Ichthyofauna of the Little Snake River, Colorado, 1994.

FINAL REPORT

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Contribution 91 of the Larval Fish Laboratory

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Report to :

U. S. National Park Service
Rocky Mountain Region
Denver, CO

and

Colorado River Endangered Fish
Recovery Implementation Program
U. S. Fish and Wildlife Service
Denver, CO

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Contribution 91 of the Larval Fish Laboratory

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EXECUTIVE SUMMARY

The Little Snake River is the largest tributary of the Yampa River and is used seasonally by two endangered fishes: Colorado squawfish (*Ptychocheilus lucius*) and humpback chub (*Gila cypha*). The goal of this study was to determine the importance of the Little Snake River to endangered fishes. We also wanted to characterize fish composition and reproduction in the Little Snake River. Our objectives were to identify when and why Colorado squawfish and humpback chub occupy the Little Snake River and identify the fish composition of the Little Snake River during runoff and base-flow. The objectives were achieved only partially because endangered fishes were not captured, preventing an assessment of endangered fish use of the Little Snake River. This study was done in 1994, a similar study was conducted in 1995 with similar objectives.

The study area included three sites chosen based on their unique geomorphology on the Little Snake River. All sites were on Bureau of Land Management lands in Moffat County, Colorado. Water temperature was recorded hourly from May 16 - Oct 24 on the Yampa and Little Snake rivers. Fish were collected with a variety of gear that depended on river access, discharge level, and habitat conditions. Sampling gear included electrofishing, trammel nets, gill nets, angling, seines, dipnet, and cast net. Fish were collected on two occasions during runoff and on two occasions during baseflow. Also during baseflow, we sampled one site with a four-pass removal sampling design using bank electrofishing to obtain a population estimate of each species within a typical refugia pool.

During 1994, total discharge at 207,300 acre feet was extremely low on the Little Snake River. Maximum daily discharge peaked twice, once on April 25 at 68 m^3/sec and again on May 15 at 58 m^3/sec. From mid-July through mid-September, discharge was less than 0.03 m^3/sec, including 19 days of near zero discharge. Little Snake River water temperatures were higher than those in

the Yampa River in May and June to the point that Little Snake River minimum temperatures often exceeded maximum temperatures on the Yampa River. In later months during baseflow, average daily temperatures were similar between both rivers but the Little Snake River had diel fluctuations as high as 20°C between its daily high and low temperatures.

Our most significant finding was the scarcity of nonnative fishes. Of 4,490 fish collected, 69% were native species. Five native and seven nonnative species were collected. Native species included roundtail chub, speckled dace, bluehead sucker, flannelmouth sucker, and mottled sculpin. Nonnative species included red shiner, common carp, fathead minnow, redside shiner, sand shiner, white sucker, and channel catfish. No endangered fishes were seen or collected. Species in highest abundance were native bluehead sucker (31%), flannelmouth sucker (23%), and nonnative redside shiner (20%). Other numerically abundant species included speckled dace and sand shiner. Few common carp, white sucker, channel catfish, fathead minnow, or red shiner were collected. Larvae were collected for all species except common carp and channel catfish. Few roundtail chub larvae were collected even though juveniles and adults were fairly common.

All five native species spawned within the Little Snake River. Spawning was also confirmed for five of the seven nonnative species. Channel catfish and common carp larvae were not collected and their spawning was not confirmed. The small number of nonnative fish larvae collected implied limited spawning by most nonnative fishes in the Little Snake River.

After July, discharge in the Little Snake River decreased so low that many reaches were essentially devoid of fish due to insufficient water levels. During this low-flow period, fish of all sizes tended to congregate in refugia pools located in the Upper and Lower reaches. During July base-flows, the removal sampling method was effective for sampling refugia pools. The technique provided a good estimate of species abundance and confirmed the paucity of nonnative species in the Little Snake River. Estimated composition of one pool we sampled was 87% native and 13% nonnative species.

The reasons for so few nonnative fishes compared to other Upper Basin rivers are unknown but the extreme physical characteristics of the Little Snake River may limit nonnative fish distribution and survival. The Little Snake River provides an extremely variable and harsh environment for which most nonnative fishes may not be well adapted. Physical processes that are extreme in the Little Snake River include a high amplitude between peak and baseflow events, a very turbid runoff, extremely low baseflows, and high amplitude of diel water temperatures during baseflow.

Our understanding of tributaries in the Upper Basin is limited, yet their contribution to the ecosystem and to endangered fish recovery may be significant and therefore deserves further research and understanding. Tributaries like this deserve study to assist us in understanding the influence of physical processes on fish communities. Extreme conditions make the Little Snake River a valuable area for use as a reference site to study the influence of geomorphology, flow, sediment, and temperatures in structuring fish communities and possibly in controlling undesirable nonnative fishes. Based on our present results and observations we recommend the following:

1. Continue sampling the Little Snake River for endangered fishes to identify their period of use and the potential significance of the Little Snake River in their life history.

2. Use the Little Snake River to study and understand which physical factors restrict nonnative species numbers and their distribution in the Little Snake River. Physical factors that warrant additional study include:
   - the unique geomorphology of the watershed,
   - discharge events including runoff, baseflow, and flash floods,
   - water quality especially turbidity and temperature, and
   - extreme variability and amplitude of seasonal discharge, seasonal sediment load, and diel water temperatures during baseflow.

3. Study the Little Snake River to understand the influence of extremely low baseflow events on the native and nonnative fish community.

4. Consider the use of population estimates as a tool for monitoring fish communities in Upper Basin studies and modify the technique for use on larger rivers.

Key words: Colorado squawfish, humpback chub, Little Snake River, native fishes, nonnative fishes, removal population estimate, reproduction, spawning, tributary.

INTRODUCTION

The Little Snake River is the largest tributary of the Yampa River and is part of the Upper Colorado River Basin (Upper Basin). Two endangered fishes, Colorado squawfish (*Ptychocheilus lucius*) and humpback chub (*Gila cypha*) occur in the Little Snake River (Miller et al. 1982; Marsh et al. 1991; Wick et al. 1991) and both species have reproducing populations in the adjacent Yampa River (Karp and Tyus 1990; Tyus 1990) but their extent and range in the Little Snake River is largely unknown. Previous information indicates that some Colorado squawfish occupy the Little Snake River temporarily just prior to their spawning migration to Yampa Canyon. In 1981, two radiotagged Colorado squawfish moved from the Yampa River into the mouth of the Little Snake River in the spring (Miller et al. 1982). In 1988, two other radiotagged Colorado squawfish moved about 10 km up the Little Snake River and remained there about one month (Wick et al. 1991). On August 20, 1990, a Colorado squawfish was collected approximately 135 km upstream of the confluence (Marsh et al. 1991). This capture not only extended the upstream range of Colorado squawfish into Wyoming, it also extended their period of occurrence into late summer.

Humpback chub were not collected in the Little Snake River until 1988 when seven humpback chub and two humpback-roundtail chub (*Gila cypha X G. robusta*) hybrids were collected in the lower 15 km (Wick et al. 1991). These fish were caught in early June, approximately during their spawning period and two of the fish had breeding tubercles suggesting spawning activity. However, none of the humpback chub collected expressed gametes and additional sampling 20 days later failed to collect larval humpback chub thus spawning was never confirmed (Wick et al. 1991).

Compared to other rivers in the Upper Basin, sampling for fishes in the warm-water zone of the Little Snake River has been scant. Because so little information was known about the fauna of this river, we wanted to assess the status of the entire fish community in the warm-water reaches of the Little Snake River and learn more about why and when Colorado squawfish and humpback chub use the Little Snake River. In 1994, we conducted this study with funding from the National Park Service and in 1995 a similar study with similar objectives was funded by the Recovery Program. The goals of this study, in 1994, were to determine the importance of the Little Snake River to endangered fishes, specifically Colorado squawfish and humpback chub and in the process, to characterize the composition of fish in the Little Snake River.

Objectives:

1. To identify when and why Colorado squawfish and humpback chub occupy the Little Snake River.
2. To identify the fish composition of the Little Snake River during runoff and baseflow.

STUDY AREA

The Little Snake River is located primarily in northwestern Colorado, but much of the watershed is in southwestern Wyoming (Figure 1). The river drains two very different physiographic regions, the Southern Rocky Mountains and the arid Wyoming Basin (Hunt 1974). Total drainage area is 9,700 km^2 and mean annual runoff is 412,400 acre-feet/year (Ugland et al. 1995). Discharge is both seasonal and extreme. For example, mean-monthly discharge is 40 m^3/sec in May, but base flows regularly approach zero between July and November (Ugland et al. 1995). Highest measured peak flow was 473 m^3/sec on May 18, 1984 (Ugland et al. 1995).

Most of the warm-water habitat in the Little Snake River occurs in Colorado. Within Colorado we identified three different reaches, each with unique geomorphological characteristics. These characteristics included the local topography and geology, river gradient, and predominant substrate. Locations were identified from U.S. Geological Survey (USGS) topographic maps of Moffat County (1:50,000 scale). Specific locations on the river were identified on the map by delineating river kilometers (RK) starting at the confluence with the Yampa River. An upper reach from RK 160 to RK 80 contained gravel and cobble substrates and riffle-pool habitats that maintained highly diverse fish habitats at all flow levels. At runoff; riffles, pools, and eddies were abundant in this reach and at baseflow large refugia pools were common. A middle reach between RK 80 and RK 15 was located in a broad, unconfined riverbed with low gradient and predominately sand substrate. Habitat diversity in this reach was low at all water levels. During runoff, most of the habitat in this reach was homogeneous run with a few eddies that provided some velocity refuge for fish. During baseflow, much of the habitat in this reach was marginal because flow dispersed through the broad sandbed providing little refugia for large fishes. The riverbed in the lower reach (RK 15 to RK 5) was confined by a canyon that not only constricted the river

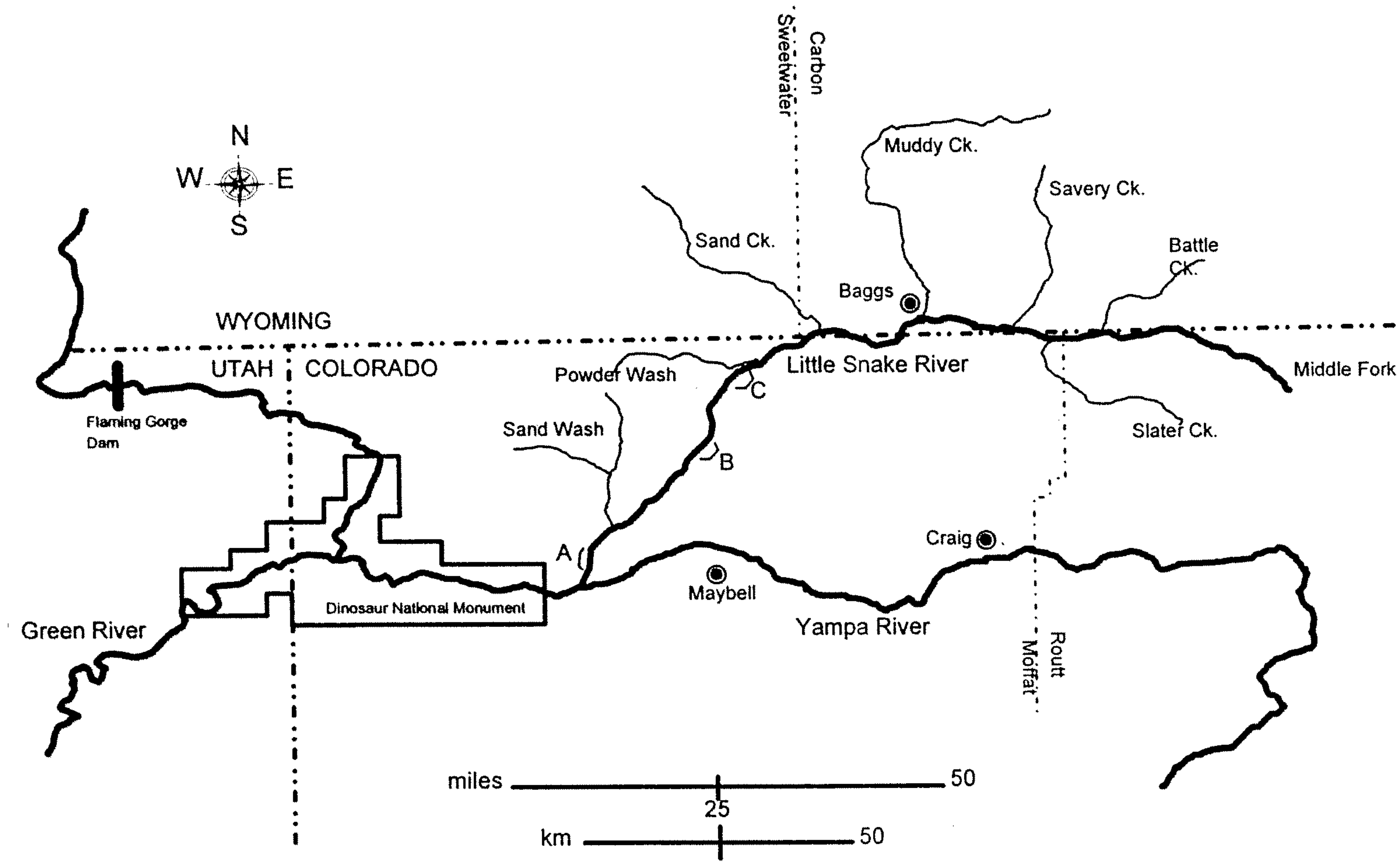

Figure 1. Little Snake River drainage basin, Colorado and Wyoming. A, B, and C denote lower, middle, and upper sampling sites.

but also added boulder and cobble substrates. At higher discharge, deep, turbulent eddies were formed by the higher velocities and larger substrates in the canyon. These habitats became deep, low-velocity pools at baseflow that provided refugia for over-wintering fishes.

We selected one 8-km study site within each of the three reaches (Figure 1). Each site was on Bureau of Land Management public lands in Moffat County, Colorado.

1. The upper site was between RK 95 and 103 and was accessed via Moffat County Road-147 (RK 102).
2. The middle site was at Moffat County Road-26 (RK 64) and included RK 61 through 69.
3. The lower site was below Moffat County Road-10 bridge (RK 15) between RK 7 and 15.

METHODS

Discharge and water temperature

Mean daily discharge for water year 1994 included records from October 1, 1993 to September 30, 1994. Records were from the USGS, "Little Snake River near Lily, Colorado" gage #09260000 located at RK 15 at an elevation of 1733 m (Ugland et al. 1995).

Water temperature was recorded hourly from May 16 until October 24, 1994 on the Yampa and Little Snake rivers by Ryan, Temp-Mentor® thermographs. One thermograph was placed in the Yampa River at Moffat County Road-25 bridge, approximately 1.5 km above the confluence with the Little Snake River and another was placed on the Little Snake River at RK 15 near the USGS gaging station. Thermographs were checked bi-weekly to insure they remained submerged as water levels dropped.

Conductivity and pH were measured on each fish sampling trip. Measurements for pH were taken using a Cole Parmer®, model pHTestr 2 and conductivity was measured with a Cole Parmer®, model TDSTestr 3 (range 1-1990 μS).

Fish collections

In 1994, we sampled for fish at each of the three sites on the Little Snake River during runoff and baseflow. We sampled at runoff because endangered fishes were previously collected during this time by Wick et al. (1991) and we sampled at baseflow to identify what species remain during low flows. Larval fish were collected to identify which species reproduced within the Little Snake River. Fish were collected during runoff on May 13-16 and June 7-11 and during baseflow on June 17-19 and July 11-15. On October 21-24, a few additional seine samples were taken while we assisted with a channel monitoring study. Sample gear and methods targeted both large and small fish and varied depending on river access, discharge, habitat, and safety. Small fish were collected with small seine, dipnet, and castnet and large fish with large seine, angling gear, electrofishing boat, backpack-electroshocker, bank-electrofisher, gill net, and trammel net (Appendix Table A.1). Trammel and gill nets were set in eddies along the eddy-run interface and fish were removed from nets every 30 minutes to reduce their stress. Angling gear included worms, crickets, dry-flies, and spoon-type lures with barbless hooks. Seine and dipnet gear were used to sample near-shore and backwater habitats and a cast net was used to sample large, shallow pools that were difficult to seine.

All fish were measured for maximum total length (Anderson and Gutreuter 1983) and those over 100 mm were cradled in a net and weighed with Homs or Chatillon brand spring scales (Jennings 1989). All fish were released alive after measurements unless fish identification was uncertain, then fish were anaesthetized and overdosed with tricaine (trade name Finquel®) and preserved in 10% formalin for laboratory identification. Preserved specimens were later transferred to 3% buffered formalin, identified, and cataloged at the Larval Fish Laboratory, Colorado State University.

For data analysis, fish were segregated into life stages based on morphological development (Snyder 1981; Snyder and Muth 1990). Life stages included larva, juvenile, and adult; size at each stage varied by species (Table 1). For additional clarity, species were grouped into large-bodied or small-bodied forms based on the approximate length at which they become adults. Large-bodied species were considered adults at $\geq$200 mm and small-bodied species were considered adults at <200 mm (Table 1). Spawning period was estimated for each species based on when adult fish expressed sperm or eggs or had secondary

Table 1. Approximate length at beginning of juvenile and adult life stages for fishes collected from the Little Snake River, Colorado, 1994. Fish smaller than juvenile size are larva. Data adapted from Snyder (1981) and Snyder and Muth (1990). Common and scientific names from Robins et al. (1991).

		Total length (mm)	
		Juvenile	Adult
Native species			
roundtail chub*	*Gila robusta*	25	200
speckled dace	*Rhinichthys osculus*	20	50
bluehead sucker*	*Catostomus discobolus*	25	200
flannelmouth sucker*	*Catostomus latipinnis*	30	300
mottled sculpin	*Cottus bairdi*	15	40
Nonnative species			
red shiner	*Cyprinella lutrensis*	15	40
common carp*	*Cyprinus carpio*	20	250
sand shiner	*Notropis stramineus*	15	40
fathead minnow	*Pimephales promelas*	15	40
redside shiner	*Richardsonius balteatus*	20	60
white sucker*	*Catostomus commersoni*	25	200
channel catfish*	*Ictalurus punctatus*	25	200

* Large-bodied species attain an adult size at $\geq$200mm, other species are small-bodied forms and attain adult size at $<$200mm total length.

sexual characteristics such as spawning coloration or breeding tubercles. Spawning was confirmed and time of spawning was estimated based on when larvae were collected.

Population Estimate for the Upper Site

As part of standard sampling of the upper site during base-flow, large-bodied fish were collected at one site using a four-pass, removal, sampling design. This was done to obtain abundance estimates for each species and to test if removal sampling in a river of this size was practical at base flow.

The sample site was a pool, 130-m long that averaged 23-m wide (width ranged 9-26 m) and was similar to other baseflow refugia pools in the upper reach. Within the thalweg, which was about 5-m wide, average depth was 0.8 m and maximum depth was 1.2 m. Outside the thalweg, along the margins of the pool, depths were < 0.5 m due to sand deposition. Substrate in the reach was predominately gravel, but the pool also contained sand and boulders. To meet the assumption of closure required by the population estimator, fish were confined in the reach with nets (White et al. 1982). An upstream riffle was blocked by a 10-mm mesh net and a shallow, downstream, low-velocity run was blocked with a trammel net partially covered by a 10-mm mesh net.

Fish were collected for the population estimate by bank electrofishing. A 5000-watt generator provided electricity to a Coffelt® VVP-15 set to 300 volts, 2.5-4 amps, 30 pulses/second, and 40% pulse width. Three netters stood 1-m abreast and electrofished in an upstream direction. Fish were collected and held in a live-car during each pass. Fish removed from the trammel net were counted and included with fish caught by electrofishing on each pass. All fish were released alive after the fourth and final pass. Population size of each species within the pool was estimated with the computer program CAPTURE (White et al. 1982).

RESULTS

Discharge and water temperature

During the 1994 water year, total discharge was very low in the Little Snake River. Annual runoff was 207,300 acre feet, about half of the 70-year average. Winter baseflow prior to runoff was about 3 m^3/sec from November through March and was ice covered. Runoff started in March and continued until mid-June. Daily discharge peaked at 68 m^3/sec on April 25 and again at 58 m^3/sec on May 15 (Figure 2). Discharge decreased rapidly in June and from mid-July through mid-September, discharge was less than 0.03 m^3/sec, including 19 days of near zero discharge (Ugland et al. 1995). In August and September, localized rain caused two spates that increased discharge from near zero to about 2.0 m^3/sec for several days and deposited large amounts of clay and silt within the river bed.

During runoff, mean daily discharge on the two sampling trips ranged 55-57 m^3/sec and 10-19 m^3/sec. During baseflow, mean daily discharge on the two trips ranged 3-4 m^3/sec and 0.02-0.03 m^3/sec (Figure 2). Associated with runoff was high turbidity caused by the large sediment load. This turbidity cleared during baseflow except during temporary spate events. Conductivity increased as discharge declined. During runoff, conductivity ranged 163-220 μS and during baseflow it ranged 500-1080 μS. Water pH was only collected during baseflow and was 8.4 in June and 8.9 in July.

In May and June, during runoff, water temperatures in the Little Snake River were generally higher than in the Yampa River; even minimum daily temperatures in the Little Snake River exceeded maximum daily temperatures on the Yampa River (Appendix Figures B.1-B.2). From July through October, daily average temperatures were similar between both rivers, but the Little Snake River typically had greater diel temperature fluctuations (Appendix Figures B.3-B.6).

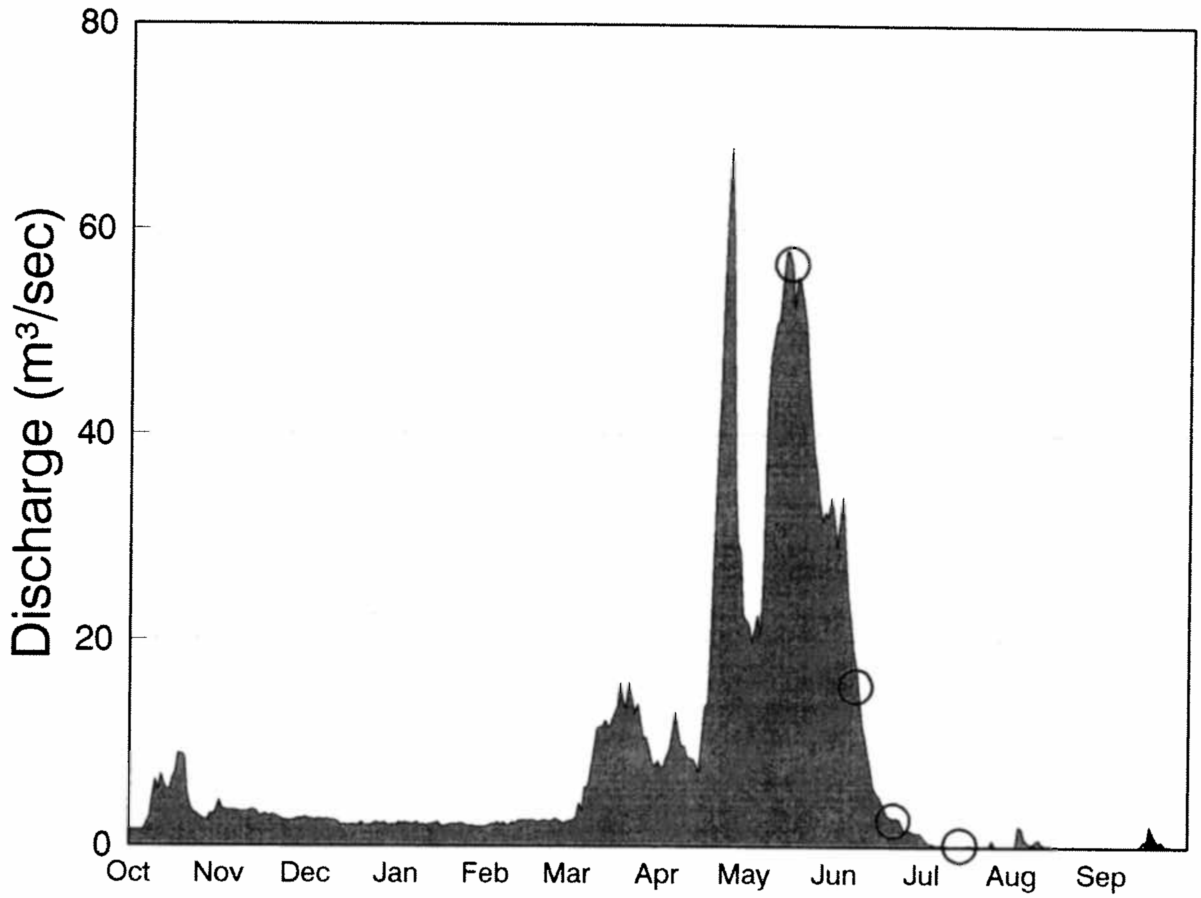

Figure 2. Mean daily discharge of Little Snake River at U.S. Geological Survey gage #09260000, near Lily, Colorado, 1994 water year. Open circles indicate discharge during sampling.

As discharge declined in the Little Snake River, diel water temperature variability increased. On July 13, when discharge dropped below 0.03 m^3/sec on the Little Snake River, the difference between the daily high and low temperatures was almost 20^{0}C. On the same date, Yampa River discharge was 4.5 m^3/sec and diel water temperature variation was only 4^{0}C (Appendix Figure B.3). Hourly water temperatures cycled daily from a low just before sunrise to a high a few hours before sunset.

Fish Community

Each site and discharge level presented different obstacles to effective sampling and required different sampling gear, especially during the extremely low baseflow. For example, a shallow rapid located downstream of the boat launch made the lower site accessible only by raft even during runoff. The site was accessible only by foot during baseflow because discharge was too low for any type of boat. We sampled the site at both flow levels with trammel net, seine, cast net, and angling. The middle site was too shallow for a boat at all flow levels, and the monotonous habitat contained no suitable sites for large-fish sampling gear so we sampled it only by seine at all flow levels. The upper site was the only site sampled by electrofishing boat and seine during runoff; at low flow, it was sampled by bank electrofisher and seine. Because such different effort and gear were used at each site we did not compare fish captures between sites or seasons. Catch per effort was not calculated because different gear were used at each site and season and because catch varied greatly depending on the habitat and sampling efficiency. Attempts to standardize catch rates by effort would therefore be misleading so we combined all sites, sample gear, and sample trips and reported the total number of each species by life stage.

From May through October, five native and seven nonnative species were collected. We collected no endangered fishes even though we sampled the same sites where Wick et al. (1991) previously captured humpback chub and Colorado squawfish. Of 4,490 fish collected, 69% were native species (Table 2). The most abundant taxa (31%) were native bluehead sucker (*Catostomus discobolus*), 23% were flannelmouth sucker (*Catostomus latipinnis*), and 20% were nonnative redside shiner (*Richardsonius balteatus*). All of the five native species except mottled sculpin (*Cottus bairdi*) and larval roundtail chub were relatively abundant (Figure 3; Appendix Figures C.1-C.5). The most common nonnative species collected were sand shiner (*Notropis stramineus*) and redside shiner, all other nonnative species were few in number (Table 2; Appendix Figures C.6-C.10) All common carp (*Cyprinus carpio*) and channel catfish (*Ictalurus punctatus*) collected were adults or juveniles (Figure 4).

Reproduction

Collection of larvae confirmed reproduction in 1994 of native: roundtail chub, speckled dace (*Rhinichthys osculus*), bluehead sucker, flannelmouth sucker, and mottled sculpin and nonnative: red shiner (*Cyprinella lutrensis*), sand shiner, fathead minnow (*Pimephales promelas*), white sucker (*Catostomus commersoni*), and redside shiner (Table 2). Few larvae of roundtail chub, mottled sculpin, red shiner, fathead minnow, or white sucker were collected and no larvae of channel catfish or common carp were collected.

Roundtail chub spawned between late June and early July based on adult roundtail chub expressing milt on June 18, and with orange or red spawning color between June 18 and July 13. In mid-June, 49% of all roundtail chub (n = 16) collected were in spawning color while only 14% of roundtail chub (n = 59) collected in mid-July were in spawning color. Collections in May and June also

Table 2. Number of fish collected by life stage from the Little Snake River, Colorado, 1994.

Species	Larvae	Juveniles	Adults	Total
Native species				
roundtail chub	6	169	45	220
speckled dace	207	187	70	464
bluehead sucker	1178	105	91	1374
flannelmouth sucker	703	232	79	1014
mottled sculpin	2	3	7	12
Nonnative species				
red shiner	4	0	16	20
common carp	0	1	13	14
sand shiner	222	138	35	395
fathead minnow	1	0	2	3
redside shiner	32	731	117	880
white sucker	12	13	7	32
channel catfish	0	0	23	23
Unidentified species[a]				
unidentified minnow	4	0	0	4
unidentified sucker	35	0	0	35
Total	2406	1579	505	4490

[a] Diagnostic characteristics missing due to damaged specimens.

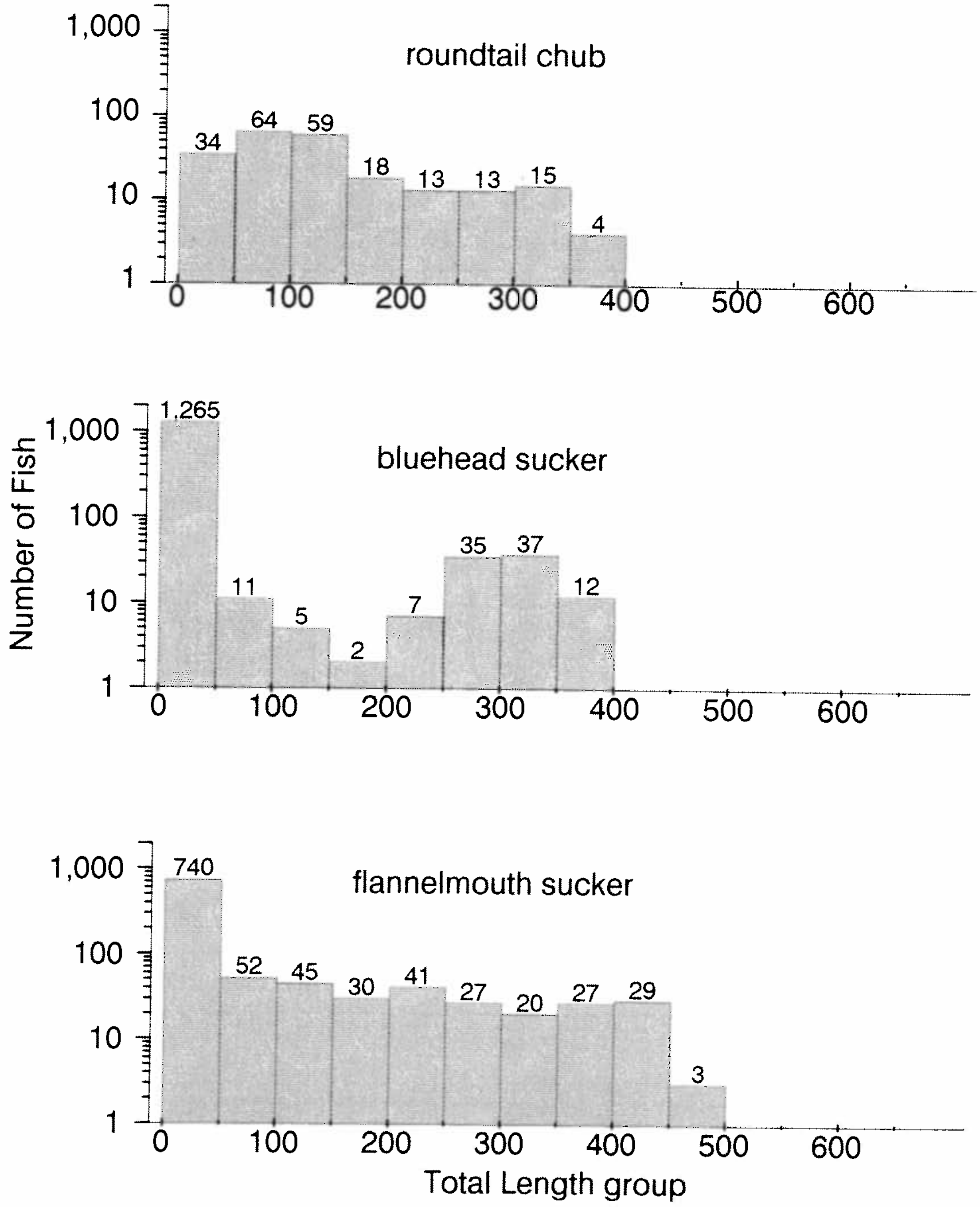

Figure 3. Length-frequency distribution of large-bodied native fishes collected from the Little Snake River, Colorado, 1994. Note that Y-axis scale is logarithmic.

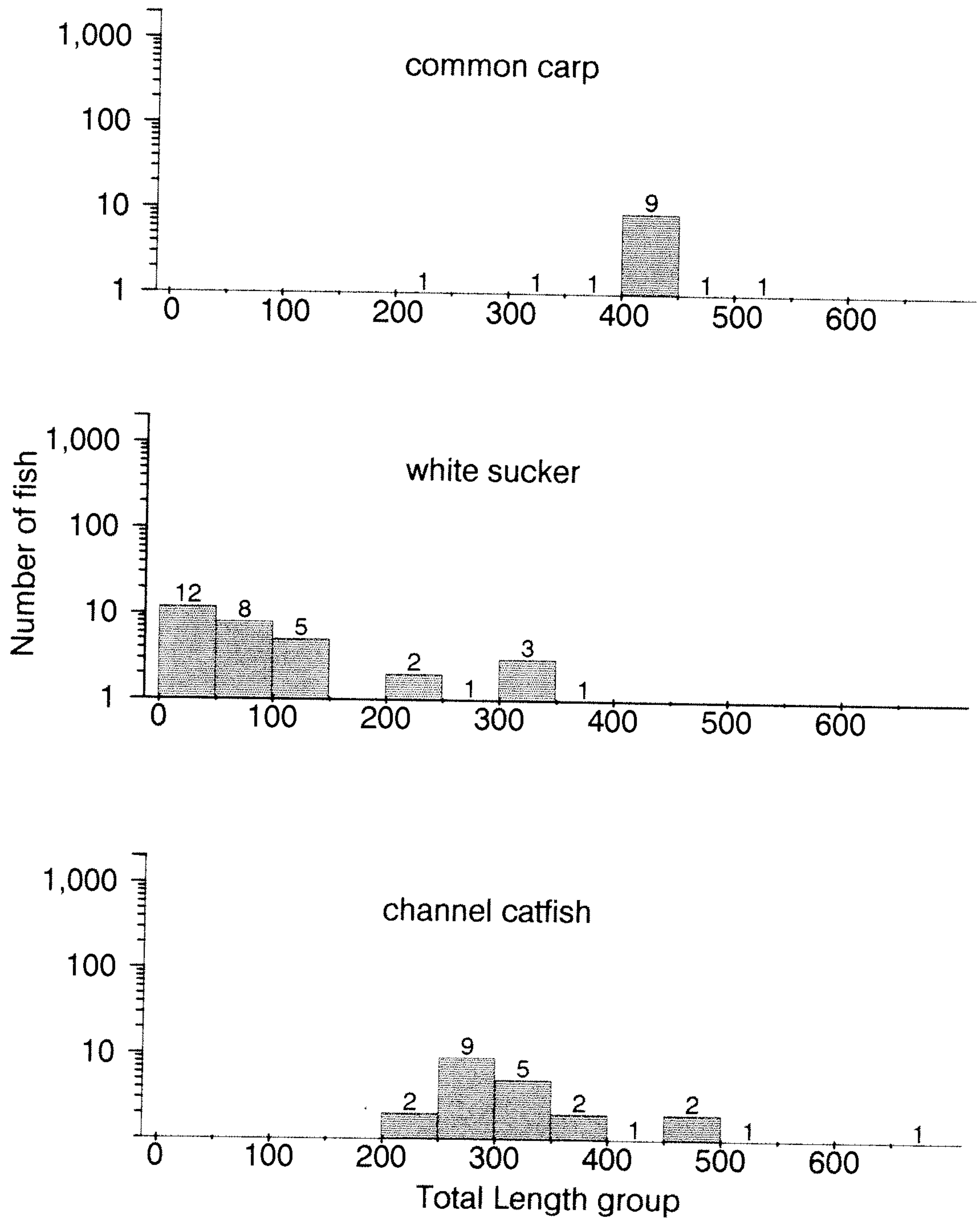

Figure 4. Length-frequency distribution of large-bodied nonnative fishes collected from the Little Snake River, Colorado, 1994. Note that Y-axis scale is logarithmic.

contained yearling (35-60mm) and larger fish (70-100mm, estimated Age 2+), confirming reproduction the previous two years.

Flannelmouth sucker spawned in early May based on collection of 14 adults with spawning tubercles including nine males and two females that expressed gametes. Adult flannelmouth sucker caught on later trips did not have secondary spawning characteristics. Early June collection of flannelmouth sucker larvae confirmed May spawning (Appendix Figure C.2). Yearling-sized flannelmouth sucker juveniles collected from May through July confirmed 1993 spawning, overwinter survival, and retention of young flannelmouth sucker within the Little Snake River.

Bluehead sucker spawned in early to mid May. Of 22 adult bluehead sucker collected on May 14, 68% had breeding tubercles including four males and two females that expressed gametes. After May, adult bluehead sucker had no secondary spawning characteristics and larvae were abundant in all collections (Appendix Figure C.4). Juvenile and yearling-sized fish (25-60 mm) collected from May through July confirmed spawning in 1993, overwinter survival, and retention of larval bluehead sucker within the Little Snake River.

Speckled dace spawned in early June, based on fish collected in spawning color and expressing milt and based on larval collections in mid June and July (Appendix Figure C.4). Mottled sculpin spawned in May or June based on larvae collected in early June.

Few nonnative species were collected in spawning condition, but a 60-mm redside shiner in brilliant spawning color and a sand shiner expressing milt were both collected on June 9. Red shiner, fathead minnow, and white sucker adults were rarely collected, but a few larvae of each species were collected, indicating some reproduction in 1994 (Table 2). White sucker spawned in late May based on

June larval collections (Appendix Figure C.10). Redside shiner and sand shiner probably spawned in early June because their larvae were collected in mid June (Appendix Figures C.6-C.7) and red shiner spawned in early July because their larvae where collected in mid July (Appendix Figure C.8). Spawning of common carp and channel catfish was not confirmed because neither species was observed in spawning condition and no larvae were collected.

Population Estimate for the Upper Site

On July 12 and 13, a pool at the upper site (RK 102) was sampled by depletion methods during an extremely low discharge (0.02 m^3/sec). Water temperature was 14.5^{0}C, conductivity 1080 μS, pH 8.4 and visibility was 1.2 m (max. depth). Prior to sampling, one person snorkeled the reach for about 15 minutes and observed only about 10 fish, mostly suckers. The reach was effectively blocked with nets and we believe no fish escaped during sampling. Four electrofishing passes were conducted and time required for each successive pass was 70 min, 50 min, 45 min, and 35 min. All habitat was uniformly covered on each pass and subsequent passes required less time due to decreasing number of fish handled.

All fish captured were longer than 90 mm. About ten mottled sculpin adults were observed but not captured because they were smaller than the dipnet mesh. Native species comprised 87% of the sampled population estimated at 310 individuals of six species (Appendix D). Flannelmouth sucker were the most abundant species captured, followed by other natives including bluehead sucker and roundtail chub. Nonnative fishes were much less abundant and included channel catfish, white sucker, and common carp. Total weight of all fish collected was 67 kg. Total weights of each species were: flannelmouth sucker (26 kg), bluehead sucker (16 kg), common carp (10 kg), roundtail chub (8 kg), channel catfish (6 kg), and white sucker (1 kg).

DISCUSSION

Spring run-off in the Little Snake River starts with low-elevation snow melt and spring rains in the Wyoming Basin and eventually includes melting snows in the higher elevations of the Rocky Mountains. Early spring runoff is typically warmer in the Little Snake River than runoff during the same period on the Yampa River. These higher temperatures provided potential growth advantages for fish using the Little Snake River during the early spring compared those using the cooler Yampa River and may explain movements of fish from the Yampa River into the Little Snake River. Although temperatures were not obtained for the initial runoff period in March and April, temperatures obtained after mid May were significantly warmer in the Little Snake River than the Yampa River through the remaining runoff period. Wick et al. (1991) observed movements of Colorado squawfish and humpback chub from the Yampa River into the Little Snake River in the early spring when we observed Little Snake River temperatures were typically warmer than those in the Yampa River. Because no endangered fishes were captured, we were unable to evaluate relationships between temperature and endangered fish movements in the Little Snake River. Therefore, our objective of assessing endangered fish use of the Little Snake River was not met.

Our most significant finding was the scarcity of nonnative fish. Many nonnative species normally found in the Yampa River were missing from collections in the Little Snake River and many nonnative species that were collected were few in number. The ratio of native and nonnative species was similar to the ratio observed by Wick and Hawkins (1989b) and the fish collected were similar in species and abundance. The reasons for so few nonnative fishes are unknown but the geomorphology of the watershed and the extreme physical characteristics of the Little Snake River may limit nonnative fish distribution and survival. The Little Snake River provides an extremely variable and harsh environment for which most nonnative fishes may not be well adapted. The geomorphology of the watershed and local weather conditions combine to produce physical processes that are extreme in the Little Snake River. These extreme processes include a high amplitude between peak and baseflow events, a very turbid runoff, extremely low baseflows, and high amplitude of diel water temperatures during baseflow. Nonnative fish may also be limited by the lack of off-channel habitat that provides low-velocity refugia during runoff and is typically common in other Upper Basin rivers. These processes may influence nonnative survival or movement in the Little Snake River and may explain their low number and limited distribution.

All five native species collected in the Little Snake River successfully spawned in 1994. It is interesting that few roundtail chub larvae were collected especially given the number of juvenile and adult fish captured. This phenomenon was also observed by Wick and Hawkins (1989a). Sites with gravel and cobble substrates suitable for roundtail chub spawning occurred mostly in the Upper Reach, although some suitable spawning sites also occurred in the Lower Reach. Most juvenile roundtail chub probably moved downstream from spawning areas in the Upper Reach during runoff.

The small number of nonnative fish larvae implied limited spawning by most nonnative fishes in the Little Snake River. The lack of larvae indicated little or no reproductive success by channel catfish and common carp, although channel catfish larvae are also rarely collected even in areas like the Yampa River where adults are relatively abundant.

After July, discharge in the Little Snake River decreased so low that many reaches were essentially devoid of fish due to insufficient water levels. During this low-flow period, fish of all sizes tended to congregate in refugia pools located in the Upper and Lower reaches. No refugia pools were observed in the middle reach. Refugia pools were often deep (> 1 m) but good visibility allowed us to observe fish in many pools that we did not sample. We visually estimated most baseflow pools to contain hundreds of large-bodied adult fish and in one large pool in the canyon at the lower site, we estimated over a thousand, large-bodied, juvenile and adult fish.

Our sample of one of these low-flow refugia pools provided a good quantitative estimate of the fish community with a fairly simple and practical technique. The technique provided a good estimate of species abundance and confirmed the paucity of nonnative species in the Little Snake River. Although native fish were seven times more abundant than nonnative species at the sample site, biomass of native fishes was only three times greater. This indicates that most nonnative fish were large adults while native fish included a range of sizes and life stages.

Physical and biological processes during this low-flow period may play a strong role in structuring the fish community in the Little Snake River. Understanding the influence of these processes may provide insight into why the Little Snake River contains so few nonnative species. Physical processes that typically influence fish community structure during low flow are temperature, oxygen, and flow (Schoener 1987). During most of the low-flow period, diel temperature fluctuations were tremendous in the Little Snake River. In July, daily temperature fluctuations of 20^0 were common (Appendix Figure B.3.). These diel changes were almost always greater than those observed in the Yampa River. Even with these extremes, we observed no adverse effects such as fish kills or algal blooms typically associated with high temperatures. Two flash flood events caused by localized rainfall probably also had a strong influence on the structure of the fish community in these low-flow pools. We did not sample after these spates and do not know their affect on fish; however, the potential negative effects were many. The magnitude of these spates may have swept some fish away from refugia areas and the heavy loads of fine sediments including suspended clays could have suffocated fish. Fine sediments deposited by these events could also kill benthic invertebrates and reduce food availability for remaining fish. Further study may reveal if native and nonnative fishes respond differently to these events.

The confinement of fish in refugia pools also increases the affect of biological processes such as predation, competition, and disease; each of which could be extreme. With such a large concentration of fish in each pool and with little inflow, food is probably limited for herbivorous and insectivorous fishes in these isolated pools. Although nonnative predators were not necessarily abundant in these pools, predation from even a few individuals could be intense because of the confined conditions and clear water. The most common large-bodied, predatory species were channel catfish and roundtail chub. Other, small-bodied predatory cyprinids (i.e., red shiner or fathead minnow) typically found in abundance in other Upper Basin rivers were relatively rare in these pools.

CONCLUSIONS

The Little Snake River is a river of extreme physical conditions, its discharge varies seasonally from flood in the spring to drought in the fall. Based on total runoff volume it is considered the largest tributary on the Yampa River, yet based on its flow pattern it is almost an intermittent stream. These extremes are primarily caused by the weather and geomorphology of the watershed.

The Little Snake River provides spawning habitat and refugia for all life stages of most native fishes. Native fishes were abundant and widespread within the Little Snake River and their reproduction probably contributes native fish to the Yampa River by the export of young fish. Nonnative species found in the adjacent Yampa River and considered problematic by Hawkins and Nesler (1991) were rare or nonexistent in the Little Snake River. The reasons for the lack of nonnative fishes is unknown but may be related to the physical environment, especially the extremes of physical variability. This variability is most evident in the high amplitude between base and peak flow, diel water temperature fluctuations, and turbidity of the Little Snake River. Native fishes apparently persist and reproduce in these extreme conditions, through either physiological or behavioral adaptations that nonnative fishes apparently lack. For this reason, it would be important to maintain the physical variability found in the Little Snake River.

Our understanding of tributaries in the Upper Basin is limited, yet their contribution to the ecosystem and to endangered fish recovery may be significant and deserves further research and understanding. Tributaries like this deserve study to assist us in understanding the influence of physical processes on fish communities. Extreme conditions make the Little Snake River a valuable area for use as a reference site to study the influence of flow, sediment, and temperatures in structuring fish communities and possibly in controlling undesirable nonnative fishes.

RECOMMENDATIONS

1. Continue sampling the Little Snake River for endangered fishes to identify their period of use and the potential significance of the Little Snake River in their life history.

2. Use the Little Snake River to study and understand which physical factors restrict nonnative species numbers and their distribution in the Little Snake River. Physical factors that warrant additional study include:
   - the unique geomorphology of the watershed,
   - discharge events including runoff, baseflow, and flash floods,
   - water quality especially turbidity and temperature, and
   - extreme variability and amplitude of seasonal discharge, seasonal sediment load, and diel water temperatures during baseflow.

3. Study the Little Snake River to understand the influence of extremely low baseflow events on the native and nonnative fish community.

4. Consider the use of population estimates as a tool for monitoring fish communities in Upper Basin studies and modify the technique for use on larger rivers.

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APPENDIX A

Sampling gear used to collect fish
from the Little Snake River, Colorado, 1994.

Table A.1. Sampling gear used to collect fish from the Little Snake River, Colorado, 1994. Recovery Program database codes are in parentheses.

Gear	Description
<u>Seines</u>	
small seine (SU)	1.3 m X 1.3 m, 1 mm mesh
medium seine (SM)	3 m X 1.3 m, 1 mm mesh
large seine (SX)	4.5 m X 2 m, 2 mm mesh
extra large seine (SZ)	28 m X 2.3 m, 10 mm mesh
<u>Nets</u>	
experimental gillnet (GA)	12 m X 1.5 m
trammel net (TR)	34 m X 2.4 m, 0,3 m panel, 25 mm mesh 15 m X 2.4 m, 20 cm panel, 25 mm mesh
<u>Electrofishing</u>	
Boat electrofisher (EL)	5.5 m aluminum jon boat with Honda® 5000 watt, 240 volt generator, Coffelt Electronics® Model VVP-15 control box, boom mounted anodes with multiple cables and two single-cable, rear-mounted cathodes.
Backpack electrofisher (EP)	Coffelt Electronics® Model BR-3 backpack electrofisher with 12 volt battery input.
Bank electrofisher (EB)	Honda® 5000 watt, 240 volt generator, Coffelt Electronics® Model VVP-15 control box and two Model H-5, hand-held electrodes with 25.4 X 17.8 cm diamond shaped anodes.
<u>Miscellaneous</u>	
Dipnet (DN)	30.5 cm "D-ring" mouth, 1 mm mesh
Angling (AN)	worm, cricket, spoon, spinner, or dry fly
Castnet (CA)	2.4 m diameter, 6.4 mm mesh

APPENDIX B

Diel water temperatures measured hourly from the Little Snake and Yampa rivers, May - October 1994.

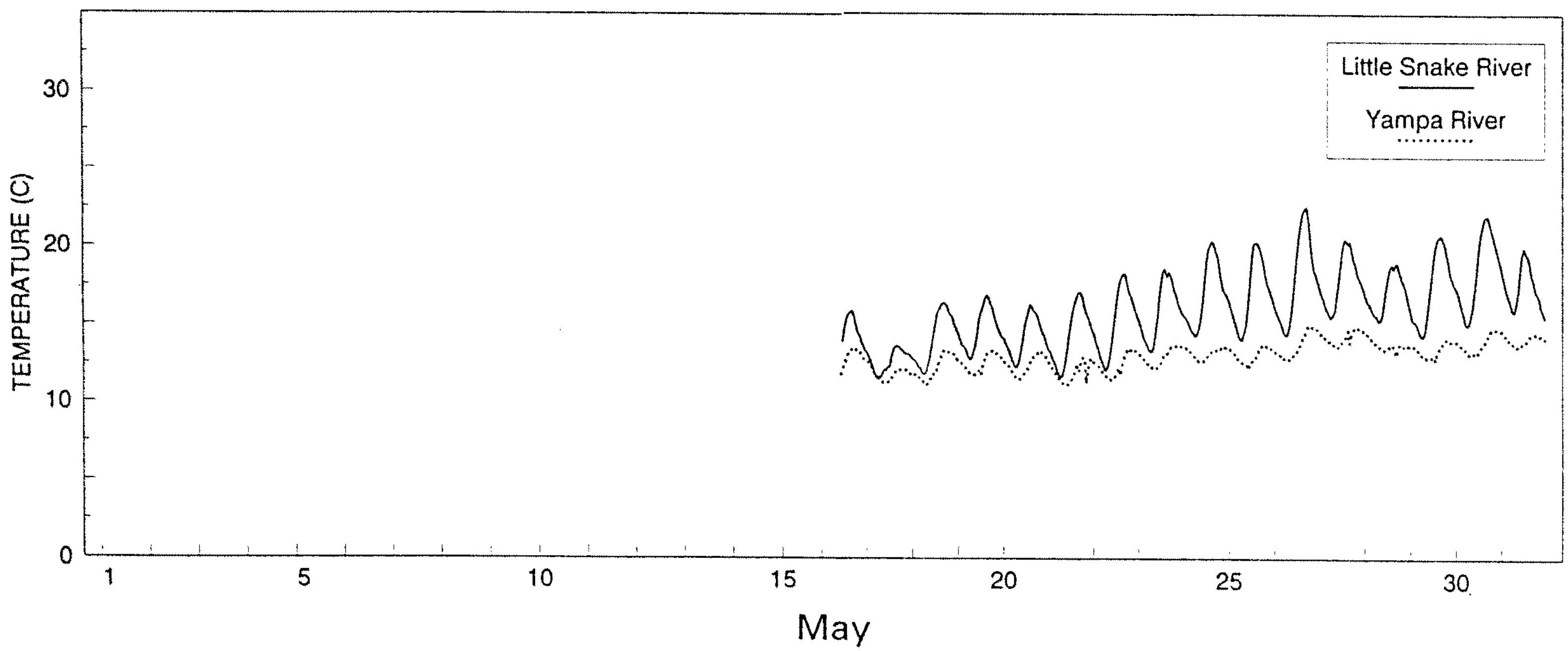

Figure B1. Diel water temperatures measured hourly from the Little Snake and Yampa rivers during May 1994.

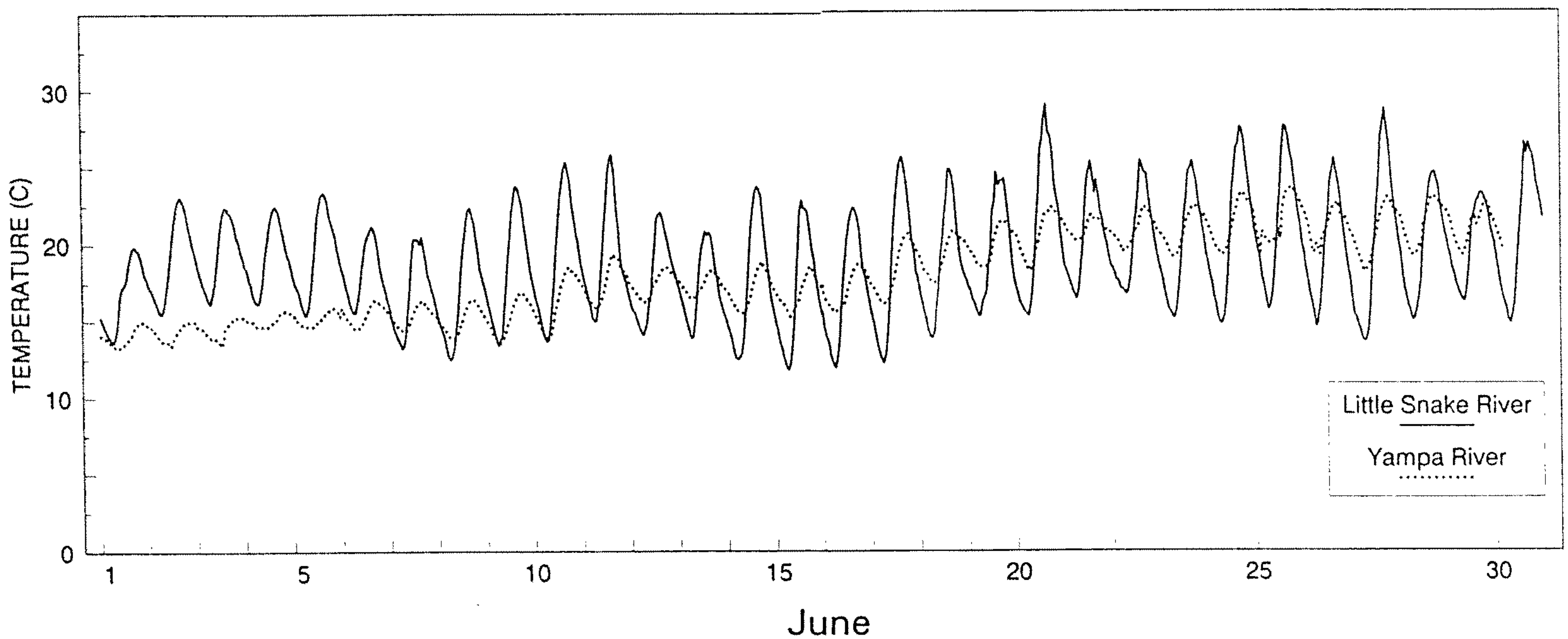

Figure B2. Diel water temperatures measured hourly from the Little Snake and Yampa rivers during June 1994.

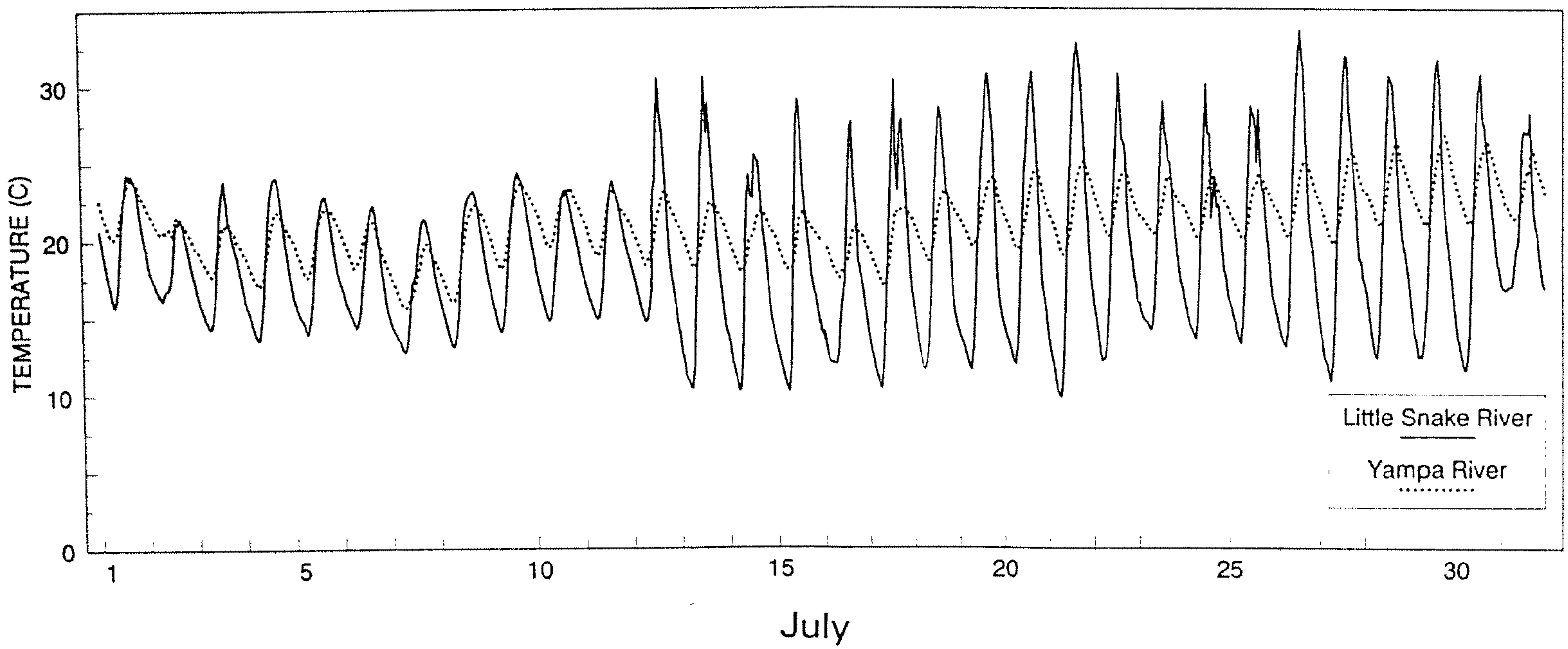

Figure B3. Diel water temperatures measured hourly from the Little Snake and Yampa rivers during July 1994.

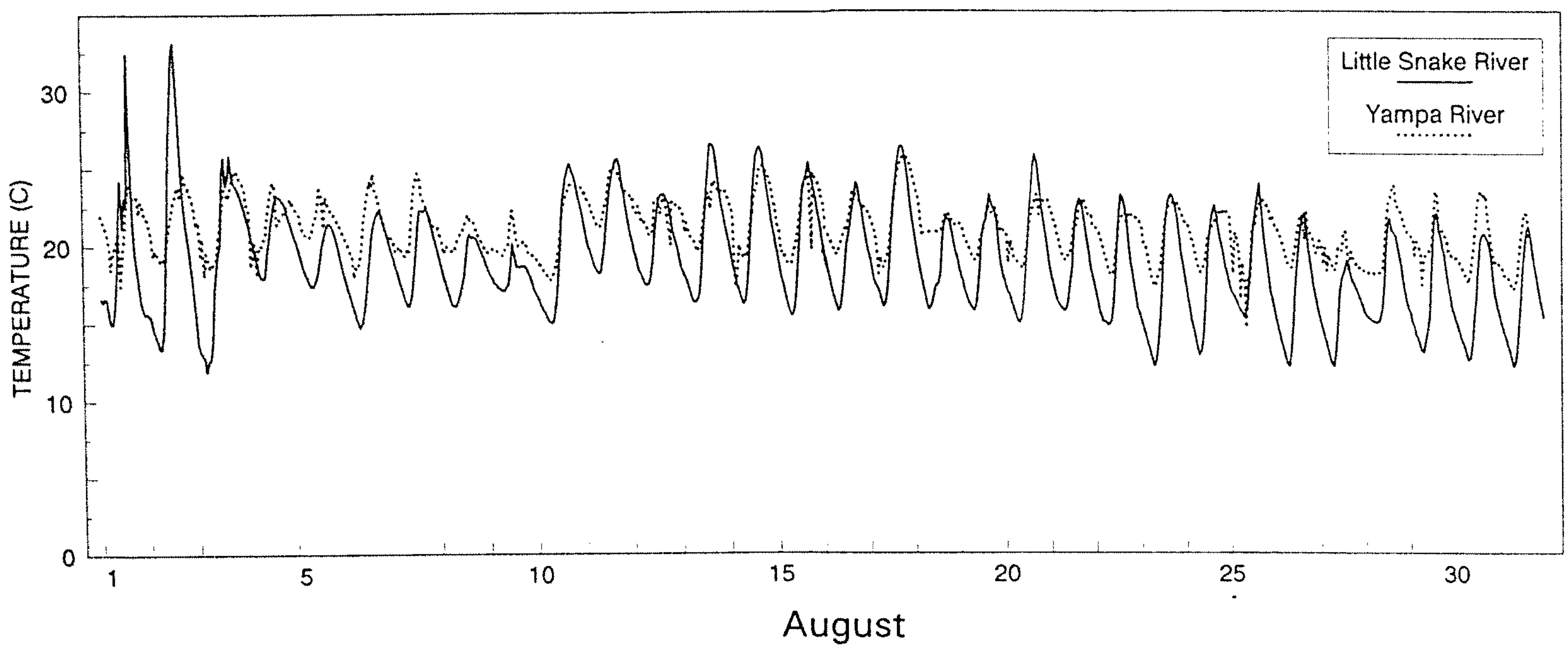

Figure B4. Diel water temperatures measured hourly from the Little Snake and Yampa rivers during August 1994.

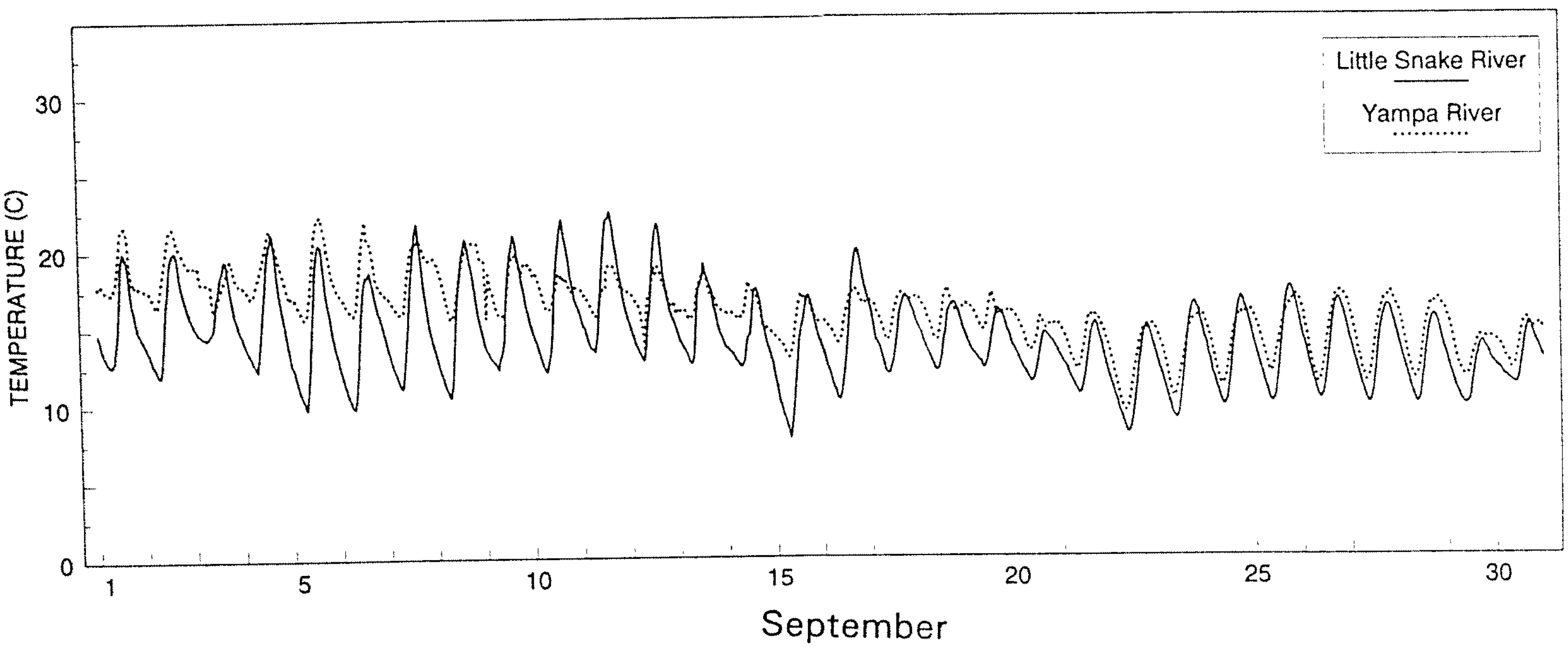

Figure B5. Diel water temperatures measured hourly from the Little Snake and Yampa rivers during September 1994.

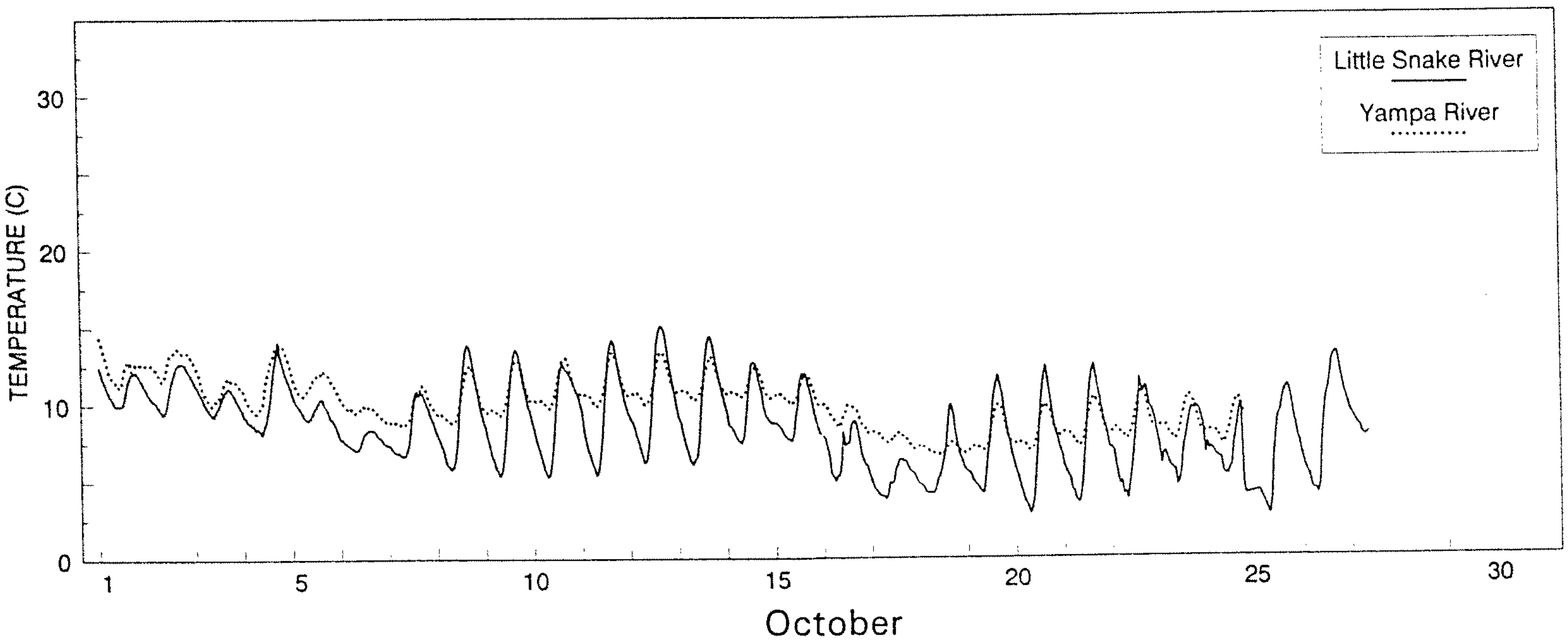

Figure B6. Diel water temperatures measured hourly from the Little Snake and Yampa rivers during October 1994.

APPENDIX C

Length-frequency of selected fishes
collected from the Little Snake River, Colorado, 1994.

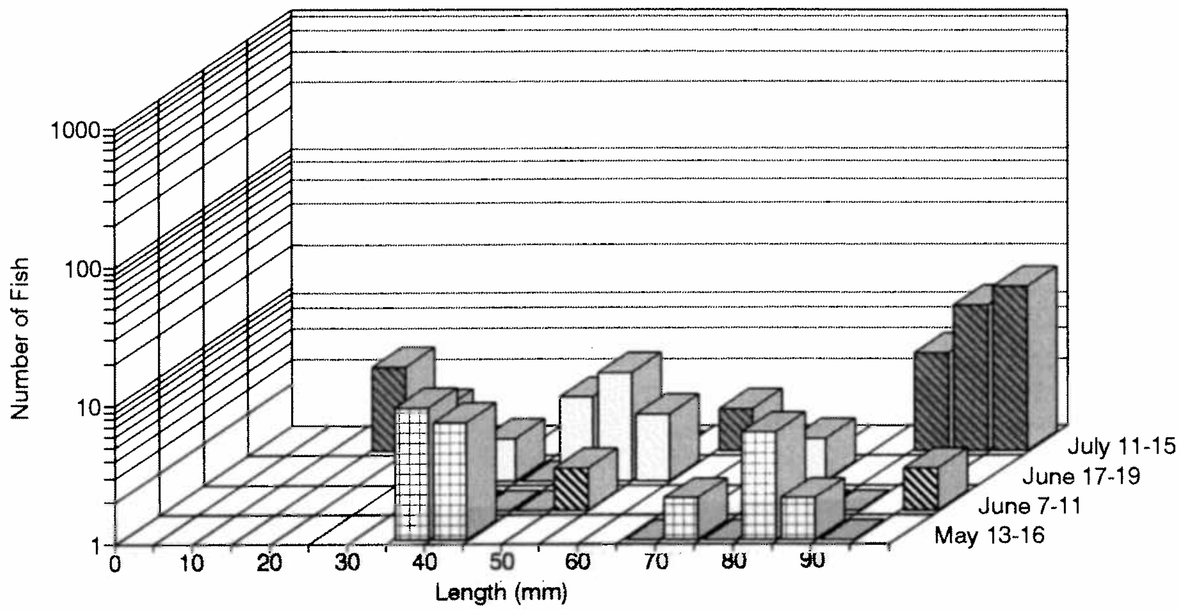

Figure C1. Length frequency of roundtail chub smaller than 100 mm total length collected from the Little Snake River, Colorado, 1994.

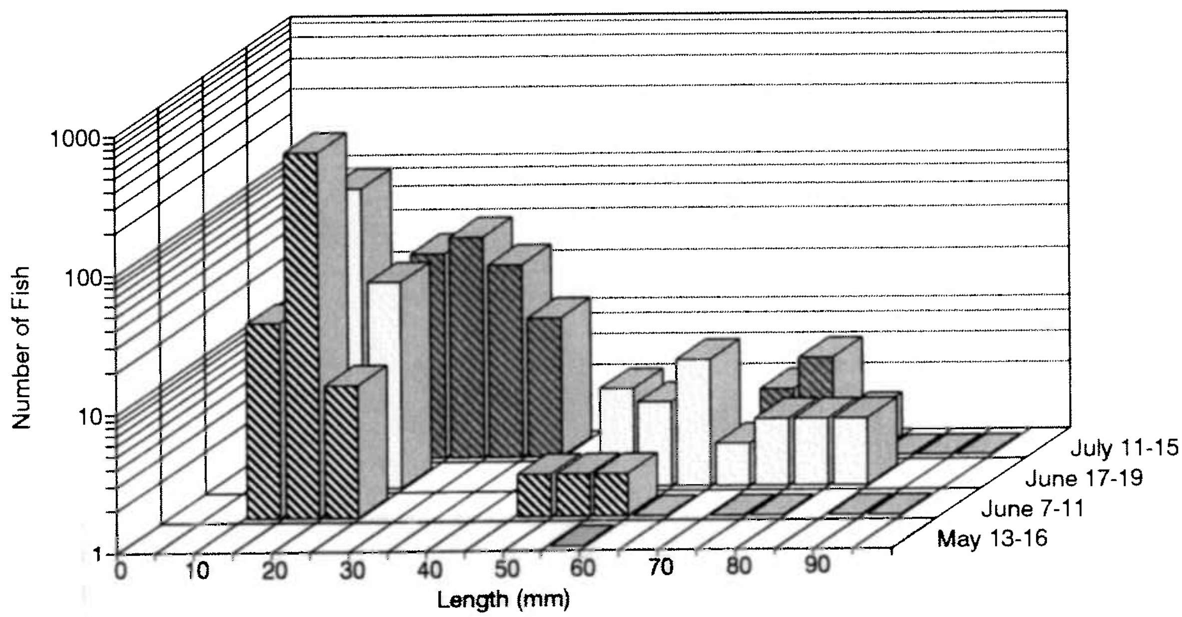

Figure C2. Length frequency of flannelmouth sucker smaller than 100 mm total length collected from the Little Snake River, Colorado, 1994.

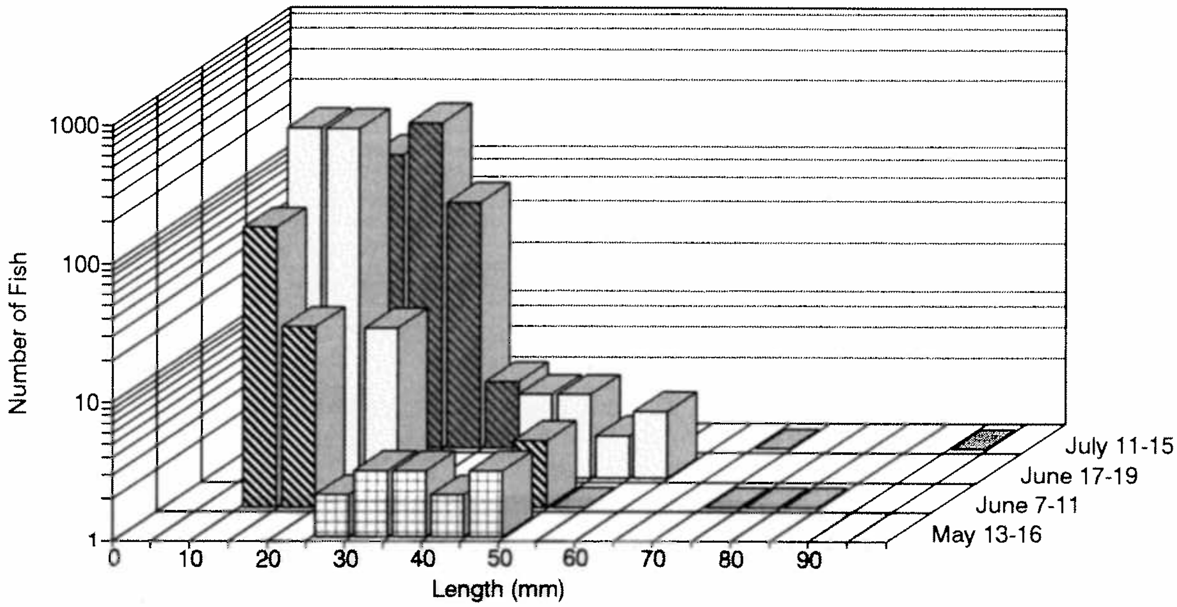

Figure C3. Length frequency of bluehead sucker smaller than 100 mm total length collected from the Little Snake River, Colorado, 1994.

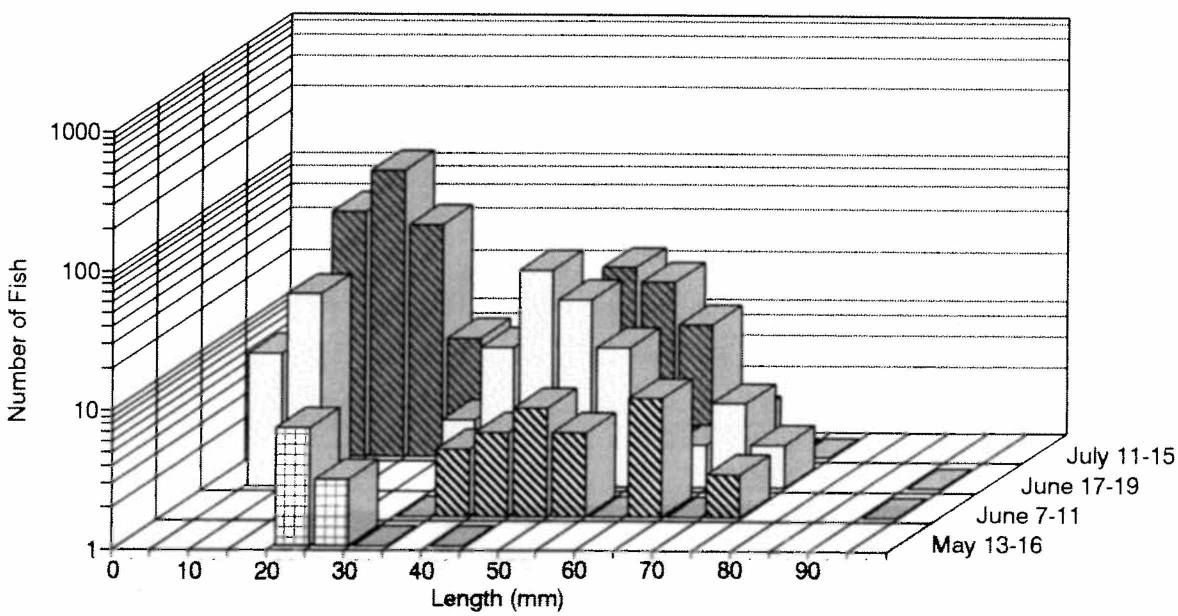

Figure C4. Length frequency of speckled dace collected from the Little Snake River, Colorado, 1994.

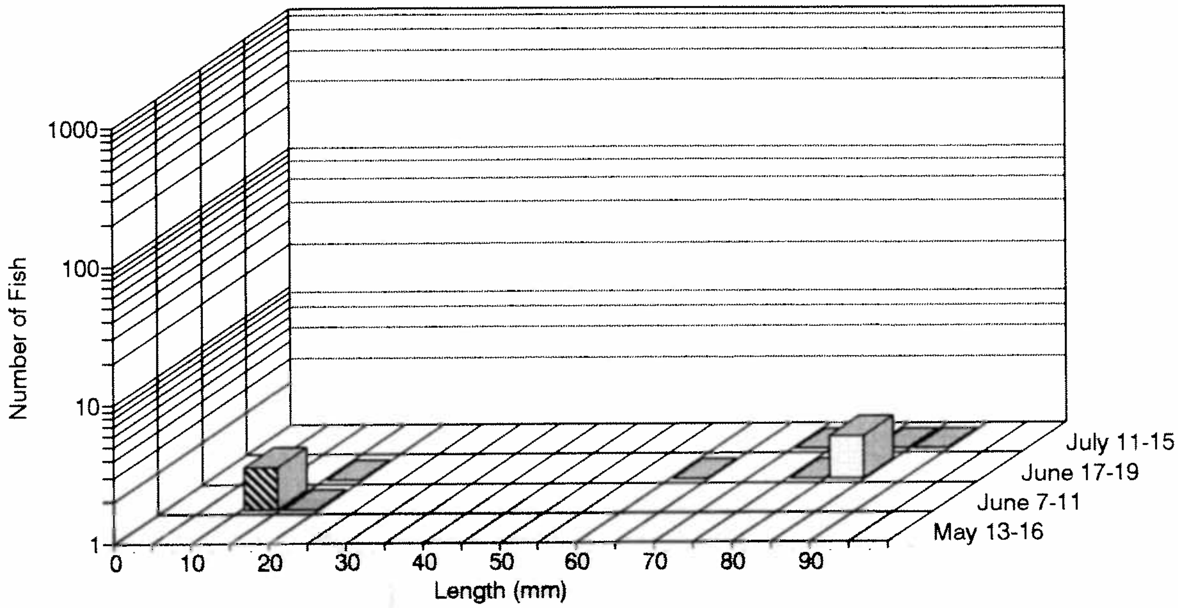

Figure C5. Length frequency of mottled sculpin collected from the Little Snake River, Colorado, 1994.

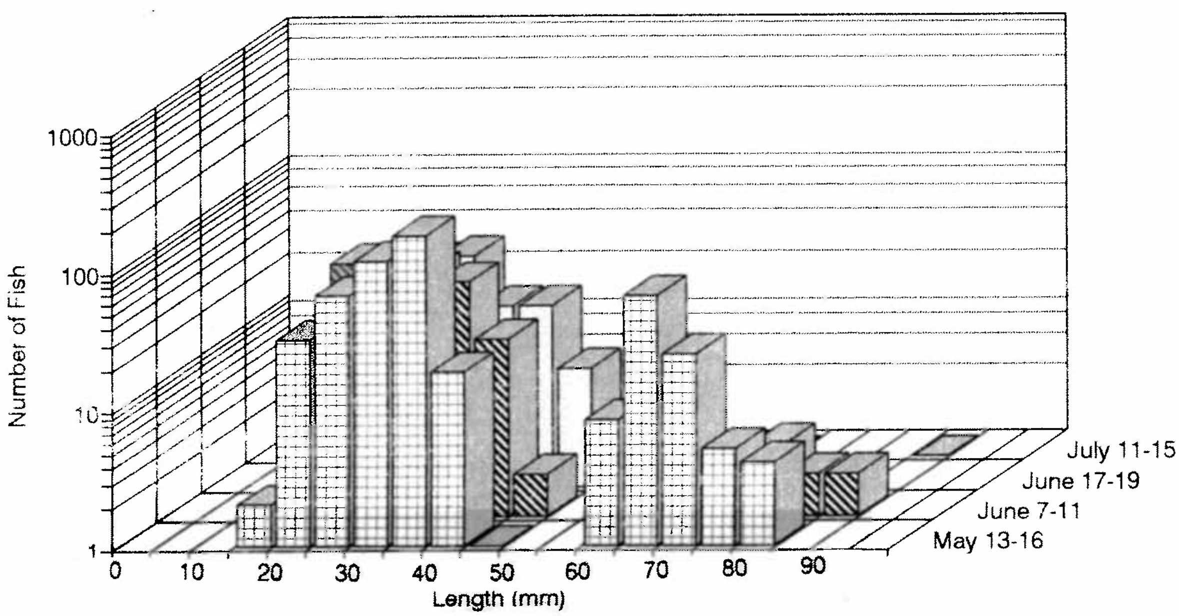

Figure C6. Length frequency of redside shiner collected from the Little Snake River, Colorado, 1994.

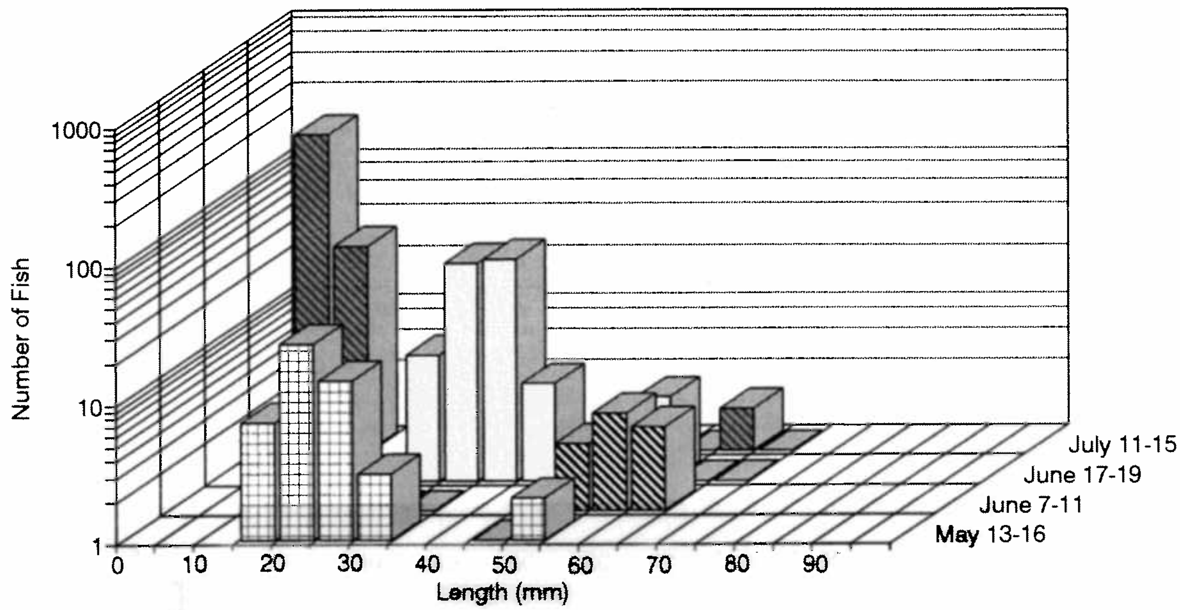

Figure C7. Length frequency of sand shiner collected from the Little Snake River, Colorado, 1994.

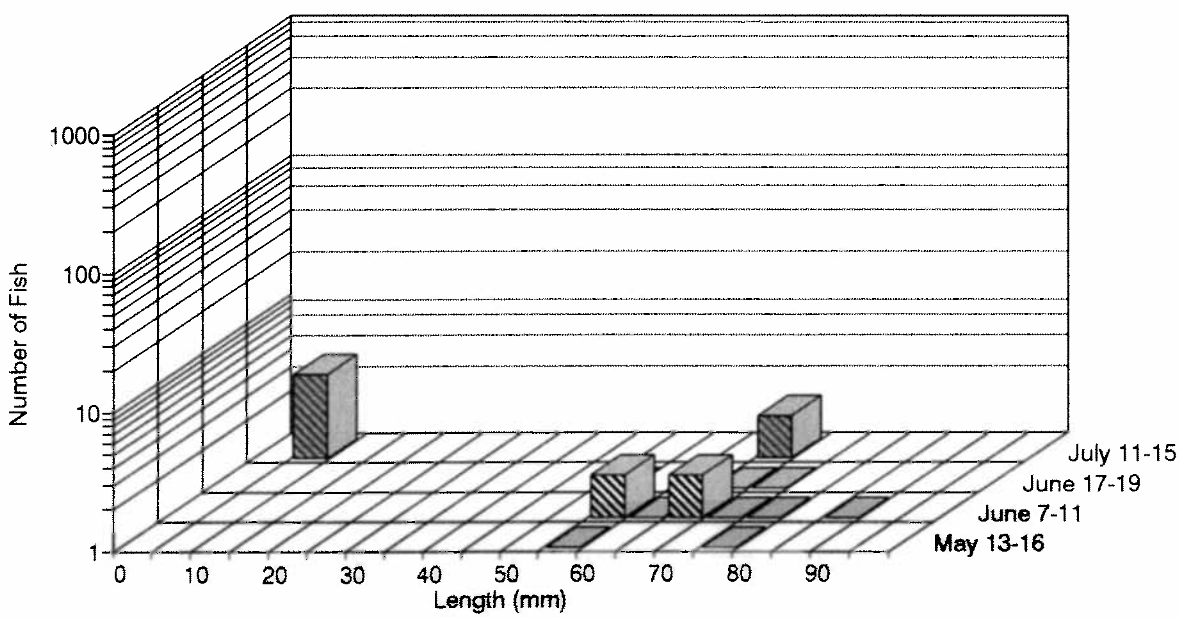

Figure C8. Length frequency of red shiner collected from the Little Snake River, Colorado, 1994.

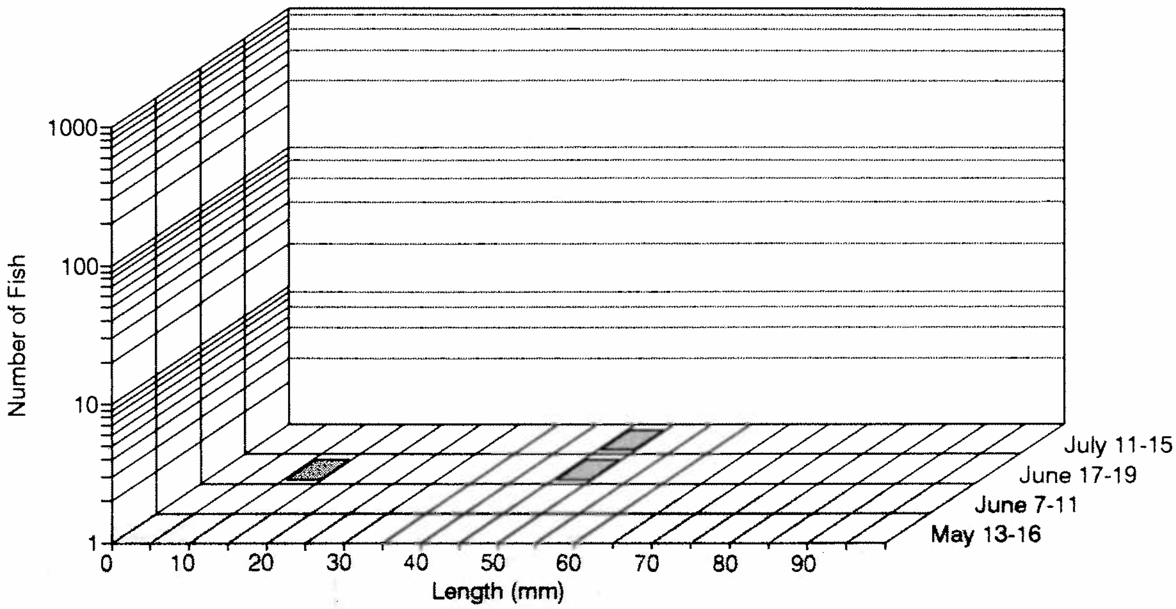

Figure C9. Length frequency of fathead minnow collected from the Little Snake River, Colorado, 1994.

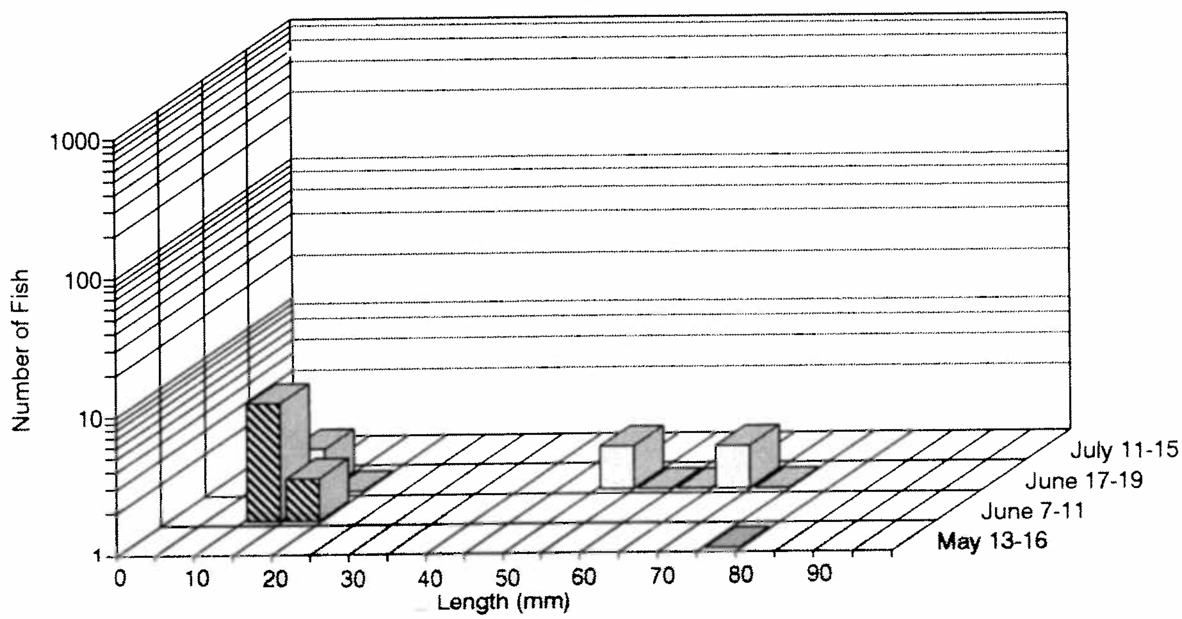

Figure C10. Length frequency of white sucker smaller than 100 mm total length collected from the Little Snake River, Colorado, 1994.

APPENDIX D

Number of fishes captured using bank electrofishing and population estimates using a four-pass, removal sampling design from a 130-m reach of the Little Snake River, Colorado, July 1994.

Table D.1. Number of fishes captured using bank electrofishing and population estimates using a four-pass, removal sampling design from a 130-m reach of the Little Snake River, Colorado, July 1994.

Species	Pass				Number	Estimated		
	1	2	3	4	Captured	Population	(95%CI)	SE
flannelmouth sucker	57	28	24	11	120	136	(127-161)	8.2515
bluehead sucker	27	20	14	9	70	89	(76-130)	12.3570
roundtail chub	8	17	10	5	40	44	(41-63)	4.5237
channel catfish	6	3	3	4	16	24	(17-91)	13.2692
white sucker	3	1	2	0	6	6	(6-6)	0.7228
common carp	3	4	2	1	10	11	(11-24)	2.2873