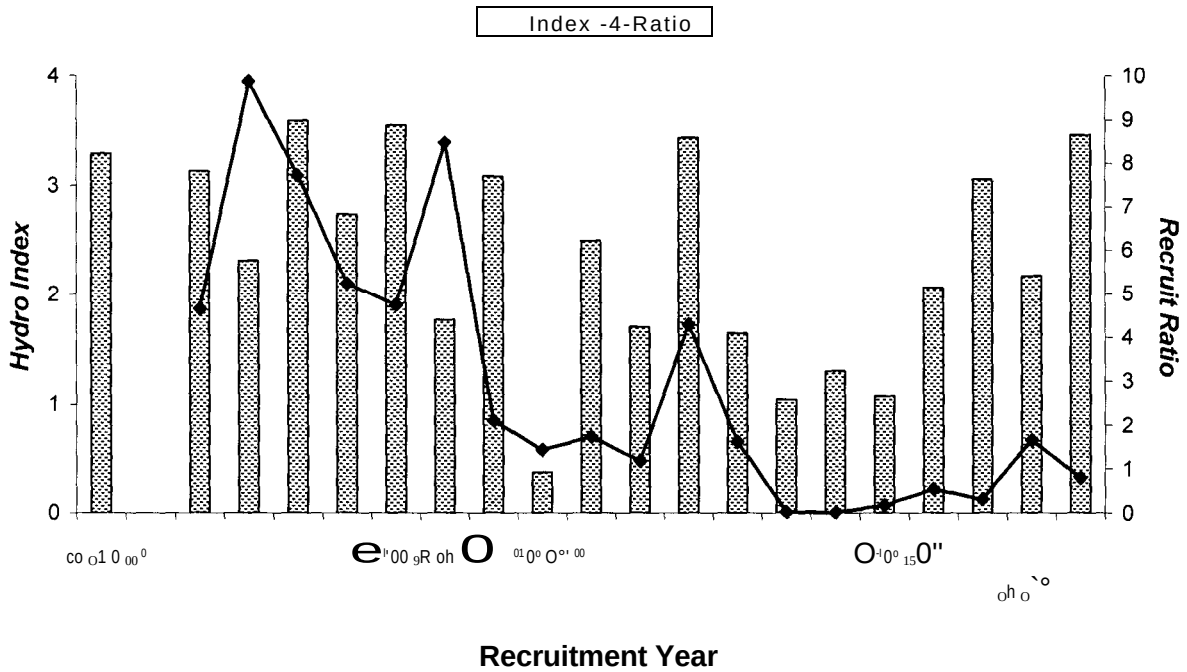


Figure 17. Values for the *Hydro Index* calculated at the USGS Heise gage, South Fork Snake River, Idaho, 1986-2006, except 1987 when corresponding fish data were unavailable. The *Recruit Ratio,* or the ratio of estimated age 1 cutthroat (102-254 mm) to rainbow trout (152-279 mm) at the Conant electrofishing section, is plotted for comparison.

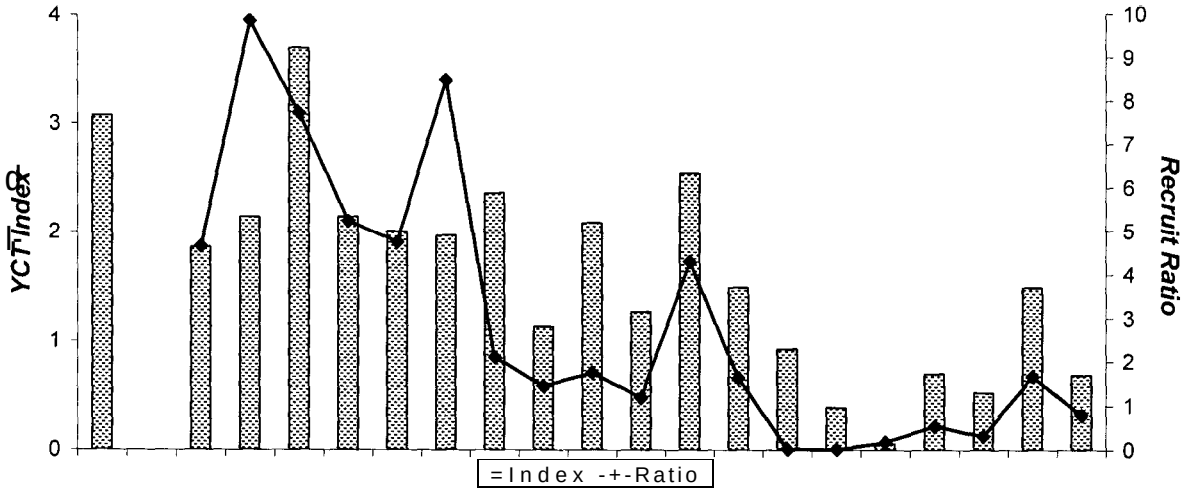


Figure 18. Values for the *YCT Index* calculated at the Conant electrofishing section, South Fork Snake River, Idaho, 1986-2006, except 1987 when recruitment data were unavailable. The *Recruit Ratio,* or the ratio of estimated age 1 cutthroat (102-254 mm) to rainbow trout (152-279 mm), is plotted for comparison.

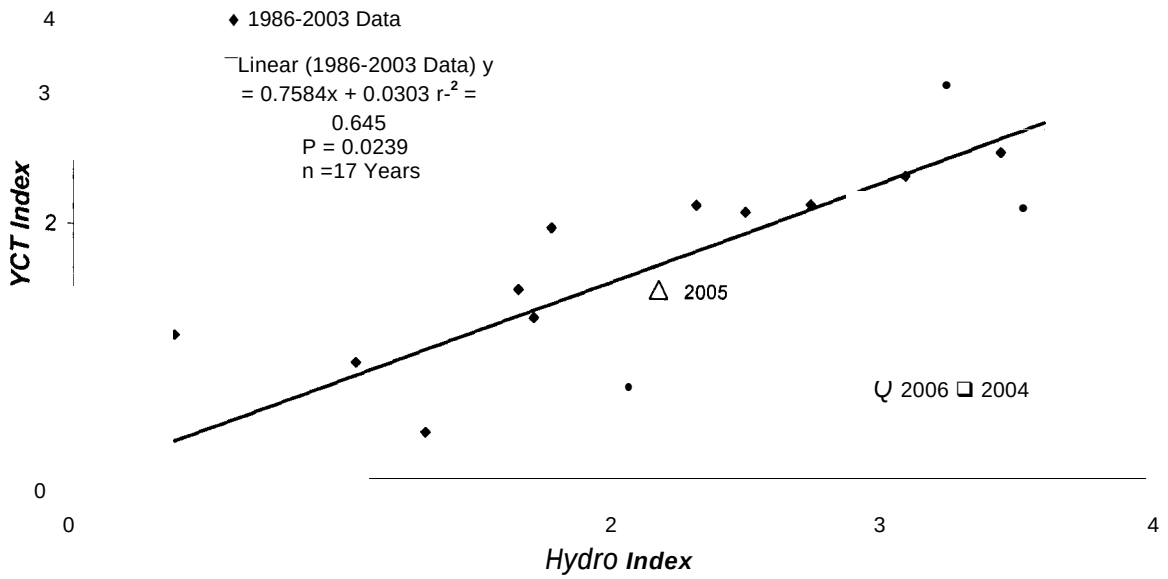
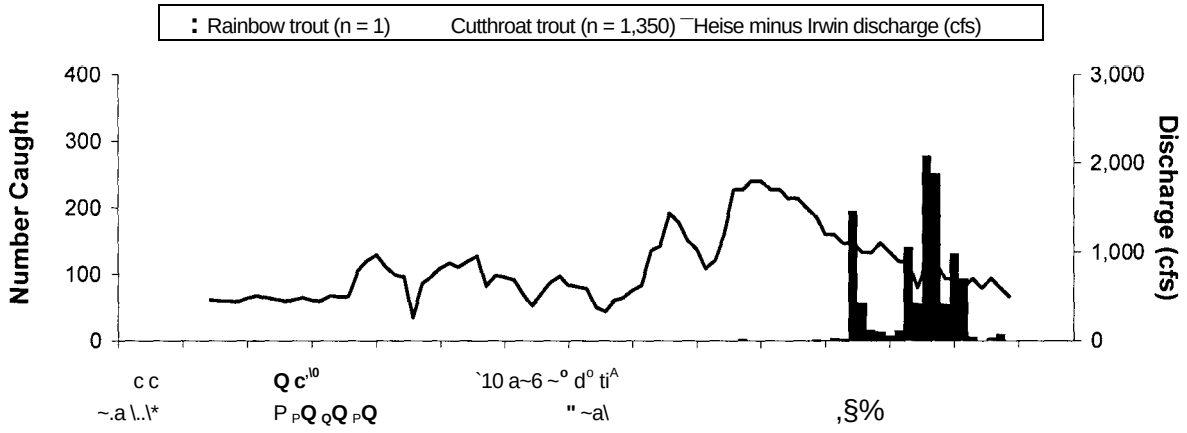
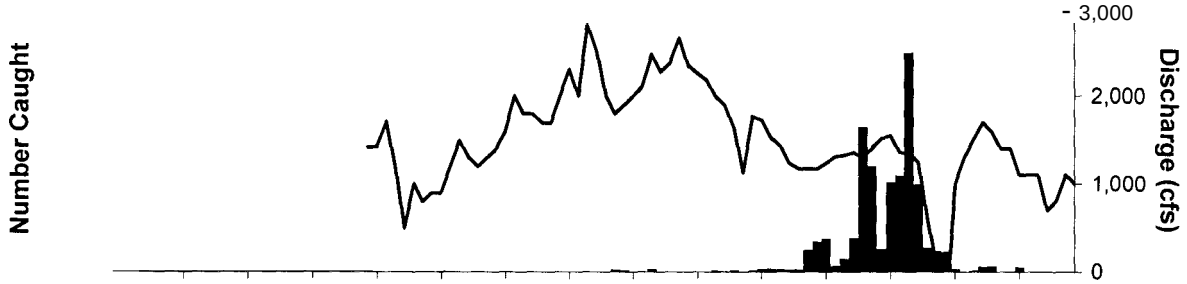


Figure 19. Relationship between the variables *YCT Index* and *Hydro Index,* South Fork Snake River, Idaho, 1986-2003, except 1987 when fish data were unavailable. The 2004-2006 data points reflect modified flow management by BOR. Note that the 2005 ordinate value was derived using cohort analysis, whereas the 2004 and 2006 values were derived using estimated densities.

Burns Creek Floating Weir - March 28 to June 23, 2003



Burns Creek Mitsubishi Weir - April 14 to June 30, 2006

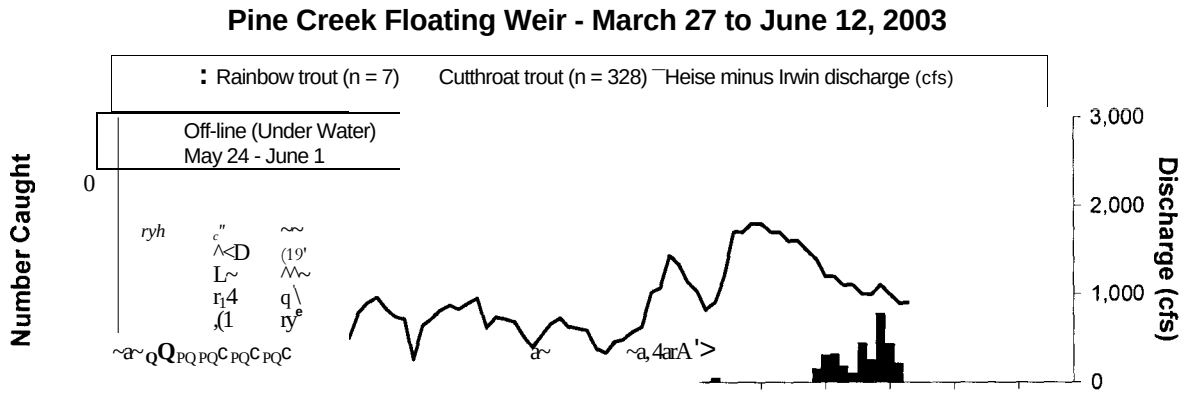


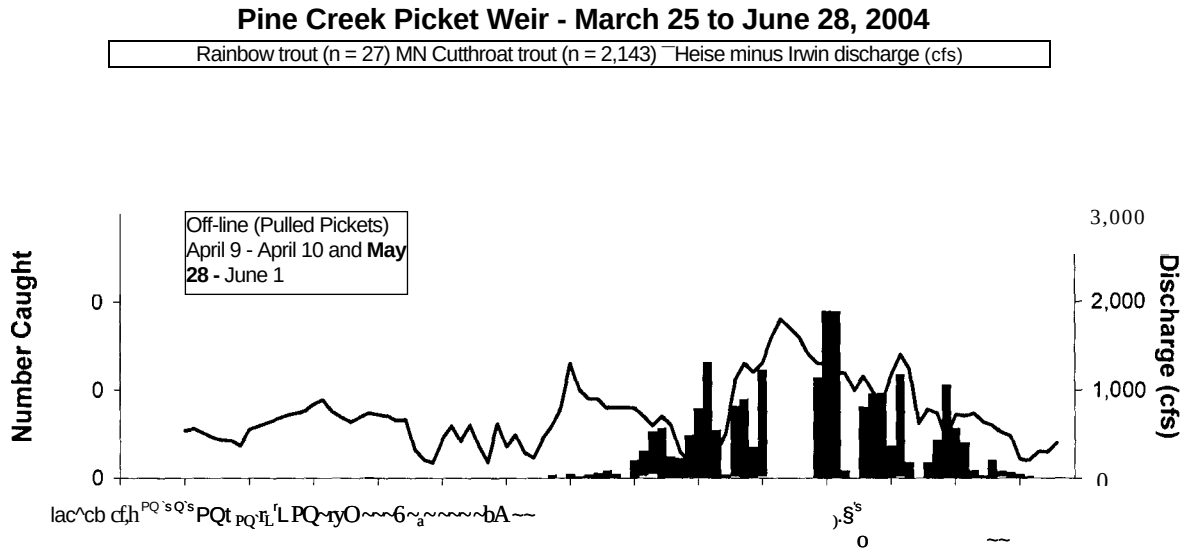
400 -

300 - 200 - 100

0

Figure 20. Number of fish caught, run timing, and approximated hydrograph at Burns Creek using the floating weir (2003, top) and Mitsubishi weir (2006, bottom), South Fork Snake River, Idaho. Note bars are stacked and that the weir was not operated in 2004 or 2005.





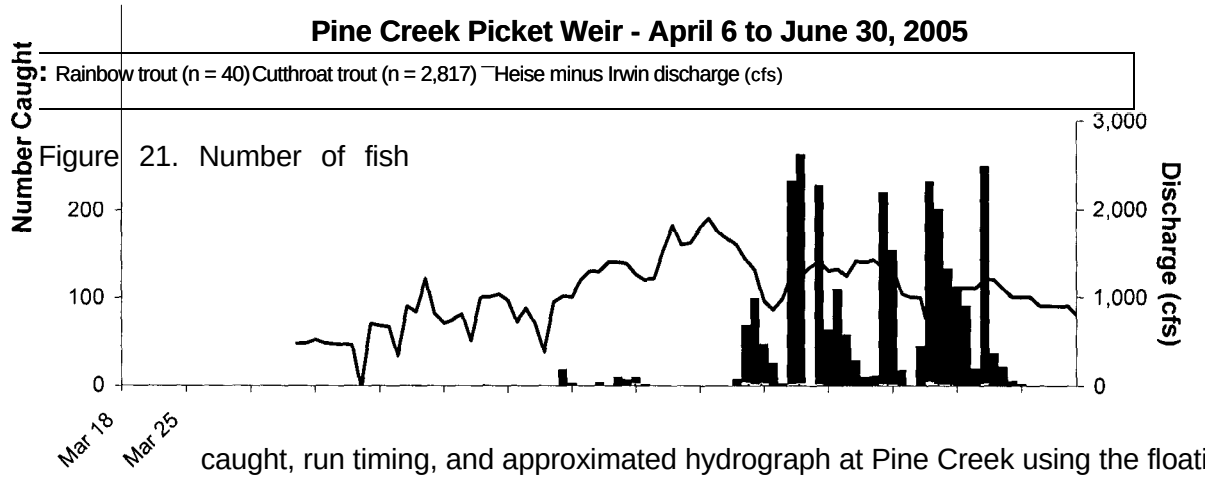
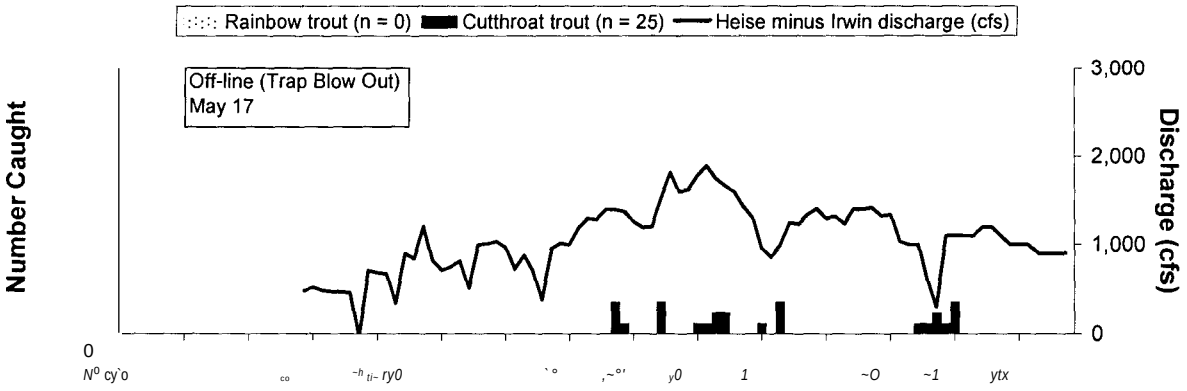


Figure 21. Number of fish caught, run timing, and approximated hydrograph at Pine Creek using the floating weir (2003, top) and hard picket weir (2004, middle; 2005, bottom), South Fork Snake River, Idaho. Note bars are stacked and that the weir was not operated in 2006.

Off-line (Pulled Pickets) May 17 - May 23 and June 1

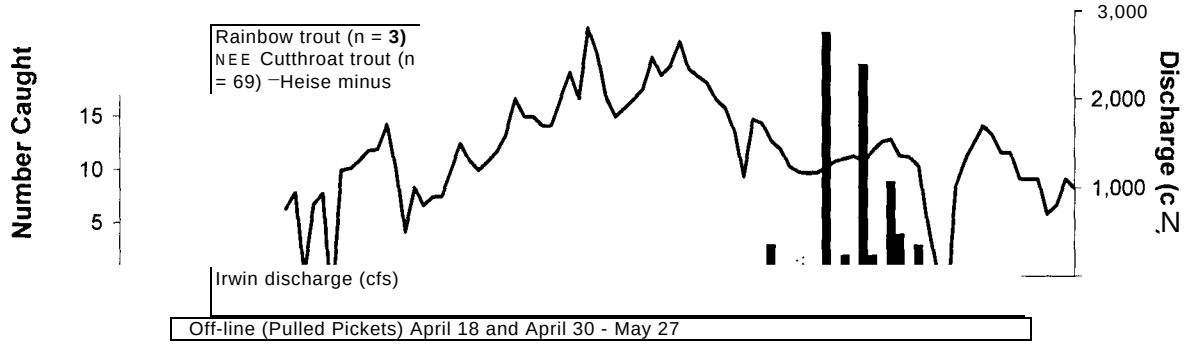
Rainey Creek Picket Weir - April 7 to June 29, 2005



Rainey Creek Picket Weir - April 7 to June 29, 2005

Rainbow trout (n = 0) Cutthroat trout (n = 25) Heise minus Irwin discharge (cfs)

Rainey Creek Picket Weir - April 5 to June 30, 2006



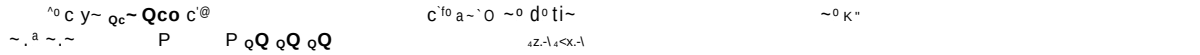
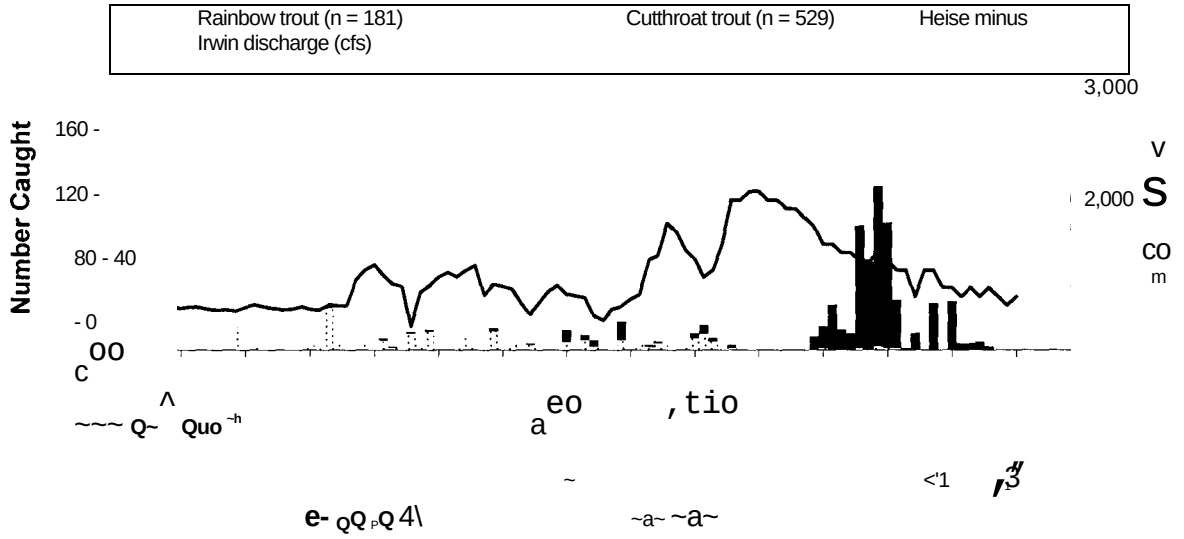
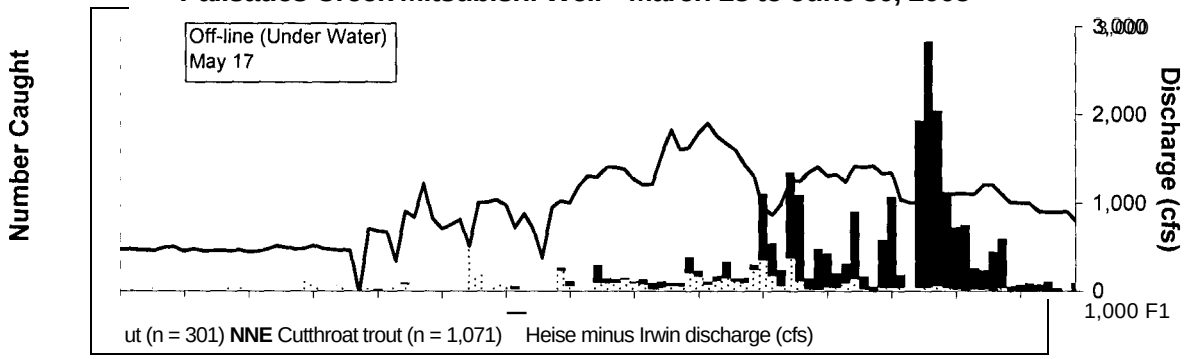


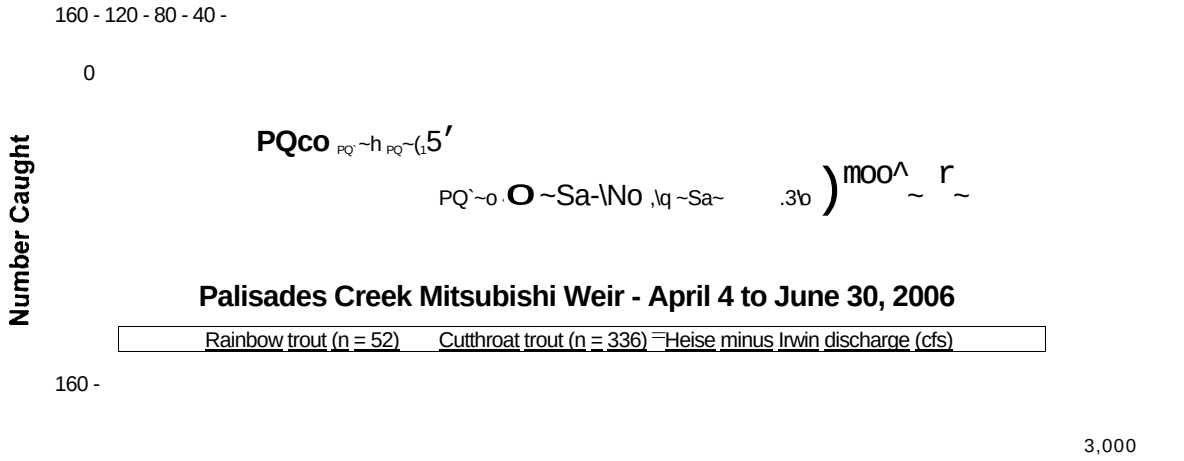
Figure 22. Number of fish caught, run timing, and approximated hydrograph at Rainey Creek using the hard picket weir (2005, top; 2006, bottom), South Fork Snake River, Idaho. Note bars are stacked and that the weir was not operated in 2003 or 2004.

Palisades Creek Floating Weir - March 24 to June 24, 2003



Palisades Creek Mitsubishi Weir - March 18 to June 30, 2005





Palisades Creek Mitsubishi Weir - April 4 to June 30, 2006

Rainbow trout (n = 52) Cutthroat trout (n = 336) Heise minus Irwin discharge (cfs)

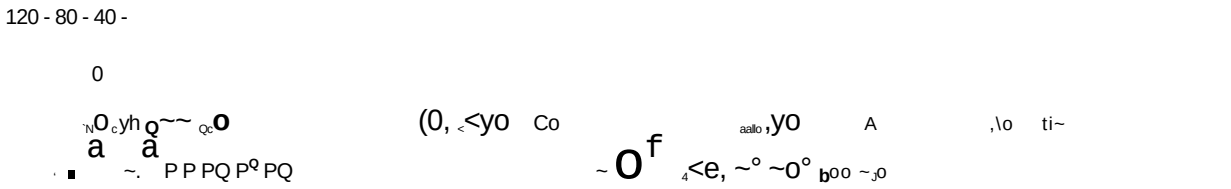
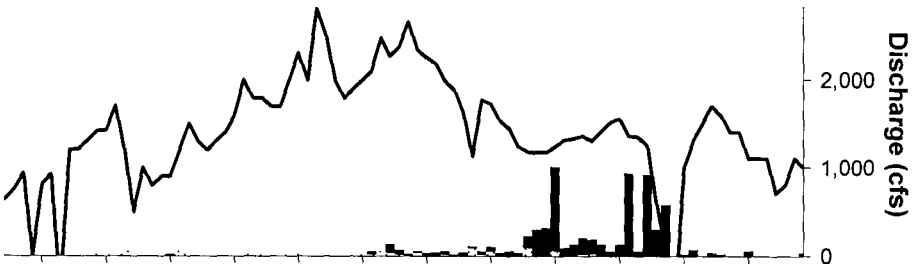


Figure 23. Number of fish caught, run timing, and approximated hydrograph at Palisades Creek using the floating weir (2003, top) and Mitsubishi weir (2005, middle; 2006, bottom), South Fork Snake River, Idaho. Note bars are stacked and that the weir was not operated in 2004.



APPENDICES

Appendix A. Summary of South Fork Snake River, Idaho, fishing regulations 1970-2007.

Year	Season	Trout bag & size limit	Special
1970	May 30 - Nov 30	7 lb. + 1 fish, not to exceed 15 fish	Whitefish open 3/1 to 4/30 Irwin to Dam; Mouth to Heise cable open all year
1971	May 29 - Nov 30	Same	Same
1972	May 27 - Nov 30	7 lb. + 1 fish, not to exceed 10 fish	Same
1973	May 26 - Nov 30	Same	All species open 3/1 to 9/30 Irwin to Dam; Mouth to Heise cable open all year
1974	May 25 - Nov 30	10 fish, not more than 2 exceeding 14"	Same
1975	May 24 - Nov 30	Same	Same
1976	May 29 - Nov 30	10 fish, not more than 5 exceeding 12", and not more than 2 exceeding 18"	Same
1977	May 28 - Nov 30	6 fish, only 2 over 16"	Same, except dam tailrace closed
1978	May 27 - Nov 30	Same	Dam tailrace closed; all species open 5/27 to 9/30 Irwin to Dam; Mouth to Heise cable open 5/27 to 12/31
1979	May 26 - Nov 30	Same	Dam tailrace closed; all species open 4/1 to 9/30 Irwin to Dam; Mouth to Heise cable open all year
1980	May 24 - Nov 30	Same	Same
1981	May 23 - Nov 30	Same	Same
1982	May 29 - Nov 30	Same	Same, except open 9/1 to 11/30 within 100 yards of Burns Creek
1983	May 28 - Nov 30	Same	Same
1984	May 26 - Nov 30	Same, except Heise cable to Irwin only 2 CT, none between 10-16"	Same
1985	May 25 - Nov 30	Same, except added hybrids	Same
1986-1987	May 24/23-Nov 30	Same	Same
1988-1989	May 28/27-Nov 30	6 fish, only 2 over 16"; except Heise cable to Dam only 2 CT or HYB, none between 10-16"	Mouth to Heise cable open all year; open 9/1 - 11/30 within 100 yards of Burns Creek
1990-1991	May 26/25-Nov 30	6 fish (except only 2 CT or HYB, none between 8-16", on all rivers and streams)	Mouth to Heise cable open all year
1992-1993	May 23/29-Nov 30	2 fish, none between 8-16"	Same
1994-1995	May 28/27-Nov 30	Same	Same
1996-1997	May 25/24-Nov 30	Same	Same
1998	May 23 - Nov 30	Same	Same
1999	May 29 - Nov 30	6 fish (except only 2 CT, HYB, or BRN, none between 8-16")	Same
2000-2001	May 27/26-Nov 30	6 fish (except only 2 CT or BRN, none under 16")	Same
2002-2003	May 25/24-Nov 30	Same	Same
2004-2005	Jan 1-Dec 31	No harvest CT; no limits RB or HYB; 2 BRN, none under 16"	Entire river open all year
2006-2007	Jan 1-Dec 31	Same	Same

Appendix B. Mark-recapture statistics for the Conant electrofishing section, South Fork Snake River, Idaho, 1986-2006.

Appendix B-1. Sampling dates, flows, and catch rates at the Conant electrofishing section, South Fork Snake River, Idaho, 1986-2006. Flows were recorded at the USGS Irwin gage.

Sampling dates	Range of flows (m^3/s)	Range of flows (ft^3/s)	Mean flow (m^3/s)	Catch rate (trout/day)[a]
11/4,5, 6, 7,20 1986	100.3-107.0	3,540-3,780	101.7	413
11/5,6 1987[b,d]	24.6-26.6	869-941	25.6	174
10/3,4,11 1988	102.0-105.1	3,600-3,710	103.5	630
10/18,19,27 1989	84.7-86.7	2,990-3,060	86.0	930
10/11,12,18 1990	98.8-104.5	3,490-3,690	100.8	1,292
10/7,8,15 1991	127.2-135.7	4,490-4,790	131.7	741
10/14 1992[b]	60.3	2,130	60.3	719
10/13,14,21,22 1993	74.2-108.2	2,620-3,820	90.9	481
10/7,11,14 1994[b]	34.6-69.1	1,220-2,440	52.4	368
10/5,6,12,13 1995	72.8-115.8	2,570-4,090	93.2	436
10/3,4,10,11 1996	106.5-107.3	3,760-3,790	106.9	472
10/16,17,23,27 1997[d]	70.0-99.1	2,470-3,500	84.5	851
10/7,8,14,15 1998	91.5-126.6	3,230-4,470	109.6	593
10/13,14,20,21 1999	101.1-118.1	3,570-4,170	109.6	763
10/19,26 2000[b]	87.8-95.2	3,100-3,360	91.5	603
10/4,5 2001 [b]	117.2-117.5	4,140-4,150	117.4	669
10/3,4,10,11 2002	68.0-72.8	2,400-2,570	71.6	423
10/8,9,15,16 2003	87.2-141.6	3,080-5,000	107.9	523
10/4,6,12,14 2004	112.7-114.7	3,980-4,050	113.5	423
10/4,6,12,13 2005	90.7-128.0[e]	3,200-4,520[e]	105.7[e]	340
10/3,4,11,12 2006	88.4-89.0[e]	3,120-3,140[e]	88.6[e]	478

[a] Includes recaptured fish; catch rate = total trout caught / number days sampled.
[b] No recapture runs due to low flows.
[d] Only 3.2 km of larger 4.9 km section was electrofished with drift boat.
[d] Major habitat changes with spring, 1997, runoff.
[e] Provisional data.

Appendix B-2. Trout species composition and relative abundance (percent of catch) at the Conant electrofishing section, South Fork Snake River, Idaho, 1982 and 1986-2006. Age 1 cutthroat trout are 102-254 mm, age 1 rainbow trout are 152-279 mm, and age 1 brown trout are 178-279 mm. Total individual fish captured during electrofishing is in parentheses.

	Cutthroat trout[s]		Rainbow trout		Brown trout		Lake trout	Kokanee	Total	
Year	All	Age 1	All	Age 1	All	Age 1	All	All	All	Age 1
1982°'°	79.0 (181)	ND°	0.9 (2)	ND	19.2 (44)	ND	0.9 (2)	0.0 (0)	100.0 (229)	ND
1986°	83.1 (1,647)	59.7 (191)	2.4 (47)	4.7 (15)	14.4 (285)	35.6 (114)	0.2 (4)	0.0 (0)	100.0 (1,983)	100.0 (320)
1987°''	85.9 (299)	87.6 (85)	1.7 (6)	2.1 (2)	12.4 (43)	10.3 (10)	0.0 (0)	0.0 (0)	100.0 (348)	100.0 (97)
1988	87.8 (1,570)	54.2 (115)	3.2 (58)	9.0 (19)	8.9 (159)	36.8 (78)	0.1 (1)	0.0 (0)	100.0 (1,788)	100.0 (212)
1989	89.2 (2,291)	66.5 (165)	4.0 (103)	14.9 (37)	6.8 (175)	18.5 (46)	0.0 (0)	0.0 (0)	100.0 (2,569)	100.0 (248)
1990	84.3 (2,978)	71.7 (849)	6.1 (216)	12.2 (145)	9.5 (335)	16.0 (190)	0.1 (4)	0.0 (0)	100.0 (3,533)	100.0 (1,184)
1991	80.1 (1,646)	51.2 (290)	7.3 (150)	18.4 (104)	12.6 (259)	30.4 (172)	0.0 (0)	0.0 (0)	100.0 (2,055)	100.0 (566)
1992[`]	83.2 (598)	62.2 (115)	4.7 (34)	11.4 (21)	12.1 (87)	26.5 (49)	0.0 (0)	0.0 (0)	100.0 (719)	100.0 (185)
1993	84.6 (1,528)	54.5 (109)	6.3 (113)	13.5 (27)	9.2 (166)	32.0 (64)	0.0 (0)	0.0 (0)	100.0 (1,807)	100.0 (200)
1994[`]	78.5 (867)	70.4 (357)	9.1 (100)	12.4 (63)	12.3 (136)	17.2 (87)	0.0 (0)	0.1 (1)	100.0 (1,104)	100.0 (507)
1995	68.6 (1,121)	31.4 (150)	15.7 (256)	36.5 (174)	15.8 (258)	32.1 (153)	0.0 (0)	0.0 (0)	100.0 (1,635)	100.0 (477)
1996	66.4 (1,190)	49.9 (371)	15.3 (274)	23.5 (175)	18.1 (325)	26.6 (198)	0.1 (1)	0.1 (1)	100.0 (1,791)	100.0 (744)
1997°	54.3 (1,676)	34.6 (489)	27.2 (840)	40.7 (575)	18.4 (567)	24.6 (348)	0.0 (1)	0.1 (2)	100.0 (3,086)	100.0 (1,412)
1998	58.7 (1,312)	56.0 (424)	20.3 (454)	15.2 (115)	21.0 (469)	28.8 (218)	0.0 (1)	0.0 (0)	100.0 (2,236)	100.0 (757)
1999	62.7 (1,803)	36.6 (269)	19.5 (560)	28.3 (208)	17.8 (513)	35.0 (257)	0.0 (0)	0.0 (0)	100.0 (2,876)	100.0 (734)
2000[`]	66.4 (800)	42.8 (110)	22.5 (271)	38.1 (98)	11.1 (134)	19.1 (49)	0.0 (0)	0.0 (0)	100.0 (1,205)	100.0 (257)
2001[`]	58.1 (778)	36.4 (122)	25.5 (341)	37.3 (125)	16.4 (219)	26.3 (88)	0.0 (0)	0.0 (0)	100.0 (1,338)	100.0 (335)
2002	52.5 (845)	14.4 (44)	33.8 (543)	65.6 (200)	13.6 (219)	20.0 (61)	0.1 (1)	0.0 (0)	100.0 (1,608)	100.0 (305)
2003	47.1 (924)	31.1 (183)	33.4 (655)	45.2 (266)	19.5 (383)	23.6 (139)	0.0 (0)	0.0 (0)	100.0 (1,962)	100.0 (588)
2004	41.4 (658)	25.2 (141)	35.4 (564)	44.9 (251)	23.2 (369)	29.9 (167)	0.0 (0)	0.0 (0)	100.0 (1,591)	100.0 (559)
2005	47.9 (627)	43.0 (147)	26.7 (350)	34.8 (119)	25.3 (332)	22.2 (76)	0.1 (1)	0.0 (0)	100.0 (1,310)	100.0 (342)
2006	41.3 (745)	21.7 (162)	31.6 (571)	42.7 (318)	27.1 (489)	35.6 (265)	0.0 (0)	0.0 (0)	100.0 (1,805)	100.0 (745)

Includes hatchery cutthroat trout.
[b] Only 1.9 km of larger 4.9 km section was electrofished; data from Moore and Schill (1984). °
Electrofishing conducted in early November rather than October.
° ND = no data.
[e] No recapture runs due to low flows.
[`] Only 3.2 km of larger 4.9 km section was electrofished with drift boat.
[e] Major habitat changes with spring, 1997, runoff.

Appendix B-3. Mean total length and quality stock density (QSD) of trout captured in the fall at the Conant electrofishing section, South Fork Snake River, Idaho, 1986-2006. Total individual fish captured during electrofishing equals n. QSD = (number >406 mm / number >203 mm) x 100.

Year	Cutthroat trout[a]			Rainbow trout			Brown trout			All[b]		
	n	Mean (mm)	QSD (%)	*n*	Mean (mm)	QSD (%)	*n*	Mean (mm)	QSD (%)	*n*	Mean (mm)	QSD (%)
1986[c]	1,647	330	8.5	47	308	11.4	285	337	29.0	1,983	330	11.5
1987[c,e]	299	298	14.9	6	262	0.0	43	249	11.5	348	292	14.3
1988	1,570	338	5.6	58	327	12.3	159	309	22.8	1,788	335	7.3
1989	2,291	354	8.8	103	323	20.6	175	343	38.5	2,569	351	11.2
1990	2,978	319	8.4	216	269	13.3	335	266	20.4	3,533	310	9.7
1991	1,646	332	11.2	150	252	6.6	259	275	14.1	2,055	320	11.3
1992[d]	598	333	9.0	34	283	2.9	87	264	6.6	719	323	8.4
1993	1,528	351	15.3	113	341	18.2	166	329	34.2	1,807	348	17.2
1994[d]	867	298	11.2	100	251	13.4	136	237	7.4	1,104	287	10.9
1995	1,121	350	21.2	256	278	10.5	258	287	15.8	1,635	328	18.7
1996	1,190	311	8.7	274	262	6.6	325	284	12.7	1,791	297	9.2
1997[f]	1,676	291	4.5	840	263	4.3	567	275	12.5	3,086	279	6.0
1998	1,312	296	4.8	454	318	13.3	469	279	8.4	2,236	297	7.4
1999	1,803	309	2.6	560	313	11.6	513	293	9.1	2,876	307	5.5
2000[d]	800	315	2.3	271	307	13.8	134	312	12.8	1,205	312	6.0
2001[d]	778	312	1.8	341	304	16.9	219	311	17.6	1,338	310	8.2
2002	845	338	4.0	543	326	23.6	219	339	34.0	1,608	334	14.4
2003	924	327	5.6	655	298	19.1	383	270	29.2	1,962	306	14.0
2004	658	324	13.3	564	294	23.7	369	314	23.9	1,591	311	19.4
2005	627	322	14.0	350	295	24.3	332	247	21.7	1,310	296	18.3
2006	745	329	17.6	571	274	15.4	489	266	17.4	1,805	295	16.8

[a] Includes hatchery cutthroat trout.
[b] Includes other trout, i.e. lake trout and kokanee.
[b] Electrofishing conducted in early November rather than October.
[d] No recapture runs due to low flows.
[e] Only 3.2 km of larger 4.9 km section was electrofished with drift boat.
[f] Major habitat changes with spring, 1997, runoff.

Appendix B-4. Mark-recapture statistics for age 1 and older cutthroat trout (>102 mm), rainbow trout (>152 mm), and brown trout (>178 mm) at the Conant electrofishing section, South Fork Snake River, Idaho, 1986-2006. Cases where R<3 and unbiased density estimates are not possible (Ricker 1975) are in bold.

	Cutthroat trout[a]				Rainbow trout				Brown trout			
Year	*M*[b]	*C*[b]	*R*[b]	*R/C* (%)	*M*	*C*	*R*	*R/C* (%)	*M*	*C*	*R*	*R/C* (%)
1986°	1,170	546	70	12.8	**32**	**16**	**2**	**12.5**	183	105	8	7.6
1987[`,d,e]	**281**	ND[d]	**ND**	**ND**	**5**	ND	ND	**ND**	**26**	ND	**ND**	ND
1988	1,100	561	98	17.5	**41**	**18**	**1**	**5.6**	113	46	4	8.7
1989	1,416	1,050	200	19.0	57	55	10	18.2	92	76	11	14.5
1990	1,733	1,522	317	20.8	113	109	14	12.8	173	117	12	10.3
1991	1,145	625	140	22.4	98	54	9	16.7	150	119	19	16.0
1992[d]	**595**	**ND**	ND	**ND**	**34**	**ND**	ND	**ND**	**76**	**ND**	ND	ND
1993	972	623	100	16.1	74	41	6	14.6	101	64	10	15.6
1994[d]	**853**	ND	ND	ND	**87**	ND	ND	**ND**	**110**	ND	ND	ND
1995	631	542	77	14.2	130	140	17	12.1	150	108	13	12.0
1996	707	548	72	13.1	155	111	5	4.5	212	124	18	14.5
1997[f]	910	895	164	18.3	429	467	72	15.4	344	281	82	29.2
1998	674	682	61	8.9	216	247	26	10.5	257	216	49	22.7
1999	1,019	883	117	13.3	345	241	29	12.0	293	241	31	12.9
2000[d]	**797**	ND	ND	**ND**	**260**	**ND**	ND	**ND**	**133**	ND	**ND**	ND
2001 [d]	**776**	ND	ND	ND	**321**	ND	ND	ND	**208**	ND	**ND**	ND
2002	495	394	50	12.7	295	257	**24**	9.3	111	104	9	8.7
2003	422	571	72	12.6	272	360	29	8.1	143	165	27	16.4
2004	315	379	51	13.5	227	304	29	9.5	169	202	22	10.9
2005	391	254	30	11.8	172	142	11	7.7	115	95	10	10.5
2006	423	365	54	14.8	289	251	23	9.2	215	223	31	13.9

[a] Includes hatchery cutthroat trout.
[b] m = number of fish marked on marking run; C = total number of fish captured on recapture run; *R* = number of recaptured fish on recapture run.
° Electrofishing conducted in early November rather than October.
[d] No recapture runs due to low flows; ND = no data.
[a] Only *3.2* km of larger *4.9* km section was electrofished with drift boat.
[f] Major habitat changes with spring, *1997,* runoff.

Appendix B-5. Estimated abundance, N, of age 1 and older cutthroat trout (?102 mm), rainbow trout (>152 mm), and brown trout (>178 mm) at the Conant electrofishing section, South Fork Snake River, Idaho, 1986-2006. Confidence intervals at +95% are in parentheses. Cases where R<3 and unbiased estimates are not possible (Ricker 1975) are in bold.

Year	Cutthroat trout[a]		Rainbow trout		Brown trout		Total	
	N/section	N/km	N/section	N/km	N/section	N/km	N/section	N/km
1986[b]	14,162 (1,970)	2,890 (402)	***NUE***[c]	***NUE***	3,142 (1,239)	641 (253)	17,304	3,531
1987[b,d,e]	***NE***[d]	***NE***	***NE***	***NE***	***NE***	***NE***	***NE***	***NE***
1988	7,307 (726)	1,491 (148)	***NUE***	***NUE***	1,667 (1,521)	340 (310)	8,974	1,831
1989	7,890 (528)	1,610 (108)	310 (128)	63 (26)	937 (794)	191 (162)	9,137	1,865
1990	11,418 (846)	2,330 (173)	1,002 (316)	204 (64)	1,806 (650)	369 (133)	14,226	2,903
1991	6,854 (665)	1,399 (136)	658 (264)	134 (54)	954 (252)	195 (52)	8,466	1,728
1992[d]	***NE***	*NE*	***NE***	***NE***	***NE***	***NE***	***NE***	***NE***
1993	7,409 (734)	1,512 (150)	538 (250)	110 (51)	662 (380)	135 (78)	8,609	1,757
1994[d]	*NE*	***NE***	***NE***	***NE***	***NE***	***NE***	***NE***	***NE***
1995	6,028 (719)	1,230 (147)	1,325 (354)	270 (72)	1,442 (863)	294 (176)	8,795	1,795
1996	7,360 (1,101)	1,502 (225)	2,911[1] (2,058)	594[f] (420)	1,537 (383)	314 (78)	11,808	2,410
1997[9]	5,609 (373)	1,145 (76)	2,962 (358)	604 (73)	1,808 (995)	369 (203)	10,379	2,118
1998	8,286 (999)	1,691 (204)	2,258 (385)	461 (79)	1,219 (176)	249 (36)	11,763	2,401
1999	9,051 (798)	1,847 (163)	3,207 (621)	654 (127)	2,507 (829)	512 (169)	14,765	3,013
2000[d]	***NE***	***NE***	***NE***	***NE***	***NE***	***NE***	***NE***	***NE***
2001 [d]	***NE***	***NE***	***NE***	***NE***	***NE***	***NE***	***NE***	***NE***
2002	4,119 (582)	841 (119)	3,845 (956)	785 (195)	1,409 (600)	288 (122)	9,373	1,913
2003	4,114 (583)	840 (119)	4,563 (1,106)	931 (226)	1,174 (487)	240 (99)	9,851	2,010
2004	2,344 (301)	478 (61)	2,595 (511)	530 (104)	1,879 (998)	383 (204)	6,818	1,391
2005	3,224 (1,005)	658 (205)	2,061 [f] (1,035)	421[f] (211)	toll` (513)	206[f] (105)	6,296	1,285
2006	3,668 (512)	749 (104)	3,319 (871)	677 (178)	1,614 (343)	329 (70)	8,601	1,755

[a] Includes hatchery cutthroat trout.
[b] Electrofishing conducted in early November rather than October.
NUE = unbiased estimate not possible as R<3.
[d] No recapture runs due to low flows; NE = no estimate.
Only 3.2 km of larger 4.9 km section was electrofished with drift boat. `
Modified Peterson rather than log-likelihood estimate.
[9] Major habitat changes with spring, 1997, runoff.

Appendix B-6. Estimated abundance, N, of age 1 cutthroat trout (102-254 mm), rainbow trout (152-279 mm), and brown trout (178-279 mm) at the Conant electrofishing section, South Fork Snake River, Idaho, 1986-2006. Confidence intervals at ±95% are in parentheses. Cases where estimates are not possible are in bold.

Year	Cutthroat trout		Rainbow trout		Brown trout		Total		Cutthroat trout *N*/ rainbow trout *N*	Cutthroat trout *N*/ brown trout *N*
	N/section	N/km	N/section	N/km	N/section	N/km	N/section	N/km		
1986[a]	4,683 (1,313)	956 (268)	***NE***[b]	***NE***	1,930 (1,172)	394 (239)	***NE***	***NE***	***NE***	*2.4*
1987[a,c,d]	***NE***	***NE***	***NE***	***NE***	322[e]	66[e]	***NE***	***NE***	***NE***	***NE***
1988	1,448 (412)	296 (84)	310[e]	63[e]	1,197 (1,441)	244 (294)	2,955[e]	603[e]	4.7[e]	1.2
1989	1,184 (221)	242 (45)	120 (66)	24 (14)	97 (43)	20 (9)	1,401	286	9.9	12.2
1990	6,328 (806)	1,291 (165)	819 (310)	167 (63)	1,407 (571)	287 (116)	8,554	1,746	7.7	4.5
1991	2,762 (584)	564 (119)	526 (250)	107 (51)	689 (202)	141	3,977	812	5.3	4.0
1992[c]	1,214[e]	248[e]	255[e]	52[e]	530[e]	108[e]	1,999[e]	408[e]	4.8[e]	2.3[e]
1993	1,680 (448)	343 (91)	198 (180)	40 (37)	214 (109)	44 (22)	2,092	427	8.5	7.9
1994[c]	2,311[e]	472[e]	1,096[e]	224[e]	1,680[e]	343[e]	5,087[e]	1,038[e]	2.1[e]	1.4[e]
1995	1,563 (450)	319 (92)	1,083 (350)	221 (71)	688 (238)	140 (49)	3,334	680	1.4	2.3
1996	4,093 (1,046)	835 (213)	2,343[e]	478[e]	1,049 (325)	214 (66)	7,485[e]	1,528[e]	1.7[e]	3.9
1997`	2,535 (306)	517 (62)	2,136 (299)	436 (61)	719 (78)	147 (16)	5,390	1,100	1.2	3.5
1998	3,961 (854)	808 (174)	921 (293)	188 (60)	656 (126)	134 (26)	5,538	1,130	4.3	6.0
1999	2,748 **(525)**	561 (107)	1,685 (550)	344 (112)	1,069 (246)	218 (50)	5,502	1,123	1.6	2.6
2000[c]	29[e]	6[e]	1,202[e]	245[e]	***NE***	***NE***	***NE***	***NE***	<0.1[e]	***NE***
2001`	43[e]	9[e]	2,796[e]	571[a]	322[e]	66[e]	3,161[a]	**645**[e]	<0.1[a]	0.1[e]
2002	406 (171)	83 (35)	2,268 (893)	463 (182)	579 (340)	118 (69)	3,253	664	0.2	0.7
2003	1,707 (515)	348 (105)	3,116 (1,069)	636 (218)	459 (104)	94 (21)	5,282	1,078	0.5	3.7
2004	514 (121)	105 (25)	1,617 (445)	330 (91)	682 (192)	139 (39)	2,813	**574**	0.3	0.8
2005	1,700[e]	347[e]	1,023[e]	209[e]	165[e]	34[e]	2,889[e]	590[e]	1.7[e]	10.3[e]
2006	1,607 (447)	328 (91)	2,013 (518)	411 (106)	1,072 (226)	219 (46)	4,692	958	0.8	1.5

[a] Electrofishing conducted in early November rather than October.
NE = no estimate.
` No recapture runs due to low flows.
[d] Only 3.2 km of larger 4.9 km section was electrofished with drift boat.
[e] Estimated using cohort analysis (Dr. Rob Van Kirk, Idaho State University, personal communication).
` Major habitat changes with spring, 1997, runoff.

Appendix C. Mark-recapture statistics for the Lorenzo electrofishing section, South Fork Snake River, Idaho, 1987-2006.

Appendix C-1. Sampling dates, flows, and catch rates at the Lorenzo electrofishing section, South Fork Snake River, Idaho, 1987-2006. Flows were recorded at the USGS Lorenzo gage.

Sampling dates	Range of flows (m^3/s)	Range of flows (ft^3/s)	Mean flow (m^3/s)	Catch rate (trout/day)[a]
9/29,30; 10/7 1987	58.6-69.7	2,070-2,460	64.5	183
10/4,6,11 1988	30.9-34.3	1,090-1,210	33.1	205
10/13,16,23 1989	24.7-25.5	871-899	25.1	197
10/3,4,10 1990	49.8-79.0	1,760-2,790	67.7	265
9/18,19,30 1991	60.3-77.3	2,130-2,730	71.5	346
9/23,27; 10/4,7 1993	46.2-71.9	1,630-2,540	56.6	244
10/2,4,10,11 1995	27.4-45.0	967-1,590	36.1	358
9/28,29; 10/6,7 1999[b]	49.6-86.7	1,750-3,060	67.0	378
9/17,18,24,26 2002	73.9-122.3	2,610-4,320	97.8	335
9/18,19,24,26 2003	65.1-90.6	2,300-3,200	81.4	322
9/21,22,28,29 2005	67.7-87.0	2,390-3,070	78.0	310
9/19,21,27,28 2006	24.2-49.9[c]	855-1,760[c]	37.0[c]	601

[a] Includes recaptured fish; catch rate = total trout caught / number days sampled.
[b] Major habitat changes with spring, 1997, runoff.
Provisional data.

Appendix C-2. Trout species composition and relative abundance (percent of catch) at the Lorenzo electrofishing section, South Fork Snake River, Idaho, 1987-2006 excluding years not sampled. Age 1 cutthroat trout are 102-254 mm, age 1 rainbow trout are 152-279 mm, and age 1 brown trout are 178-279 mm. Total individual fish captured during electrofishing is in parentheses.

	Cutthroat trout[a]		Rainbow trout		Brown trout		Lake trout	Kokanee	Total	
Year	All	Age 1	All	Age 1	All	Age 1	All	All	All	Age 1
1987	38.3 (203)	17.1 (18)	0.4 (2)	1.0 (1)	61.3 (325)	81.9 (86)	0.0 (0)	0.0 (0)	100.0 (530)	100.0 (105)
1988	36.3 (210)	11.9 (20)	1.0 (6)	0.0 (0)	62.7 (363)	88.1 (148)	0.0 (0)	0.0 (0)	100.0 (579)	100.0 (168)
1989	34.4 (191)	28.1 (32)	0.5 (3)	0.9 (1)	65.1 (362)	71.1 (81)	0.0 (0)	0.0 (0)	100.0 (556)	100.0 (114)
1990	37.8 (288)	41.7 (133)	0.3 (2)	0.0 (0)	61.9 (471)	58.3 (186)	0.0 (0)	0.0 (0)	100.0 (761)	100.0 (319)
1991	36.8 (359)	20.9 (110)	0.6 (6)	0.4 (2)	62.6 (610)	78.7 (414)	0.0 (0)	0.0 (0)	100.0 (975)	100.0 (526)
1993	36.8 (342)	6.7 (21)	1.6 (15)	2.2 (7)	61.6 (572)	91.1 (285)	0.0 (0)	0.0 (0)	100.0 (929)	100.0 (313)
1995	32.3 (441)	15.0 (68)	0.7 (9)	0.2 (1)	67.1 (917)	84.7 (383)	0.0 (0)	0.0 (0)	100.0 (1,367)	100.0 (452)
1999[b]	23.1 (331)	4.9 (28)	0.5 (7)	0.2 (1)	76.4 (1,093)	94.9 (541)	0.0 (0)	0.0 (0)	100.0 (1,431)	100.0 (570)
2002	18.4 (232)	7.6 (19)	0.5 (6)	0.4 (1)	81.2 (1,026)	92.0 (229)	0.0 (0)	0.0 (0)	100.0 (1,264)	100.0 (249)
2003	13.2 (161)	4.4 (16)	0.3 (4)	0.0 (0)	86.4 (1,051)	95.6 (346)	0.1 (1)	0.0 (0)	100.0 (1,217)	100.0 (362)
2005	6.9 (81)	4.9 (15)	0.6 (7)	1.3 (4)	92.5 (1,080)	93.8 (287)	0.0 (0)	0.0 (0)	100.0 (1,168)	100.0 (306)
2006	7.7 (172)	4.1 (49)	0.9 (21)	0.7 (8)	91.4 (2,054)	95.2 (1,135)	0.0 (0)	0.0 (0)	100.0 (2,247)	100.0 (1,192)

[a] Includes hatchery cutthroat trout.
[b] Major habitat changes with spring, 1997, runoff.

Appendix C-3. Mean total length and quality stock density (QSD) of trout captured in the fall at the Lorenzo electrofishing section, South Fork Snake River, Idaho, 1987-2006 excluding years not sampled. Total individual fish captured during electrofishing equals n. QSD = (number >406 mm / number >203 mm) x 100.

	Cutthroat trout[a]			Rainbow trout			Brown trout				All trout[b]	
Year	*n*	Mean (mm)	QSD (°/a)	*n*	Mean (mm)	QSD (%)	*n*	Mean (mm)	QSD (%)	*n*	Mean (mm)	QSD (%)
1987	203	325	6.1	2	290	0.0	325	329	19.6	530	327	14.3
1988	210	332	9.9	6	311	0.0	363	309	22.0	579	317	17.2
1989	191	331	19.2	3	341	0.0	362	301	35.2	556	311	28.7
1990	288	297	9.9	2	512	100.0	471	257	23.2	761	273	17.4
1991	359	301	12.9	6	303	0.0	610	232	10.1	975	258	11.2
1993	342	325	5.3	15	294	15.4	572	261	13.1	929	285	9.9
1995	441	317	13.7	9	325	11.1	917	234	15.4	1,367	261	14.6
1999[c]	331	334	8.0	7	350	0.0	1,093	272	7.8	1,431	287	7.8
2002	232	316	2.3	6	340	16.7	1,026	321	14.4	1,264	321	12.1
2003	161	332	2.6	4	353	0.0	1,051	296	17.3	1,217	301	15.1
2005	81	333	10.7	7	294	0.0	1,080	285	18.1	1,168	288	17.3
2006	172	310	10.2	21	309	10.0	2,054	284	14.6	2,247	286	14.2

a Includes hatchery cutthroat trout.
b Includes other trout, i.e. lake trout and kokanee. °
Major habitat changes with spring, 1997, runoff.

Appendix C-4. Mark-recapture statistics for age-1 and older cutthroat trout (>102 mm), rainbow trout (>152 mm), and brown trout (>178 mm) at the Lorenzo electrofishing section, South Fork Snake River, Idaho, 1987-2006 excluding years not sampled. Cases where R<3 and unbiased density estimates are not possible (Ricker 1975) are in bold.

	Cutthroat trout[a]				Rainbow trout				Brown trout			
Year	*M*[b]	*C*[b]	*R*[b]	R/C (%)	*M*	*C*	*R*	*R/C* (%)	*M*	*C*	*R*	*R/C* (%)
1987	146	63	6	9.5	**2**	**0**	**0**	**0.0**	225	102	12	11.8
1988	133	88	13	14.8	**3**	**2**	**0**	**0.0**	241	130	23	17.7
1989	119	74	13	17.6	1	**2**	**0**	**0.0**	199	97	22	22.7
1990	208	91	12	13.2	**2**	**0**	**0**	**0.0**	260	93	23	24.7
1991	199	175	17	9.7	**0**	**6**	**0**	**0.0**	319	234	47	20.1
1993	144	201	18	9.0	**6**	**8**	**0**	**0.0**	238	270	27	10.0
1995	264	196	22	11.2	**4**	**5**	**0**	**0.0**	325	341	41	12.0
1999[c]	194	163	26	16.0	**3**	**4**	**0**	**0.0**	500	588	55	9.4
2002	108	138	14	10.1	**4**	**3**	1	**33.3**	457	579	61	10.5
2003	90	81	11	13.6	**2**	**2**	**0**	**0.0**	557	432	61	14.1
2005	37	47	4	8.5	**5**	**2**	**0**	**0.0**	440	486	67	13.8
2006	112	71	14	19.7	**10**	**12**	**1**	**8.3**	1,154	933	140	15.0

[a] Includes hatchery cutthroat trout.
[b] m = number of fish marked on marking run; C = total number of fish captured on recapture run; *R* = number of recaptured fish on recapture run.
° Major habitat changes with spring, 1997, runoff.

Appendix C-5. Estimated abundance, N, of age 1 and older cutthroat trout (>102 mm), rainbow trout (>152 mm), and brown trout (>178 mm) at the Lorenzo electrofishing section, South Fork Snake River, Idaho, 1987-2006 excluding years not sampled. Confidence intervals at +95% are in parentheses. Cases where R<3 and unbiased estimates are not possible (Ricker 1975) are in bold.

Year	Cutthroat trout[a]		Rainbow trout		Brown trout		Total	
	N/section	N/km	N/section	N/km	N/section	N/km	N/section	N/km
1987	2,027 (992)	422 (207)	***NUE***[b]	***NUE***	2,548 (769)	531 (160)	4,575	953
1988	896 (227)	187 (47)	***NUE***	***NUE***	1,442 (421)	300 (88)	2,338	487
1989	1,188 (468)	248 (98)	***NUE***	***NUE***	890 (181)	185 (38)	2,078	433
1990	1,478[c] (695)	308° (145)	***NUE***	***NUE***	1,307 (473)	272 (99)	2,785	580
1991	2,136 (699)	445 (146)	***NUE***	***NUE***	1,773 (270)	369 (56)	3,909	814
1993	2,337 (744)	487 (155)	***NUE***	***NUE***	2,663 (506)	555 (105)	5,000	1,042
1995	2,727 (555)	568 (116)	***NUE***	***NUE***	3,066 (486)	639 (101)	5,793	1,207
1999[d]	1,608 (388)	335 (81)	***NUE***	***NUE***	5,520 (774)	1,150 (161)	7,128	1,485
2002	1,179 (311)	246 (65)	***NUE***	***NUE***	4,942 (563)	1,030 (117)	6,121	1,275
2003	1,137 (636)	237 (133)	***NUE***	***NUE***	4,446 (529)	926 (110)	5,583	1,163
2005	364[c] (258)	76[c] (54)	***NUE***	***NUE***	3,702 (437)	771 (91)	4,066	847
2006	556 (122)	116 (25)	***NUE***	***NUE***	8,453 (708)	1,761 (148)	9,009	1,877

[a] Includes hatchery cutthroat trout.
[b] NUE = unbiased estimate not possible as R<3.
Modified Peterson rather than log-likelihood estimate. [d]
Major habitat changes with spring, 1997, runoff.

Appendix C-6. Estimated abundance, N, of age 1 cutthroat trout (102-254 mm), rainbow trout (152-279 mm), and brown trout (178-279 mm) at the Lorenzo electrofishing section, South Fork Snake River, Idaho, 1987-2006 excluding years not sampled. Confidence intervals at ±95% are in parentheses. Cases where estimates are not possible are in bold.

Year	Cutthroat trout		Rainbow trout		Brown trout		Total		Cutthroat trout ***N/*** rainbow trout *N*	Cutthroat trout ***N/*** brown trout *N*
	N/section	N/km	N/section	N/km	N/section	N/km	N/section	N/km		
1987	469 (494)	98 (103)	***NE***[a]	***NE***	1,206 (668)	251 (139)	1,675	349	***NE***	*0.4*
1988	98 (59)	20 (12)	***NE***	***NE***	618 (184)	129 (38)	716	149	***NE***	0.2
1989	470 (383)	98 (80)	***NE***	***NE***	310 (110)	65 (23)	780	163	***NE***	1.5
1990	***NE***	***NE***	***NE***	***NE***	700 (168)	146 (35)	700	146	***NE***	***NE***
1991	680 (269)	142 (56)	***NE***	***NE***	1,499 (243)	312 (51)	2,179	454	***NE***	0.5
1993	378 (269)	79 (56)	***NE***	***NE***	1,706 (396)	355 (83)	2,084	434	***NE***	*0.2*
1995	841 (316)	175 (66)	***NE***	***NE***	2,003 (352)	417 (73)	2,844	593	***NE***	*0.4*
1999[b]	298 (188)	62 (39)	***NE***	***NE***	3,154 (588)	657 (123)	3,452	719	***NE***	0.1
2002	213 (146)	44 (30)	***NE***	***NE***	1,827 (433)	381 (90)	2,040	425	***NE***	0.1
2003	334 (471)	70 (98)	***NE***	***NE***	2,230 (459)	465 (96)	2,564	534	***NE***	0.1
2005	***NE***	***NE***	***NE***	***NE***	1,841 (393)	384 (82)	1,841	384	***NE***	***NE***
2006	179 (84)	37 (17)	***NE***	***NE***	5,716 (641)	1,191 (134)	5,895	1,228	***NE***	<0.1

[a] NE = no estimate.
[b] Major habitat changes with spring, 1997, runoff.

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