Ichthyofauna of the Little Snake River, Colorado, 1995 with notes on movements of humpback chub.

FINAL REPORT

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Recovery Implementation Program for the Endangered
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U. S. Fish and Wildlife Service
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Contribution 125 of the Larval Fish Laboratory

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EXECUTIVE SUMMARY

The Little Snake River, a tributary of the Yampa River in the Colorado River Basin, provides habitat for endangered Colorado pikeminnow (*Ptychocheilus lucius*) and humpback chub (*Gila cypha*). As an unregulated river, the Little Snake River, exhibits extreme hydrological conditions influenced by the geology, topography, and climate of the Southern Rocky Mountains and the arid Wyoming Basin which it drains. Effects of these hydrological conditions on the fish community are unknown but potentially important given occurrence of endangered fish and the relatively low abundance of nonnative species in the Little Snake River.

The goals of this study were to better understand the longitudinal and seasonal composition of the fish community in the Little Snake River with an emphasis on location and movements of humpback chub. Objectives included:

1. Describe longitudinal composition of the Little Snake River fish community.
2. Describe seasonal changes in composition of the Little Snake River fish community during spring, summer, and autumn.
3. Determine resident fishes in the Little Snake River.
4. Characterize location and movements of humpback chub in the Little Snake River using PIT tag recaptures and radio telemetry.
5. Determine which species reproduce in the Little Snake River using larval collections.

All objectives were achieved.

Three adult Colorado pikeminnow (510-830-mm total length) and four adult humpback chub (250- 292-mm total length) were captured in 1995 in the Little Snake River, 5.6 to 14.5 km upstream of the Yampa River. All were captured in June and July as flows were declining from snowmelt runoff. Humpback chub

were captured in high-velocity, recirculating eddies and Colorado pikeminnow were captured in eddies or shorelines. Two humpback chub were implanted with transmitters in mid-June and early July and both demonstrated fidelity to specific eddies in the Little Snake River until late July when they moved to the Yampa River. Both telemetered humpback chub moved 5.6 and 14.5 km out of the Little Snake River, into the Yampa River, and continued downstream an additional 26 and 24 km into Yampa Canyon. Total distances moved were 32 to 39 km and their final destinations were within 2 km of each other. These long-distance movements were similar to movements by humpback chub in the Grand Canyon for spawning and similar to distances that humpback chub move between population groups in Westwater Canyon, Utah and Black Rocks, Colorado in the Colorado River. Both telemetered humpback chub remained in the Little Snake River while average daily temperatures were 1-2 ^{0}C warmer than in the adjacent Yampa River. They left the Little Snake River when this relationship reversed and average daily temperatures in the Yampa River became warmer and just before flows reached baseflow levels in the Little Snake River. Humpback chub occupied the Little Snake River during their spawning period and moved a relatively long-distance if they originated in the Yampa River. These observations are significant because they support the possibility that humpback chub might be attempting to spawn in the Little Snake River. Spawning success was not confirmed by accepted methods such as the collection of spawning fish, juveniles, or larvae; although 14 larval *Gila* were collected, they were too small to use conventional morphometric characteristics to identify them to species. *Gila* larvae may require genetic analysis to confirm species identification. Spawning success of humpback chub will be difficult to detect if spawning fish are few resulting in small numbers of larvae that could quickly drift out of the Little Snake River.

Another significant finding was the scarcity of nonnative fishes in the Little Snake River. Of 11,370 fish collected, 72% were native species. The seven native species included Colorado pikeminnow, humpback chub, roundtail chub (*G. robusta*), speckled dace (*Rhinichthys osculus*), bluehead sucker (*Catostomus discobolus*), flannelmouth sucker (*C. latipinnis*), and mottled sculpin (*Cottus bairdi*). The nine nonnative species included red shiner (*Cyprinella lutrensis*), common carp (*Cyprinus carpio*), fathead minnow (*Pimephales promelas*), redside shiner (*Richardsonius balteatus*), sand shiner (*Notropis stramineus*), white sucker (*C. commersoni*), creek chub (*Semotilus atromaculatus*), plains killifish (*Fundulus zebrinus*), and channel catfish (*Ictalurus punctatus*).

Large-bodied species (adult size $\geq$ 200-mm total length) were largely composed (93%) of native flannelmouth sucker, bluehead sucker, and roundtail chub. Percent composition of all large-bodied species remained relatively constant among longitudinal reaches and among seasons. Small-bodied species (adult size $<$ 200-mm total length) were predominately (72%) nonnative sand shiner, redside shiner, and red shiner. The other 28% were native speckled dace and mottled sculpin. Percent composition of small-bodied species was relatively constant in all seasons except redside shiner percentages declined in autumn and redside shiner and red shiner percentages varied by reach.

Larvae were collected for four native species: bluehead sucker, flannelmouth sucker, roundtail chub, and speckled dace and five nonnative species: white sucker, sand shiner, red shiner, fathead minnow, and redside shiner. Larvae of native species were the most frequently collected larvae of both small-bodied (85%) and large-bodied species (97%).

The reasons for rarity of nonnative fishes in the Little Snake River compared to other Upper Colorado River Basin rivers are unknown but regulating factors may include extremely low baseflow, sediment laden spates during baseflow, high suspended sediment load, or high amplitude of diel water temperatures during baseflow. Understanding the relationship of these physico-chemical extremes and fish community structure would assist in perpetuating native fish assemblages in western river systems. Based on our results we recommend:

1. Identify and maintain the discharge and physico-chemical conditions in the Little Snake River that support Colorado pikeminnow, humpback chub, and a mostly native fish community. These conditions might include the timing, magnitude, and pattern of runoff and baseflow and associated physico-chemical conditions such as turbidity, diel temperature fluctuations, or sediment load.
2. Better describe the migrations and interactions of humpback chub between the Little Snake and Yampa rivers, possibly through intensive telemetry studies.
3. Identify spawning sites for humpback chub that reside in the Yampa River and Little Snake River.
4. Include humpback chub and Colorado pikeminnow that reside in the Little Snake River with Yampa River abundance estimates.

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

INTRODUCTION

The Little Snake River is a small, unregulated tributary in the Upper Colorado River Basin in Wyoming and Colorado. As an unregulated river, it contributes important components of flow and sediment to the Yampa and Green rivers (Andrews 1978; O'Brien 1987). Most tributaries, like the Little Snake River, have received little research attention and therefore the role of tributaries as habitat for endangered and native fishes is poorly understood. Previous sampling in the Little Snake River focused on the area near the confluence with the Yampa River (Miller et al.1982; Wick et al. 1991), although Hawkins et al. (1997) sampled sites 100-km upstream of the confluence. Endangered Colorado pikeminnow (*Ptychocheilus lucius*) and humpback chub (*Gila cypha*) move into the Little Snake River from the adjacent Yampa River (Miller et al.1982; Karp and Tyus 1990; Tyus 1990; Marsh et al. 1991; Wick et al. 1989 and 1991, Hawkins et al. 1997). But the intent and duration of their use of the Little Snake River was uncertain due to limited sampling. Primary questions were whether humpback chub are year-round residents in the Little Snake River or migrants from another location and, if migrants, then from where do they originate?

The goals of this study were to better understand the longitudinal and seasonal composition of the fish community of the Little Snake River with an emphasis on locations and movements of humpback chub. Our objectives were to:

1. Describe longitudinal composition of the Little Snake River fish community.
2. Describe seasonal changes in composition of the Little Snake River fish community during spring, summer, and autumn.
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4. Characterize location and movements of humpback chub in the Little Snake River using PIT tag recaptures and radio telemetry.
5. Determine which species reproduce in the Little Snake River using larval collections.

STUDY AREA

Headwaters of the Little Snake River originate in northwestern Colorado and south-central Wyoming and drain portions of two very different physiographic provinces, the Southern Rocky Mountains and the arid Wyoming Basin. These drainages influence form and function of downstream fish habitat. Within Colorado, we divided the Little Snake River into three major reaches distinguished by topography, geology, gradient, and predominant substrate types. In each reach, we sampled an 8-km site that was also sampled by Hawkins et al. (1997) Locations were identified by their distance in river kilometers (RK) from the Yampa River. A description of each site and reach follows (Figure 1).

From the state line at RK 160 to RK 80 (upper reach) the river contains riffle-pool sequences with mostly gravel and cobble substrate that provide diverse fish habitat. During runoff, riffles, pools, and eddies were common as were large, deep refugia pools at base flow. The specific fish sampling site was near Moffat County Road-147 between RK 103 and RK 95.

The river continues through a broad, unconfined channel with low gradient and mostly sand substrate in the middle reach from RK 80 to RK 15. Diversity of fish habitat in this reach was low at all water levels. During runoff, fish habitat was mostly homogeneous runs with few eddies. During baseflow, fish habitat was marginal or non-existent because flow dispersed through the broad, sand bed. The specific fish sampling site in this reach was between RK 69 and RK 61 near Moffat County Road-26.

The lower reach was from RK 15 to RK 0. At RK 15, the river enters a 5.5 km-long, bedrock canyon that constricts the channel, increases gradient, and produces large boulder and cobble substrate. At higher discharge, deep, turbulent eddies were present and during baseflow these same areas became deep, low-velocity, refugia pools. The remaining 9.5 km was braided, low velocity, and mostly sand substrate and greatly influenced by the stage height of the Yampa River. The specific fish sampling site was between RK 15 and RK 7. The confluence of the Yampa and Little Snake rivers is at Yampa River RK 80.8 or 80.8 km upstream from the Green River confluence.

METHODS

Discharge, water temperature, and water quality

Discharge records during the sampling period were obtained from U.S. Geological Survey gaging station, named "near Lily, Colorado", #09260000 at RK 15 (Crowfoot et al. 1996). Water quality was measured on four occasions during runoff and baseflow. Conductivity was measured with a Cole Parmer®, model TDSTestr 3 meter (range 1-1990 μS), pH with a Cole Parmer®, model pHTestr 2 meter, total hardness with a HACH® model HA-DT test kit, alkalinity with a HACH® model AL-DT test kit, dissolved oxygen with a HACH® model AL-DT test kit using a modified Winkler titration method, and light penetration with Secchi disk.

Water temperature was collected hourly by Ryan data loggers on the Little Snake River at RK 15 from May 5 through October 28 and on the Yampa River at Moffat County Road-25 bridge, 2.5 km upstream of the Little Snake River confluence, from May 5 through October 1. Loggers were checked bi-weekly to insure they remained submerged as water levels dropped.

Fish community sampling

Fish were collected on six occasions from May 16 to October 1, 1995 using techniques similar to those employed the previous year (Hawkins et al. 1997). Sampling occurred in the spring and summer during the ascending and descending limbs of runoff and in autumn during base flow. Sample dates were May 15-18, June 1-6, June 21-23, July 1-7, July 16-18, and September 27- October 1 (Figure 2). Sampling gear and methods targeted larvae, juveniles, and adults of both large- and small-bodied fish and varied depending on river access, discharge, habitat, and human safety. Small fish including larvae were collected with seines and dipnets and large fish were collected with seines, trammel nets, hoop nets, angling, and boat- and bank-electrofishing (Table 1). Trammel nets were set in eddies along the eddy-run interface and cleared of fish every 30 minutes. Angling employed baited hooks (worms or crickets), dry-flies, and spoon-type lures. Seines and dipnets were used to sample near-shore areas and backwaters. Angling , hoop net, and trammel net sampling occurred almost exclusively in the lower reach in an attempt to capture rare, endangered fishes for tagging (Table 2). Trammel and hoop nets were not used in the middle reach because of a lack of sites of suitable depth. Boat electrofishing was minimal in the middle and upper reaches because shallow riffles restricted movement.

Fish were grouped as either small-bodied or large-bodied species based on the approximate length at which they become adults. Large-bodied species were those that reach the adult stage at lengths $\geq$200 mm; small-bodied species were those that reach the adult stage at lengths $<$200 mm. Percent composition at each site and in each season was calculated separately for small- and large-bodied fish. For each species, individuals were also partitioned as larvae, juveniles, or adults based on size and morphological development (Table 3).

As part of fish community assessments during baseflow, we intensively sampled two, low-flow, refugia pools with bank electrofishing duplicating techniques and the same site sampled in 1994 (Hawkins et al. 1997). Baseflow sampling included a pool at the upper site (RK 102.2) sampled on September 28 at a discharge of 3.2 m^3/sec and another pool at the lower site (RK 5.6) sampled on October 1 at a discharge of 4.8 m^3/sec. The upstream site was 130-m long, 23-m wide, with an average depth of 0.8 m and the downstream site was 100-m long and 40 m at its greatest width with 1.3-m maximum depth and each pool was similar to other baseflow refugia pools in each reach. Each pool was isolated with block nets at up- and downstream margins to prevent fish escapement and only fish longer than 90 mm were captured due to the dipnet mesh size. We sampled each site by depletion with four electrofishing passes. Time required for successive pass was 60 min, 40 min, 40 min, and 30 min at the upstream site and 30 min, 25 min, 25 min, and 20 min at the downstream site, but the area of each site was uniformly covered on each sample pass and subsequent passes required less time due to decreasing number of fish captured and handled. If an adequate number of individuals of a species were captured, then abundance estimates were calculated for each pool using removal model Mbh (White et al. 1982). Results from depletion sampling were compared with those using other techniques in all reaches and with results using similar techniques at the same upper site in 1994.

Spawning by a particular species within the Little Snake River was confirmed by collection of larvae. Fish of uncertain identity were anaesthetized and overdosed with tricaine (trade name Finquel®) and preserved in 10% formalin. Preserved specimens were later transferred to 3% buffered formalin, identified, and cataloged at the Larval Fish Laboratory, Colorado State University under catalog numbers LFL-72444 - LFL-73992. Juvenile and adult *Gila* species were identified as humpback chub or roundtail chub (*G. robusta*) based on meristic and morphometric characters described by Snyder (1981) and Douglas et al. (1989). Small specimens of *Gila* less than 50-mm total length were preserved and identified at the Larval Fish Laboratory.

Telemetry of humpback and roundtail chub

Humpback and roundtail chub were surgically implanted with radio transmitters to determine their movements within the Little Snake River and between the Little Snake and Yampa rivers. Anesthesia and surgical techniques followed procedures of Summerfelt and Smith (1990). Transmitters were 40 MHz, weighed 2.0 g, had a thin, wire antenna, and a life expectancy of 90 days. Fish were sedated and anesthetized for surgery with a treatment bath of river water mixed with a stock solution of tricaine (200 mg/L). The dilute, acidic solution was buffered with 200 to 250 mg sodium bicarbonate ($NaHCO_2$) per 100-mg tricaine to maintain blood pH and reduce respiratory stress (Summerfelt and Smith 1990). Surgical tools and transmitter were disinfected with benzalkonium chloride (Zepharin chloride, diluted 1:128) and rinsed in sterile saline solution prior to implantation.

Anesthesia was maintained during surgery with a dilute, buffered tricaine solution (1 mg/L) in river water flushed over the gills. A 3-cm incision was made along the ventral surface, anterior to the pelvic girdle and slightly lateral to the midline. The transmitter and antenna were inserted into the body cavity and the wire antenna looped along the posterior margin of the body cavity. Suture material was 90-day absorbable monofilament. Post-surgical recovery occurred in fresh water with a 5 to 10 mg/L solution of stockman's salt (NaCl) to restore osmotic balance. Fish were held until they regained orientation and muscular control and then they were released at site of capture.

We searched for telemetered fish every other week by boat or from shore in June and July and by fixed-wing aircraft in August and September. Each search started at the last known fish location. Once a fish was contacted from shore, its specific location was triangulated from at least three locations on shore and fish activity was monitored for 1 to 5 hours. Locations via aircraft were estimated based on signal strength and not triangulation.

RESULTS

Discharge, water temperature, and water quality

During the 1995 water year, annual runoff volume in the Little Snake River was 617,500 acre feet (Crowfoot et al. 1996). Winter baseflow prior to runoff was 2 to 3 m^3/sec from October through January. Runoff peaked at 165 m^3/sec on June 8 and decreased rapidly to a base flow that ranged from 1 to 2 m^3/sec from early-August through September (Figure 2). Localized rain events in September caused three spates that temporarily increased discharge from base flow to about 4 m^3/sec and another spate that increased discharge to 13 m^3/sec.

Water temperatures were probably influenced by water volume, ambient temperature, and size and morphology of the river channel upstream. Daily water temperatures was calculated as the arithmetic mean of 24, hourly temperatures. In both the Little Snake and Yampa rivers, daily temperatures generally followed a similar pattern of warming from May through August during runoff and baseflow, followed by cooling in late September (Figure 3). Daily temperatures were similar for both rivers during the last two weeks of May, but in June and July, daily temperatures in the Little Snake River were warmer than those in the Yampa River. In June, mean daily water temperature in the Little Snake River was 14 ^{0}C (s=1.9477) and one degree warmer than temperatures in the Yampa River (0=13 ^{0}C, s=1.5201) and in July, the Little Snake River (0=19 ^{0}C, s=1.8141) was two degrees warmer than the Yampa River (0=17.2 ^{0}C, s=2.1442). By August, this relationship reversed and the Little Snake River (0 = 19.8 ^{0}C, s=0.7176) was two degrees cooler than the Yampa River (0 = 21.4 ^{0}C, s=1.0928). The Little Snake River remained about two degrees cooler (0 = 14.8 ^{0}C, s=3.1443) than the Yampa River (0 = 16.7 ^{0}C, s=3.6399) through

September when measurements in the Yampa River ceased. Daily water temperatures peaked at 21 ^{0}C in the Little Snake River on July 10 and at 23 ^{0}C in the Yampa River on September 22; although highest hourly temperature in the Little Snake River was 26 ^{0}C on July 28 and in the Yampa River was 25 ^{0}C on September 3. Generally the Little Snake River warmed earlier, in June and July, and the Yampa River warmed later, in August and September (Figure 3).

Water temperature differences between the two rivers were best revealed in hourly measurements. Although both rivers experienced a similar diel cycle that ranged from daily low temperature just before sunrise to a daily high temperature by mid-afternoon, the Little Snake River experienced a greater range of diel temperatures than the Yampa River. In June the average range of daily fluctuation was 2.4 ^{0}C (s=0.5684) in the Little Snake River and 1.8 ^{0}C (s=0.5630) in the Yampa River. In July mean daily fluctuation ranged 5.4 ^{0}C (s=2.0328) in the Little Snake River and 2.7 ^{0}C (s=1.5719) in the Yampa River . The difference between the two rivers was most noticeable in August when the range of daily fluctuation averaged 9.1 ^{0}C (s=3.4760) in the Little Snake River and 3.2 ^{0}C (s=1.6242) in the Yampa River (Figures 4 and 5). Maximum single day fluctuation was 15.5 ^{0}C on August 19 in the Little Snake River and 11.5 ^{0}C on August 1 in the Yampa River.

The two rivers also had differences in maximum and minimum temperatures on any given day. Maximum temperatures in the Little Snake River exceeded maximum temperatures in the Yampa River on a daily basis from mid-May through mid-August (Figures 4 and 5). During June and the first half of July, minimum temperatures in the Little Snake River were usually warmer than minimum Yampa River temperatures and on several days, minimum Little Snake River temperatures even exceeded maximum Yampa River temperatures. After July 19, minimum temperatures in the Little Snake River declined and were cooler than minimum temperatures in the Yampa River, while maximum daily temperatures remained higher in the Little Snake River. This pattern of Little Snake River temperatures fluctuating higher and lower than Yampa River temperatures continued until mid-August when maximum daily temperatures in the Little Snake River dropped to levels cooler than maximum temperatures in the Yampa River. By mid-August, Little Snake River maximum daily temperatures also dropped below maximums in the Yampa River.

Water quality parameters were relatively constant on three sampling occasions in May and June during runoff but conductivity, hardness, alkalinity and secchi depth increased and dissolved oxygen declined in September during baseflow (Table 4).

Fish community sampling

Nine nonnative and seven native fish species were collected including endangered Colorado pikeminnow and humpback chub. Native fishes were more abundant and widespread than nonnative fishes. Of the 11,370 fish collected, including larvae, juveniles, and adults combined, 72% were native species composed of 43% flannelmouth sucker (*Catostomus latipinnis*) , 16% speckled dace (*Rhinichthys osculus*), 10% bluehead sucker (*C. discobolus*), 3%, roundtail chub, and less than 1% of humpback chub, Colorado pikeminnow, and mottled sculpin combined (Table 5). Nonnative species were composed of 18% sand shiner (*Notropis stramineus*), 5% redside shiner (*Richardsonius balteatus*), 2% red shiner (*Cyprinella lutrensis*) 1% fathead minnow (*Pimephales promelas*), 1% white sucker (*C. commersoni*) and less than 1% each of common carp (*Cyprinus carpio*), channel catfish (*Ictalurus punctatus*), creek chub (*Semotilus atromaculatus*) and plains killifish (*Fundulus zebrinus*). Number of larvae captured (n = 5842) was about equal to number of juveniles and adults combined (n = 5528).

Four humpback chub (250 - 292-mm total length) were captured from RK 5.6-14.5 in the Little Snake River in June and July (Table 6). One of these fish was subsequently recaptured on two additional occasions in the Little Snake River. All were captured in eddies by either trammel net or angling with Mormon cricket (*Anabrus simplex*) bait. Two humpback chub were captured together from an eddy at RK 13.2 and a Colorado pikeminnow was also captured from this same eddy 2 weeks earlier. Although all four humpback chub were large enough to be sexually mature (Gorman and Stone 1997), none of the humpback chub had tubercles or other secondary sexual characteristics when captured.

Three adult Colorado pikeminnow (510 - 830-mm total length) were captured from RK 9.2-14 in the Little Snake River in June and July (Table 6). Two Colorado pikeminnow were captured in eddies by electrofishing boat or trammel net and one was captured from a low-velocity shoreline by angling with a Mormon cricket. None of the Colorado pikeminnow had tubercles or other secondary sexual characteristics.

Larval fish were collected in the Little Snake River only during descending runoff and baseflow periods and comprised only four large-bodied and five small-bodied species (Table 7). Most taxa were native. Bluehead sucker and flannelmouth sucker composed 97% of all larvae of large-bodied species and native speckled dace composed 85% of all larvae of small-bodied species. Sand shiner, were the most abundant nonnative larvae collected, but still composed only 8% of all larvae. Red shiner, fathead minnow, and redside shiner each composed only a small portion (#3%) of larvae collected. Even though seining effort was relatively equal among sites (0 = 553 m^2, Table 2), most larvae (n = 5809) were collected from the lower reach while only 33 larvae were collected from the middle and upper reaches combined. All *Gila* spp. less than 55-mm total length, including larvae, were preserved and identified in the laboratory (n = 234) except for eight juveniles that were identified and released in the field. All juveniles returned to the laboratory were subsequently identified as roundtail chub and all larvae (n = 14) were identified only to genus because there were no suitable diagnostic morphometric or meristic characteristics to separate small, larval, humpback chub from roundtail chub. Thirteen of the *Gila* larvae were between 12 and 16-mm total length and one was 24-mm total length.

Sixteen species were captured in the juvenile or adult life stage, including eight large-bodied species and eight small-bodied species. Three native species, flannelmouth sucker, bluehead sucker, and roundtail chub composed 93% of all large-bodied species collected. Relative abundance of these three species was relatively constant in all reaches and seasons (Tables 8 and 9), except that from spring to autumn, flannelmouth sucker abundance decreased and bluehead sucker abundance increased (Table 8). Nonnative channel catfish, white sucker, and common carp were few and together represented only 7% of the large-bodied taxa. Native Colorado pikeminnow, humpback chub, and flannelmouth sucker hybrids were extremely rare and composed less than 1% of the remaining large-bodied taxa (Tables 8 and 9). Native fishes generally included all life stages and were represented by a wide range of lengths (Table 5 and Figure 6). Nonnative fishes generally included only some life stages and were limited to disjunct, mostly larger length-groups (Table 5 and Figure 7).

During baseflow, 248 large-bodied fish were estimated to reside in the upper-site, low-flow pool, representing three native and two nonnative species

(Table 10). Native species included flannelmouth sucker (39%), bluehead sucker (39%), and roundtail chub (12%) and composed 90% of the estimated fish community. Nonnative species included only white sucker (4%) and common carp (6%). At the lower-site, 61 fish were estimated to reside in the baseflow pool including the same species captured at the upper site with the addition of channel catfish which were not present in the upper-site pool. We were unable to calculate an abundance estimate for all species in the lower-site pool because too few fish were captured on each sampling occasion, so abundance was calculated as the sum of all individuals captured of those species. Native species outnumbered nonnatives and composed 75% of the 61 fish estimated to reside in the lower-site pool(Table 10).

In all seasons and reaches combined, six of the eight small-bodied species collected were nonnatives and three nonnatives; sand shiner, redside shiner, and red shiner; composed 70% of all small-bodied species collected (Table 8). Red shiner, fathead minnow, and plains killifish while rare or absent in spring collections. Native species included speckled dace (28%) and mottled sculpin (0.2%). Only sand shiner, speckled dace, and redside shiner were consistently collected in all reaches and seasons. Seasonal changes in abundance were most apparent with redside shiner which decreased in abundance from 49% in spring to 5% in autumn (Table 8). Changes in relative abundance of small-bodied species were most apparent among reaches. Redside shiner abundance decreased in downstream reaches, while sand shiner and red shiner abundance increased in downstream reaches (Table 9). Other species were collected in low numbers in all reaches. Mottled sculpin were rarely collected in all reaches and seasons probably because they live in riffles which were not frequently sampled. Other small-bodied fishes and including nonnative fathead minnow, plains killifish, and creek chub were rare in all samples.

Telemetry of humpback and roundtail chub

Two of the four humpback chub captured in the Little Snake River were implanted with transmitters (Table 6). One humpback chub was captured in an eddy at RK 14.5 and implanted with a transmitter (40.680 MHz) on June 21. It occupied the Little Snake River for at least 28 days until our last ground contact on July 18. The fish maintained a high fidelity to the site of capture. During the first two weeks, we detected no movement away from the original eddy, although we did observe localized movements of the fish within the eddy. In early July, the fish moved 1-km downstream to an eddy in the canyon and then returned to RK 14.5 within three days. In mid-July this fish was located in an eddy at RK 13.2 in the canyon where it remained during our last three days of ground contact (Table 11). In addition to telemetry contacts, this fish was recaptured twice, once by trammel net and once by angling with a live cricket. The fish was in good health on both occasions and by the second recapture, 25 days after surgery, its incision was completely healed (Table 6). This fish was last observed in the Little Snake River on July 18 in run habitat at RK 13.2. Subsequent searches on July 26 could not locate the fish in the Little Snake River; however, it was located by airplane on August 9 in the Yampa River at RK 59. It had moved 14.5 km downstream from its original capture location in the Little Snake River to the Yampa River confluence and then downstream an additional 24 km into Yampa Canyon for a total distance of about 39 km.

The other telemetered humpback chub was captured in an eddy at RK 5.6 in the Little Snake River and implanted with a transmitter (40.680 MHz) on July 6. This fish also showed fidelity to the site of capture. The fish occupied the same eddy on all four occasions until our last ground contact in the Little Snake River on July 26. During most contacts the fish was actively moving within the eddy. It was located twice again by airplane in the Yampa River; on August 9 near RK 66 and on September 26 near RK 57 (Table 11). This humpback chub moved a distance of 32 km from its capture location in the Little Snake River to its final location in the Yampa River, including 5.6 km downstream in the Little Snake River to the confluence and 26 km downstream in the Yampa River. The final location of this fish (RK 57) was only 2 km from the other telemetered humpback chub that was at RK 59 in the Yampa River.

Two humpback chub were not implanted with transmitters because they were in poor condition and because one was also captured too late in the season. Based on length-weight relationships developed for Grand Canyon humpback chub in 1990 and 1991 (log weight = -5.324 + 3.117 log total length, R^2 = 0.99) by Valdez and Ryel (1995), the humpback chub that was 292-mm total length and 140 grams was only 61% of expected weight for similar-sized individuals. The other humpback chub that was 268-mm total length and 154 grams was 87% of expected weight. In addition to being in poor condition, this fish was caught on the last sampling trip and we decided not to implant it because it would not receive additional ground-based monitoring. Relative weights of the two humpback chub that were implanted were 99-100% of expected weight.

One roundtail chub was implanted with a transmitter (40.670 MHz) in the Little Snake River at RK 9.5 on July 17. It was not found during a telemetry search of the Little Snake River on July 26, but was found on August 9 near RK 85 in the Yampa River, about 5-km upstream of the Little Snake River confluence. On September 26 it was near RK 82 on the Yampa River, about 1-km upstream of the Little Snake River confluence. It moved a total of about 10 km from its release location in the Little Snake River.

Telemetered humpback chub occupied the Little Snake River from mid-June until either early or late-July when flows ranged from 19 to 93 m^3/s and were generally declining from the peak of 165 m^3/s (Figure 2). During occupation by humpback chub, daily temperatures in the Little Snake River ranged 14.4 to 21.2^0 C, averaged 18^0 C (s = 2.0904), and on a daily basis were warmer than in the Yampa River (Figures 3 and 4). Mean daily temperatures in the Little Snake River in July were 19 ^{0}C (s = 1.8141) and 2 ^{0} warmer than daily temperatures in the Yampa River. Both humpback chub and the roundtail chub apparently left the Little Snake River just prior to baseflow as daily temperatures in the Little Snake River cooled to levels lower than those in the Yampa River (Figures 3 and 5). In August, mean daily temperature in the Little Snake River, while still warm (0 = 19.8^0 C, s = 0.7176) was two degrees cooler than the Yampa River (0 = 21.4^0 C, s = 1.0928).

DISCUSSION

Discharge, water temperature, and water quality

The 1995 water year exemplified the seasonal nature and extreme variability of the Little Snake River. Annual runoff volume in 1995 was 1.5 times higher than the average of 415,200 acre feet (Crowfoot et al. 1996) and three times wetter than the previous year which discharged about half the average volume (Ugland et al. 1995). The unregulated characteristics of the river and the nature of the hydrograph in 1995 were represented by the extreme peak to base-flow ratio (165:1) primarily caused by extremely low base flows which are typical for the Little Snake River. Low baseflow dewatered all reaches but was most evident in the sandy and braided middle reach. Fish habitat was maintained in the lower and upper reaches by scattered refugia pools, connected with minimal surface flows that were very shallow and created a barrier to fish movement between pools. Shallow, widely dispersed flows also had a tremendous influence on water temperature and caused diel variations of a greater magnitude than those in the Yampa River. These and other physical influences likely caused a significant, but unknown, role in initially attracting and eventually repelling humpback chub and Colorado pikeminnow and structuring the fish community of the Little Snake River.

Fish community sampling

Humpback chub and Colorado pikeminnow occupied the lower 15 km of the Little Snake River during summer runoff. Locations and dates of their capture in 1995 matched those of previous collections of these species (Miller et al. 1982, Wick et al. 1991), demonstrating that both species use the Little Snake River on a regular basis. We found no evidence of their occurrence in the middle or upper reaches even though a Colorado pikeminnow was previously captured at about RK 135, 30-km upstream of our uppermost site (Marsh et al. 1991). Although historical accounts suggest wider distribution and year-round occurrence, telemetry data currently support only seasonal occupation of the Little Snake River by Colorado pikeminnow and humpback chub (Miller et al. 1982; Wick et al. 1989). The Little Snake River provided conditions similar to those in off-channel areas like backwaters or small, flooded tributaries that contain abundant food, warmer water, and lower velocity (Wick et al.1983). Colorado pikeminnow and humpback chub that move from the Yampa River into the warmer Little Snake River in the spring and summer would optimize their growth and gamete production (Wick et al. 1989).

Larval collections provided strong evidence of successful reproduction by native species and limited or no reproduction by most nonnative species. No endangered fish larvae were collected, although the identification of small *Gila* larvae was problematic. We were able to distinguish between juvenile *Gila* species that were preserved and examined in the laboratory and we found only juvenile roundtail chub; but, there was still uncertainty with species identification of larval *Gila* and this uncertainty will remain until valid phenotypic or genetic criteria are developed and used to determine their identification.

Native fishes numerically dominated samples at all sites and seasons and composed a high percentage (72%) of fish collected in the Little Snake River in 1995. Similar results were observed in 1994, when 69% of all fishes were native (Hawkins et al. 1997), even though 1994 was a relatively dry year compared to 1995. One commonality in 1994 and 1995 hydrographs was the extremely low baseflow that usually occurs regardless of runoff volume. In both years composition of large-bodied species remained consistent and was dominated by native flannelmouth sucker, bluehead sucker, and roundtail chub (Figure 8). Only a few of the large-bodied species collected were nonnatives; channel catfish, white sucker, and common carp each composed only a small portion (< 3%) of the fish collected. Most small-bodied species were nonnatives in both 1994 and 1995 and their composition varied each year (Figure 9). Speckled dace were the most commonly collected native small-bodied species and redside shiner and sand shiner were the most commonly collected nonnative species. Red shiner, fathead minnow, and mottled sculpin composed a very small portion of small-bodied species in both years. Creek chub and plains killifish were few and only collected in 1995. The high proportion of native fishes found in the Little Snake River was unusual compared to most Upper Colorado River Basin mainstream rivers that are typically dominated by nonnative fishes (Carlson and Muth 1989, Hawkins and Nesler 1991); although, it was similar to the high percentage (72%) observed in the Price River, a similar-sized tributary of the Green River (Cavalli 1999).

Species composition was relatively similar at all reaches even with wide (> 34 km) separation of sites and different geomorphological conditions at each site. The longitudinal differences of a few species were probably due to different thermal tolerance, but for species that were more abundant in the lower reach their abundance could also be due to infiltration from the Yampa River. Red shiner, a warm-tolerant species, was more abundant in downstream reaches than it was in cooler, upstream reaches. Cool tolerant, redside shiner, were more abundant in cooler upstream sites and as water temperatures increased in autumn their abundance declined. Abundance of most other species remained relatively constant through all seasons showing that most species collected in the Little Snake River could remain there as year-round residents. Although some individuals left the Little Snake River, such as telemetered roundtail chub, humpback chub , and Colorado pikeminnow, others apparently remained in the Little Snake River well after runoff declined to base flow and when diel temperature fluctuations were extreme. During baseflow, most refugia pools were isolated by impassible, shallow, sandy reaches and fish were trapped until sufficient flow reconnected isolated pools.

Results of depletion sampling in low-flow refugia pools were consistent with results from our general sampling at each site and validated that general sampling adequately represented the fish community. In addition, results of sampling the upper-site pool in 1995 were similar with results of sampling the same pool in 1994. The same species were collected in both years except that channel catfish were captured in 1994 and not in 1995. Total estimated number of fish of all species in the refugia pool was similar in both years and was 310 in 1994 and 248 in 1995. Except for the lack of channel catfish in 1995, the percentage of each species was strikingly similar in 1994 and 1995 (Figure 10).

The reasons why native species dominated the Little Snake River fish community were unknown. The most obvious factors that could influence the fish community in the Little Snake River are the hydrograph and its associated physico-chemical characteristics such as water temperature, water quality, and sediment transport. While similar in many aspects to the hydrographs of other unregulated rivers in the basin, the Little Snake River hydrograph contains characteristics that are often extreme, such as its peak to base flow ratio, its large sediment load, and its extremely low base flow. In addition to abiotic factors, biotic factors probably have an additional influence on the fish community in the Little Snake River, especially the lack of large, predatory, nonnative gamefish. Community ecology continues to debate the influence of abiotic and biotic parameters in shaping how communities are structured and regulated (Heins and Mathews 1987) and the Little Snake River provides an ideal location for focused studies to determine which components affect fish distribution and abundance. Understanding differences in physico-chemical components among Upper Colorado River Basin rivers will help explain differences in the fish communities in these rivers and will assist in the management of this and other rivers in the upper Colorado River Basin.

Telemetry of humpback and roundtail chub

Telemetry provided the first evidence of extended seasonal use of the Little Snake River by humpback chub and documented some of the longest distance movements observed for the species. Humpback chub typically exhibit high fidelity to specific locations. In the Colorado River at Black Rocks and the Grand Canyon, humpback chub show strong site fidelity with localized movements of less than 5 km and move very little during non-spawning periods (Valdez and Clemmer 1982; Valdez and Ryel 1995). Humpback chub in the Little Snake River also showed strong site fidelity with observed movements of less than 1 km, but also migrated fairly long distances (32 and 39 km) to Yampa Canyon in the Yampa River. These long-distance movements were similar to maximum movements (40 km) by humpback chub in the Grand Canyon for spawning and similar to distances (22 km) that humpback chub moved between population groups in Westwater Canyon, Utah and Black Rocks, Colorado in the Colorado River (Kaeding et al. 1990; Valdez and Ryel 1995). We believe that telemetered humpback chub originated in the Yampa River and moved into the Little Snake River in the spring during increasing flows when daily temperatures in the Little Snake River where warmer than temperatures in the Yampa River (Figures 3 and 4). One humpback chub remained in the Little Snake River for at least 28 days in June and July, another remained for at least 21 days in July, and both left by August just before baseflow and as daily temperatures in the Yampa River were becoming warmer than temperatures in the Little Snake River (Figures 3 and 5). Based on the long-distance moved and the time of year, it appears that the occupation of the Little Snake River by humpback chub could be for spawning.

Evidence leading to the possibility of spawning by humpback chub in the Little Snake River includes the following. Humpback chub occupied habitats in the Little Snake River during their spawning period which occurs between June and July (Kaeding et al. 1990; Karp and Tyus 1990) and when daily temperatures in the Little Snake River from June 21 until July 26 were 18^0 C (range $14.4\text{-}21.2^0$ C) and adequate for spawning. At 19.5^0 C (range $14.5\text{-}23^0$ C) humpback chub captured in the Yampa River were in breeding condition (Karp and Tyus 1990). None of the humpback chub that we captured had secondary sexual characteristics or expressed gametes, but humpback chub with tubercles have been captured in June in the same area of the Little Snake River (Wick et al. 1991). Stronger evidence of spawning in the Little Snake River would be the presence of ripe humpback chub, especially females, but definitive proof of spawning will require collection of larval or early juvenile humpback chub. We were unable to identify larval *Gila* beyond genus because there were no adequate morphometric characteristics to distinguish between larval roundtail chub and humpback chub in the small size range that we captured.

Generally we accomplished our objectives for this study. We know what fish species live in the Little Snake River, their distribution, and abundance. We also have a better understanding of the habitat use by endangered Colorado pikeminnow and humpback chub. But several questions remain, especially those regarding the reasons for long-range movements and long-duration stay of humpback chub in the Little Snake River. The predominant remaining question is whether or not humpback chub were attempting to spawn in the Little Snake River. Specific spawning sites have not been identified for humpback chub in the Upper

Basin as they have for Colorado pikeminnow and razorback sucker (*Xyrauchen texanus*), but this knowledge could be crucial for management and recovery of the species. Considering that so little is known about humpback chub reproductive ecology and early life history, we believe that identifying specific spawning sites and describing conditions necessary to maintain these sites would be invaluable for monitoring and enhancing reproductive success of adults and increasing survival of young fish.

CONCLUSIONS

1. Humpback chub and Colorado pikeminnow occupied the lower 15 km of the Little Snake River in June and July during runoff and telemetered humpback chub moved from the Little Snake River to the Yampa River in early August just before baseflow and as temperatures cooled in the Little Snake River.

2. Humpback chub moved relatively long distances (32 and 39 km) from the Little Snake River to the Yampa River and occupied the Little Snake River during their spawning period.

3. Native flannelmouth sucker, bluehead sucker, and roundtail chub composed the majority of the large-bodied fish community and nonnative channel catfish, white sucker, and common carp were rare in the Little Snake River at all seasons and reaches. Composition of large-bodied species (adults $\geq$ 200 mm total length) changed minimally among seasons or sites.

4. Nonnative sand shiner and redside shiner and native speckled dace composed the majority of small-bodied species collected, but many small-bodied nonnative species typically abundant in other rivers were rare in the Little Snake River. Composition of most small-bodied species (adults size $<$ 200 mm total length) changed minimally among seasons or sites, except for composition of redside shiner that declined in autumn and varied by reach and red shiner that also varied by reach.

RECOMMENDATIONS

1. Identify and maintain the discharge and physico-chemical conditions in the Little Snake River that support Colorado pikeminnow, humpback chub, and a mostly native fish community. These conditions might include the timing, magnitude, and pattern of runoff and baseflow and associated physico-chemical conditions such as turbidity, diel temperature fluctuations, or sediment load.

2. Better describe the migrations and interactions of humpback chub between the Little Snake and Yampa rivers, possibly through intensive telemetry studies.

3. Identify spawning sites for humpback chub that reside in the Yampa River and Little Snake River.

4. Include humpback chub and Colorado pikeminnow that reside in the Little Snake River with Yampa River abundance estimates.

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Table 1. Sampling gear used to collect fish from the Little Snake River, Colorado, 1995. Recovery Program database codes are in parentheses.

Gear	Description
Seines	
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
Nets	
block net	30 m X 2.4 m, 13-mm mesh
trammel net (TR)	34 m X 2.4 m, 0,3-m panel, 25-mm mesh
	15 m X 2.0 m, 20-cm panel, 25-mm mesh
Electrofishing	
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.
Miscellaneous	
Dipnet (DN)	30.5-cm, "D-ring" mouth, 1-mm mesh
Angling (AN)	worm, cricket, spoon, spinner, or dry fly

Table 2. Sampling effort for each gear in three reaches of the Little Snake River, 1995.

	Reach			All reaches
Gear	Lower	Middle	Upper	combined
seine and dipnet	487 m^2	604 m^2	567 m^2	1658 m^2
trammel net	48.9 hrs	0	1.8 hrs	50.7 hrs
hoop net	258.8 hrs	0	0	258.8 hrs
angling	64.9 hrs	0	0	64.9 hrs
electrofishing-boat	6.8 hrs	2 hrs	1.1 hrs	9.9 hrs
electrofishing-bank	1.7 hrs	0	2.8 hrs	4.5 hrs

Table 3. Approximate length at beginning of juvenile and adult life stages for fishes collected from the Little Snake River, Colorado. Large-bodied species were those that attain the adult stage at ≥ 200-mm total length and small-bodied species were those that attain the adult stage at < 200-mm total length. Fish smaller than juvenile size were larvae. Classifications adapted from Snyder (1981) and Snyder and Muth (1990). Common and scientific names from Robins et al. (1991).

		Total length (mm)	
		Juvenile	Adult
Large-bodied species			
Gila cypha *	humpback chub	25	200
Gila robusta *	roundtail chub	25	200
Ptychocheilus lucius *	Colorado pikeminnow	25	400
Cyprinus carpio	common carp	20	250
Catostomus discobolus *	bluehead sucker	25	200
Catostomus latipinnis *	flannelmouth sucker	30	300
Catostomus commersoni	white sucker	25	200
Ictalurus punctatus	channel catfish	25	200
Small-bodied species			
Cyprinella lutrensis	red shiner	15	40
Cottus bairdi *	mottled sculpin	15	40
Rhinichthys osculus *	speckled dace	20	50
Notropis stramineus	sand shiner	15	40
Pimephales promelas	fathead minnow	15	40
Richardsonius balteatus	redside shiner	20	60
Semotilus atromaculatus	creek chub	20	75
Fundulus zebrinus	plains killifish	10	30

* Native species

Table 4. Physical and chemical characteristics of the Little Snake River, 1995.

Date Sampled	Location (RK)	Discharge [a] (m^3/sec)	Conductivity (FS)	pH	Hardness ($CaCO_3$) (mg/L)	Alkalinity $CaCO_3$ (mg/L)	Dissolved oxygen (mg/L)	Secchi depth (mm)
May 16	101.9	79.3	200	8.0	106	95	--	60
June 4	93.8	136.2	150	7.6	120	87	8.7	60
June 5	5.6	137.9	150	8.6	88	72	8.8	40
Sept 28	102.2	3.2	500	8.3	201	245	6.8	110

[a] discharge measured at US Geological Survey "Little Snake River near Lily, Colorado" gage (# 09260000).

Table 5. Number of fish collected by life stage from the Little Snake River, Colorado, 1995. Large-bodied species were those that attain the adult stage at $\geq$ 200 mm and small-bodied species were those that attain the adult stage at lengths < 200 mm total length. See Table 3 for length range of each life stage.

Species	Larvae	Juveniles	Adults	Total
Large-bodied species				
humpback chub *	0	0	4	4
roundtail chub *	0	270	47	331
unidentified chub*[a]	14	0	0	14
Colorado pikeminnow *	0	0	3	3
bluehead sucker *	4450	270	180	4900
flannelmouth sucker *	530	413	181	1124
white sucker [b]	98	17	7	122
channel catfish	0	0	39	39
common carp	0	5	17	22
flannelmouth sucker x bluehead sucker *	0	0	3	3
flannelmouth sucker x white sucker	0	1	1	2
Small-bodied species				
red shiner	26	192	44	262
mottled sculpin *	0	1	6	7
sand shiner	57	1860	114	2031
fathead minnow	22	90	5	117
redside shiner	9	578	32	619
speckled dace *	636	1006	136	1778
creek chub	0	2	0	2
plains killifish	0	3	1	4
Total	5842	4708	820	11370

* native species

[a] Unidentified chub are *Gila* species identified only to genus.

[b] Includes five larval and one juvenile white sucker considered potential hybrids with other undetermined sucker species.

Table 6. Capture information for PIT-tagged or telemetered fish in the Little Snake River, 1995. Location of capture is river kilometers (RK) upstream from Yampa River confluence.

PIT tag number	Recap-ture	Date	Length (mm)	Weight (g)	Location (RK)	Habitat	Sampling Gear	Comments
Humpback chub								
1F3-F21-0001	No	6/21/95	255	150	14.5	eddy	trammel net	Implanted 40.660 MHz transmitter
1F3-F21-0001	Yes	7/03/95	--	--	13.4	eddy	trammel net	Fish in good health
1F3-F21-0001	Yes	7/17/95	--	--	13.2	eddy	angling	Incision healed
1F4-03F-372B	No	7/17/95	268	154	13.2	eddy	angling	Fish caught with cricket
1F4-178-1513	No	6/21/95	292	140	10.0	eddy	trammel net	Condition poor, did not implant
Not tagged	No	7/06/95	250	140	5.6	eddy	angling	Implanted 40.680 MHz transmitter
Colorado pikeminnow								
1F4-12D-1261	No	7/3/95	510	1090	13.2	eddy	trammel net	
1F4-361-330A	No	7/17/95	587	1600	14.0	shoreline	angling	Fish caught with cricket
1F4-366-694F	No	6/05/95	830	--	9.2	eddy	electrofishing boat	
Roundtail chub								
1F7-322-507C	No	7/17/95	405	560	9.5	eddy	angling	Implanted 40.670 MHz transmitter

Table 7. Percent of larvae of each species collected in the Little Snake River in summer and autumn, 1995. Large-bodied species were those that attain the adult stage at ≥ 200-mm total length and small-bodied species were those that attain the adult stage at < 200-mm total length. See Table 3 for length range of each life stage.

	------------------- Season and Flow ------------		
Species	Summer (Descending)	Autumn (Baseflow)	Combined Seasons
Large-bodied species	(n = 5088)	(n = 4)	(n = 5092)
bluehead sucker *	87	50	87
flannelmouth sucker *	10	25	10
white sucker	2	0	2
unidentified chub *	0.3	25	0.3
Small-bodied species	(n = 638)	(n = 112)	(n = 750)
speckled dace *	98	9	85
sand shiner	1	43	8
red shiner	0.5	21	3
fathead minnow	0	20	3
redside shiner	0	8	1

* native species

Table 8. Percent of juvenile and adult fishes collected by season in the Little Snake River, 1995. Large-bodied species were those that attain the adult stage at ≥ 200-mm total length and small-bodied species were those that attain the adult stage at < 200-mm total length. See Table 3 for length range of each life stage.

	------------------------ Season and Flow	----------------------------		
Species	Spring (Ascending)	Summer (Descending)	Autumn (Baseflow)	Combined Seasons
Large-bodied species	(n = 411)	(n = 375)	(n = 672)	(n = 1458)
flannelmouth sucker *	58	40	31	41
bluehead sucker *	19	24	43	30
roundtail chub *	20	25	21	22
channel catfish	0	8	2	3
white sucker	2	1	2	2
common carp	1	1	2	2
humpback chub *	0	2	0	0.4
flannelmouth sucker hybrids *	1	0.3	0.3	0.3
Colorado pikeminnow *	0.2	1	0	0.2
Small-bodied species	(n = 613)	(n = 476)	(n = 2981)	(n = 4070)
sand shiner	41	23	54	49
speckled dace *	10	32	31	28
redside shiner	49	31	5	15
red shiner	0	12	6	6
fathead minnow	0.2	0.4	3	2
mottled sculpin *	0	1	0.1	0.2
plains killifish	0	0.2	0.1	0.1
creek chub	0.2	0.2	0	0.1

* native species

Table 9. Percent of juvenile and adult fishes collected by reach of the Little Snake River, 1995. Large-bodied species were those that attain the adult stage at ≥ 200-mm total length and small-bodied species were those that attain the adult stage at < 200-mm total length. See Table 3 for length range of each life stage.

Species	Reach and location: Lower (RK 7-15)	Middle (RK 61-69)	Upper (RK 95-103)	Combined Reaches
Large-bodied species	(n=551)	(n=402)	(n=505)	(n=1458)
flannelmouth sucker *	40	44	39	41
bluehead sucker *	26	37	32	31
roundtail chub *	24	18	22	22
channel catfish	7	0	0	3
white sucker	0.4	1	3	2
common carp	2	0	3	2
humpback chub *	1	0	0	0.3
flannelmouth sucker hybrids *	0.4	0	1	0.3
Colorado pikeminnow *	1	0	0	0.2
Small-bodied species	(n=1801)	(n=1437)	(n=832)	(n=4070)
sand shiner	58	45	34	49
speckled dace *	17	37	36	28
redside shiner	7	18	28	15
red shiner	12	0.3	1	6
fathead minnow	5	0.1	0	2
mottled sculpin *	0	0	1	0.2
plains killifish	0.2	0	0	0.1
creek chub	0.1	0.1	0	0.1

* native species

Table 10. Number of fishes captured and abundance estimates at two low-flow refugia pools in the Little Snake River, Colorado, 1995.

Upper-Reach Site (RK 102.2)

	Sample occasion 1	2	3	4	Number Captured	Estimated Abundance	(95%CI)	SE	Percent Composition [c]
Native species									
flannelmouth sucker	31	22	10	13	76	96	(83-138)	12.6702	39%
bluehead sucker	22	18	11	12	63	96	(72-184)	24.5958	39%
roundtail chub	11	7	9	0	27	30	(28-44)	3.2825	12%
Nonnative species									
white sucker	3	1	5	0	9	10	(10-29)	3.3669	4%
common carp	2	6	0	3	11	16	(12-72)	10.4047	6%
Total	69	54	35	28	186	248[a]			

Lower-Reach Site (RK 5.6)

	Sample occasion 1	2	3	4	Number Captured	Estimated Abundance	(95%CI)	SE	Percent Composition [c]
Native species									
flannelmouth sucker	13	9	1	0	23	23	(23-23)	0.0895	38%
bluehead sucker	8	7	4	1	20	21	(21-33)	.---	34%
roundtail chub	2	0	0	0	2	2[b]	---	.---	3%
Nonnative species									
channel catfish	10	0	0	0	10	10[b]	---	.---	16%
white sucker	1	1	0	0	2	2[b]	---	.---	3%
common carp	1	1	1	0	3	3[b]	---	0.681	5%
Total	35	18	6	1	60	61[a]			

a Total fish was calculated by summing the estimated abundance of each species, therefore a 95% confidence interval is not applicable.
b Number of fish captured was inadequate to calculate a Lincoln-Petersen abundance estimate, so the abundance was based on sum of fish captured in all passes.
c Percent composition based on estimated abundance in upper-reach site and on number of fish captured at lower-reach site.

Table 11. Location, habitat, and observed activity of humpback chub and roundtail chub implanted with radio transmitters in the Little Snake and Yampa rivers, 1995. Fish locations on the Little Snake River (LS) are kilometers (RK) from the confluence with the Yampa River (YA) and locations on the Yampa River are kilometers from the confluence with the Green River. The Little Snake River joins the Yampa River at Yampa River RK 80.8.

Date	River	Fish Location (RK)	Habitat	Observer Location	Time of Observation	Fish Activity
Humpback chub: PIT tag number: 1F3-F21-0001, transmitter frequency 40.660 MHz						
June 21	LS	14.5	eddy	shore	1430	Implanted transmitter
June 23	LS	14.5	eddy	shore	1130	
June 28	LS	14.5	eddy	shore	1540–1915	Fish moving in eddy
July 1	LS	14.5	eddy	shore	1900	Fish inactive
July 2	LS	14.5	eddy	shore	0720–0755	Fish moving in eddy
July 3	LS	13.4	eddy	shore	1505	Fish caught in trammel net
July 6	LS	14.5	eddy	shore	0815–1025	
July 16	LS	13.2	eddy	shore	1845–1920	
July 17	LS	13.2	eddy	shore	1300	Fish captured by angling
July 18	LS	13.2	run	shore	1045	Fish 100 m downstream of July 17 location
August 9	YA	59	--	plane	----	Fish between Tepee Rapid and Tepee Campground
Humpback chub: Not PIT tagged, transmitter frequency 40.680 MHz						
July 6	LS	5.6	eddy	shore	1940–2250	Implanted transmitter
July 7	LS	5.6	eddy	shore	0700–1210	Fish moving in eddy
July 16	LS	5.6	eddy	shore	1720	
July 26	LS	5.6	eddy	shore	----	Fish moving in eddy
August 9	YA	66	--	plane	----	Fish about 1.5 km downstream of Anderson Hole
September 26	YA	57	--	plane	----	Fish about 1 km downstream of Tepee Rapid
Roundtail chub: PIT tag number: 1F7-322-507C, transmitter frequency 40.670 MHz						
July 17	LS	9.5	eddy	shore	1600	Implanted transmitter
August 9	YA	85.3	--	plane	----	Fish between Little Snake River and Cross Mountain Canyon
September 26	YA	81.6	--	plane		Fish about 1 km upstream of Little Snake River confluence

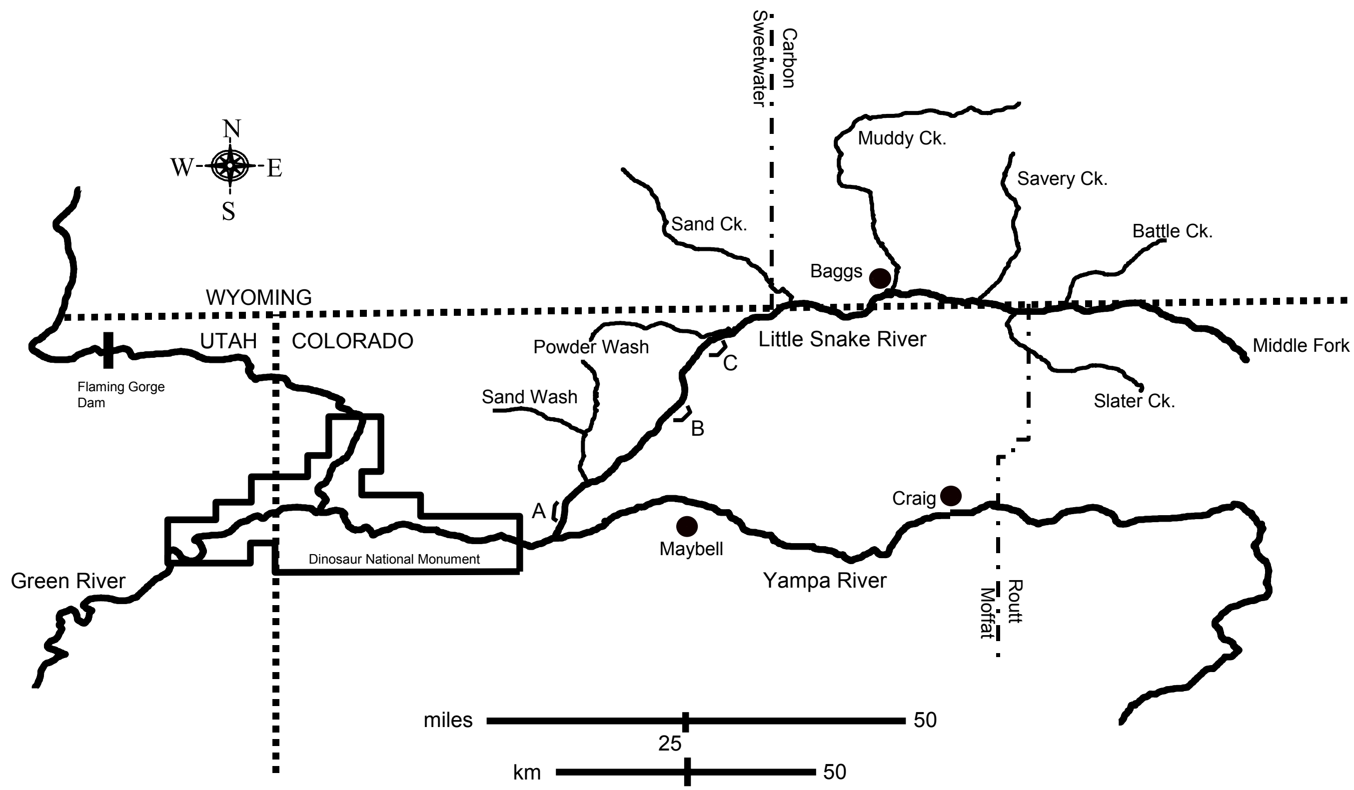

Figure 1. Little Snake River drainage basin and sites sampled in 1995. Letters designate sampling sites: A= Lower Site (RK 7-15), B= Middle Site (RK 61-69), and C= Upper Site (RK 95-103).

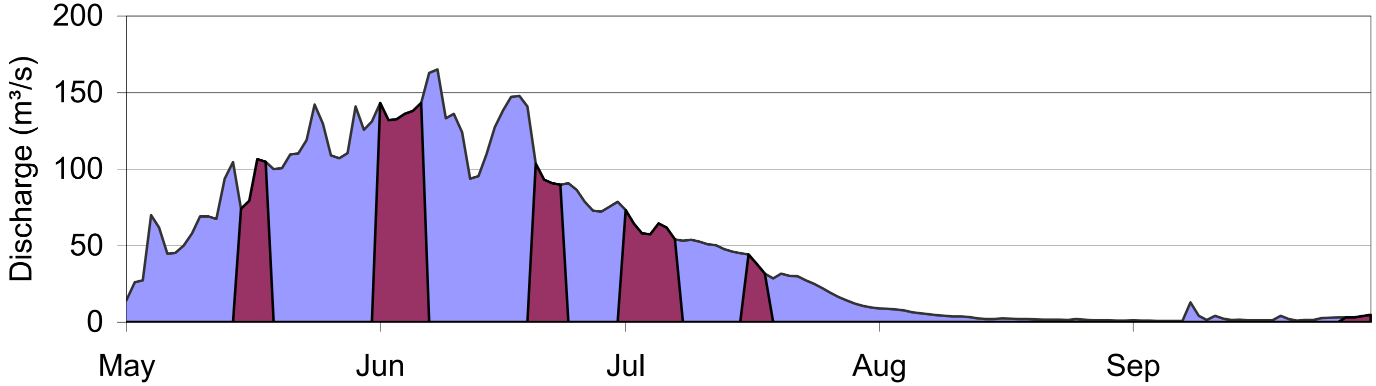

Figure 2. Mean daily discharge of the Little Snake River at U.S. Geological Survey gage #9260000, "near Lily, Colorado", from May 1 through September 31, 1995. Darker areas indicate discharge during sampling dates on May 15-18, June 1-6, June 21-23, July 1-7, July 16-18, and September 27-31.

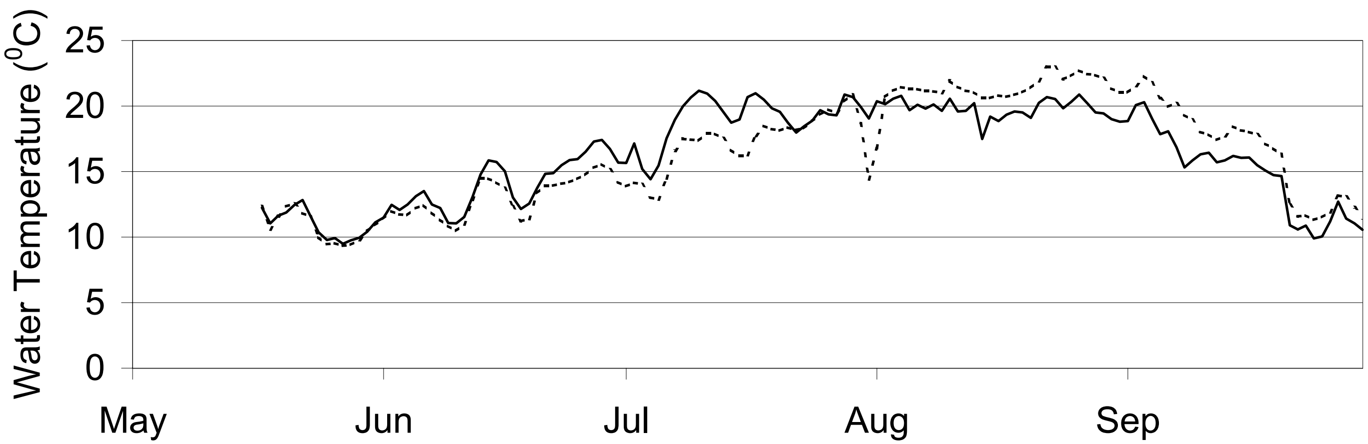

Figure 3. Mean daily water temperatures in the Little Snake River (solid line) and Yampa River (doted line) from May 17 through September 31, 1995. Little Snake River temperatures were measured 15-km upstream from the Yampa River confluence and Yampa River temperatures were measured 2.5-km upstream from the confluence.

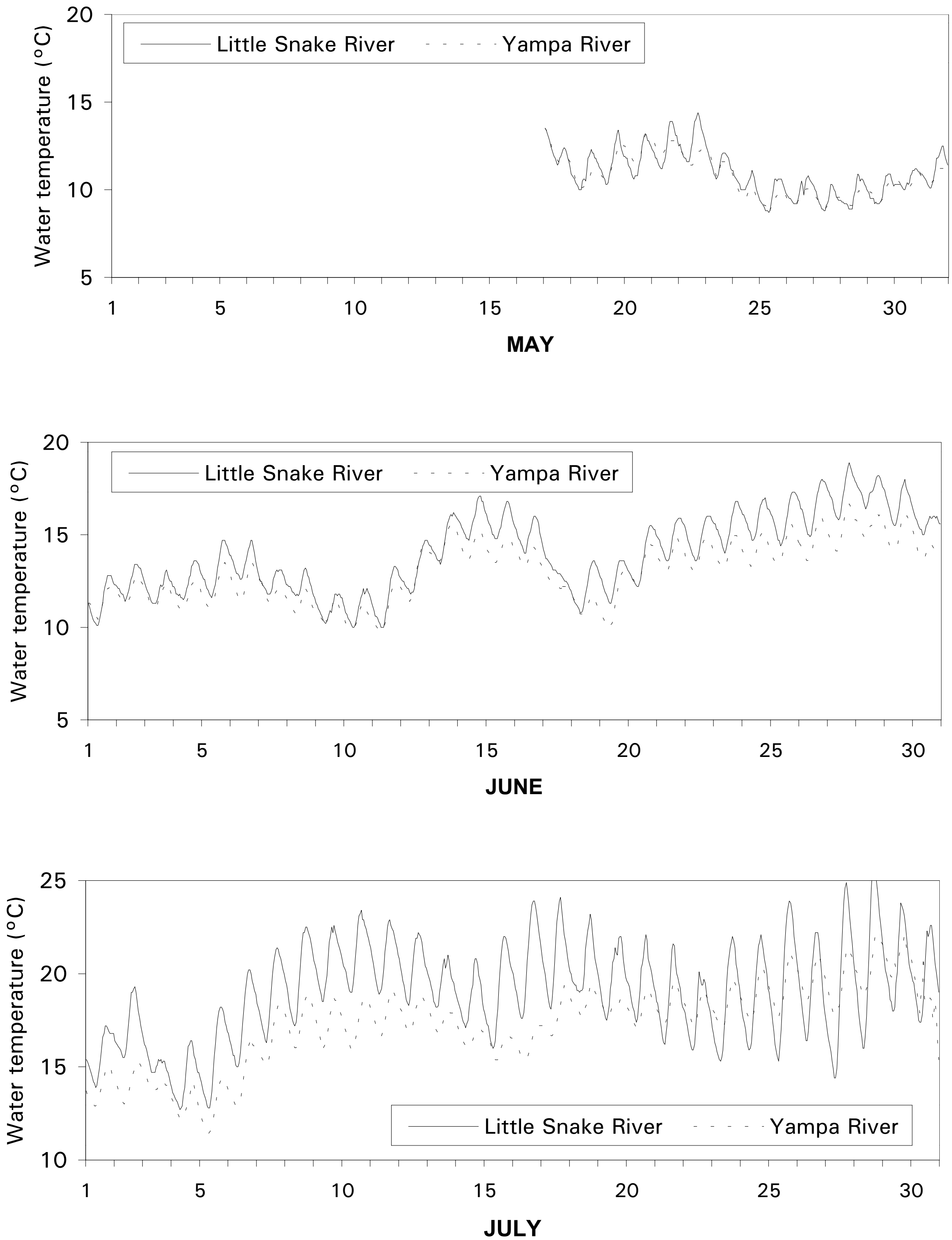

Figure 4. Hourly water temperatures in the Little Snake and Yampa rivers in May, June, and July, 1995.

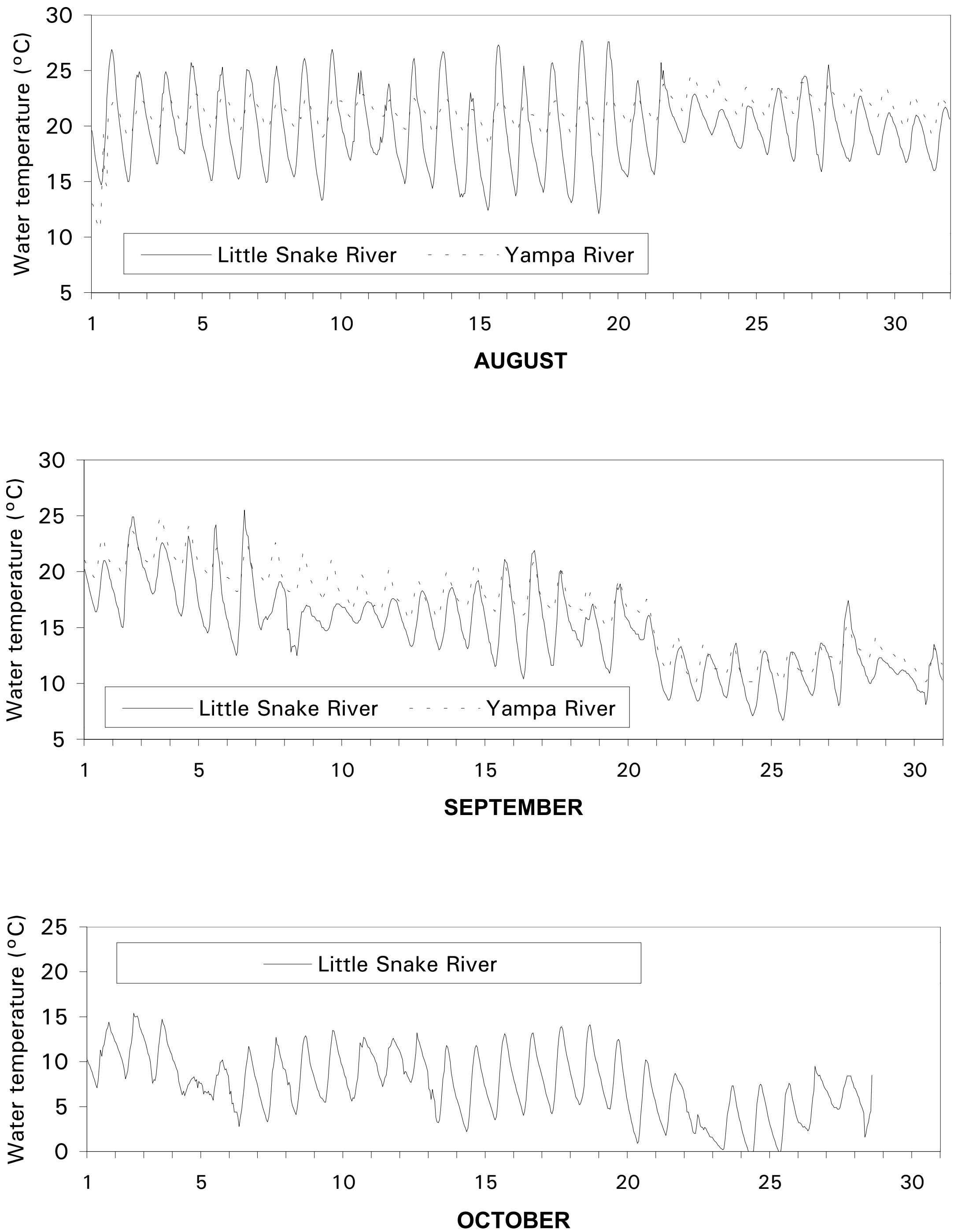

Figure 5. Hourly water temperatures in the Little Snake and Yampa rivers in August, September, and October, 1995.

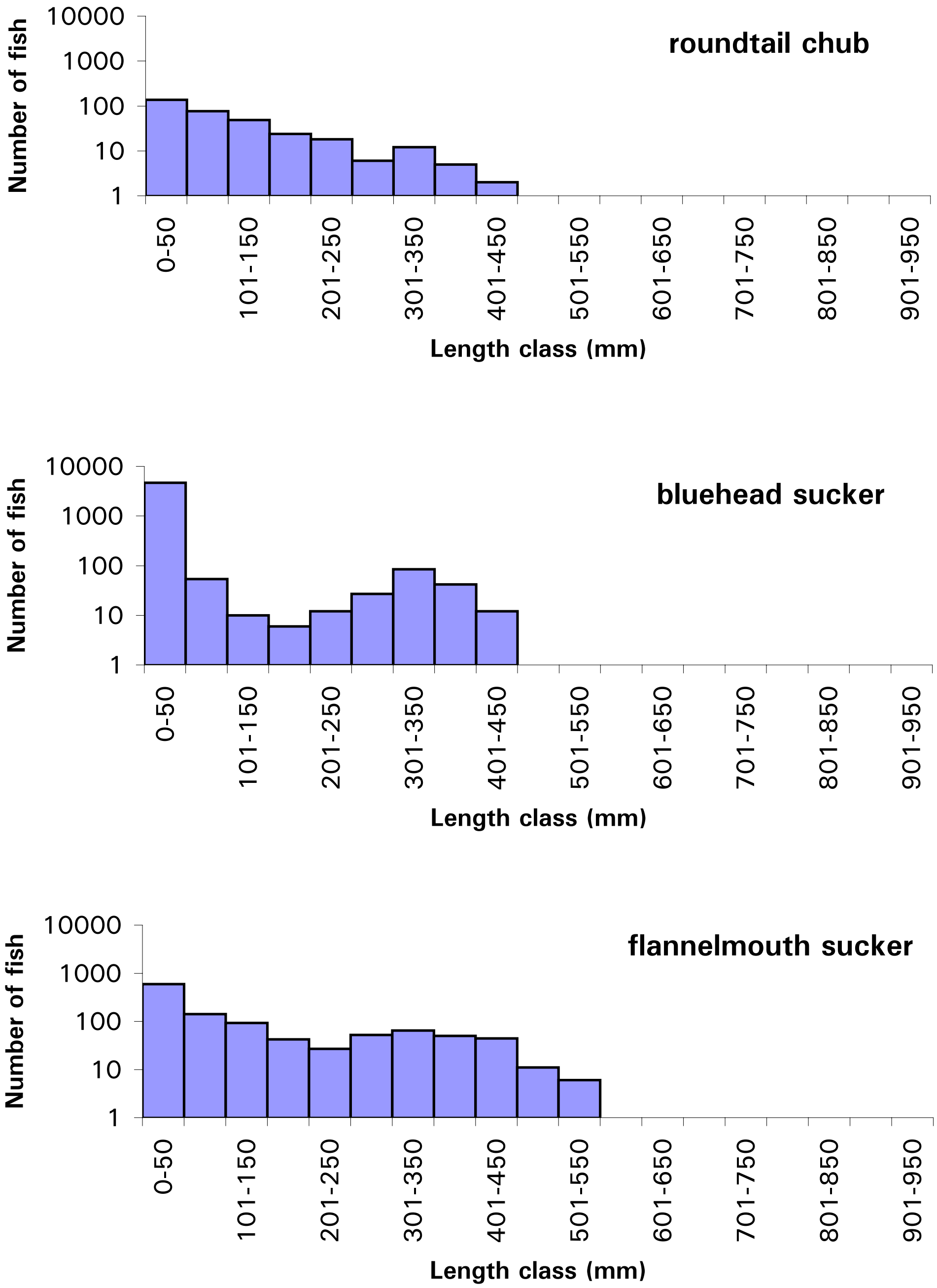

Figure 6. Length-frequency distribution of large-bodied native fishes collected from the Little Snake River, 1995. Note y-axis is logarithmic.

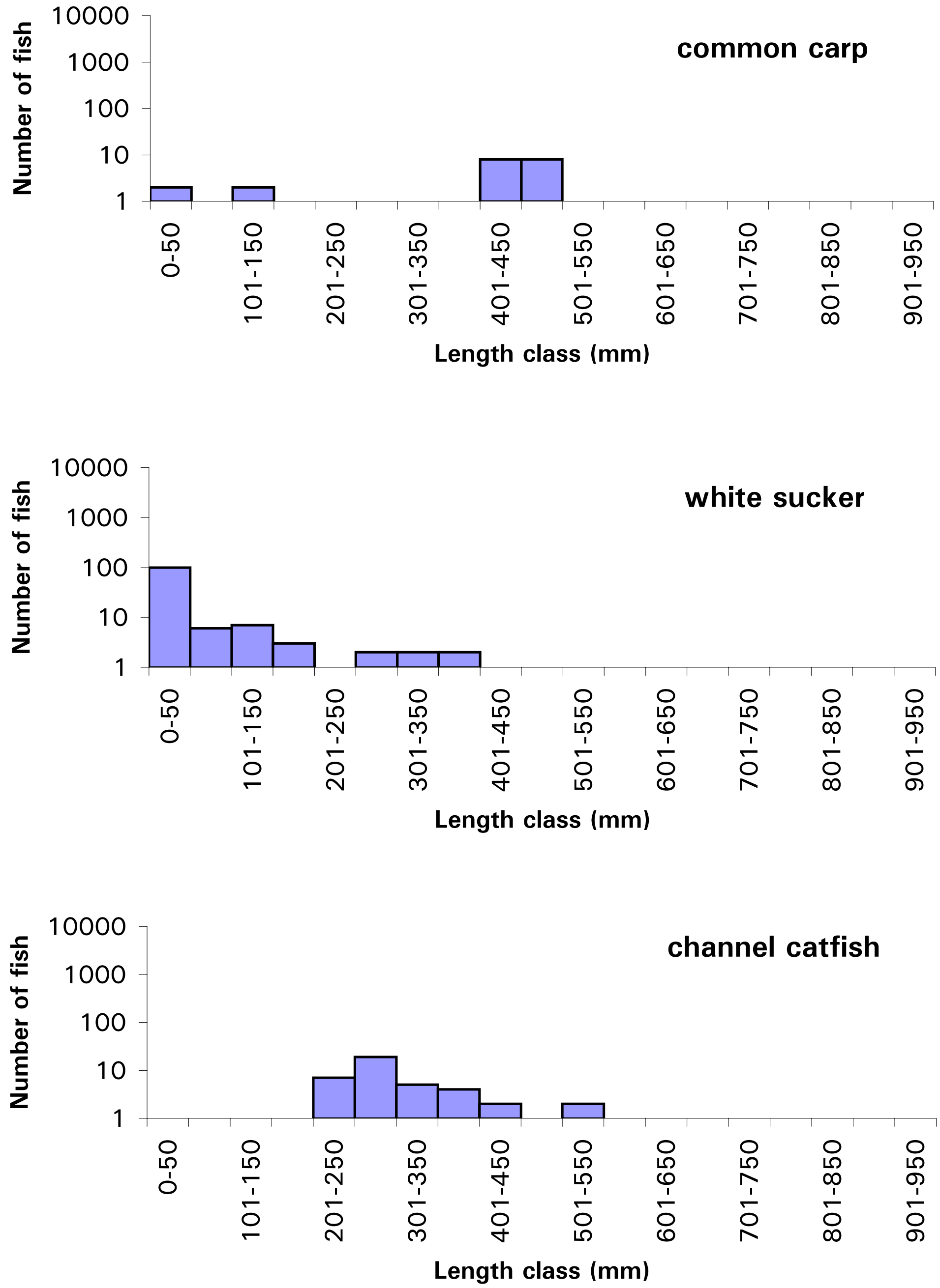

Figure 7. Length-frequency distribution of large-bodied nonnative fishes collected from the Little Snake River, 1995. Note y-axis is logarithmic.

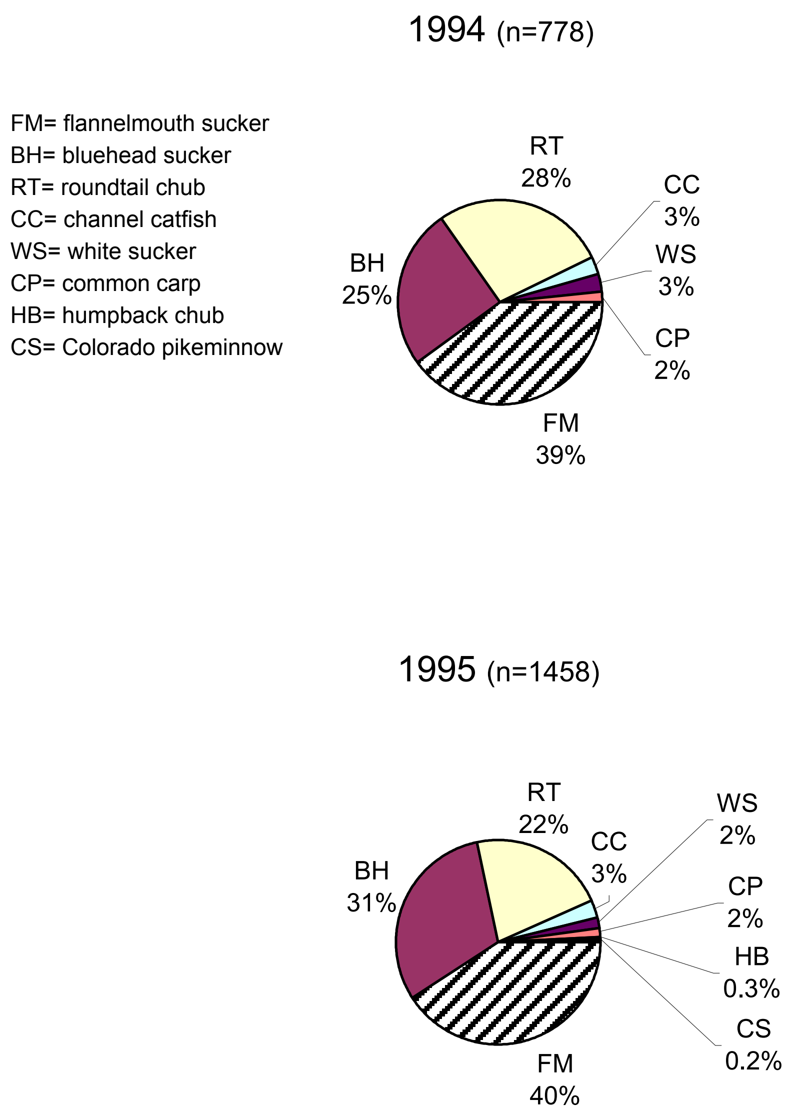

Figure 8. Percent composition of juvenile and adult large-bodied species collected in the Little Snake River in 1994 and 1995. Data for 1994 from Hawkins et al. (1997).

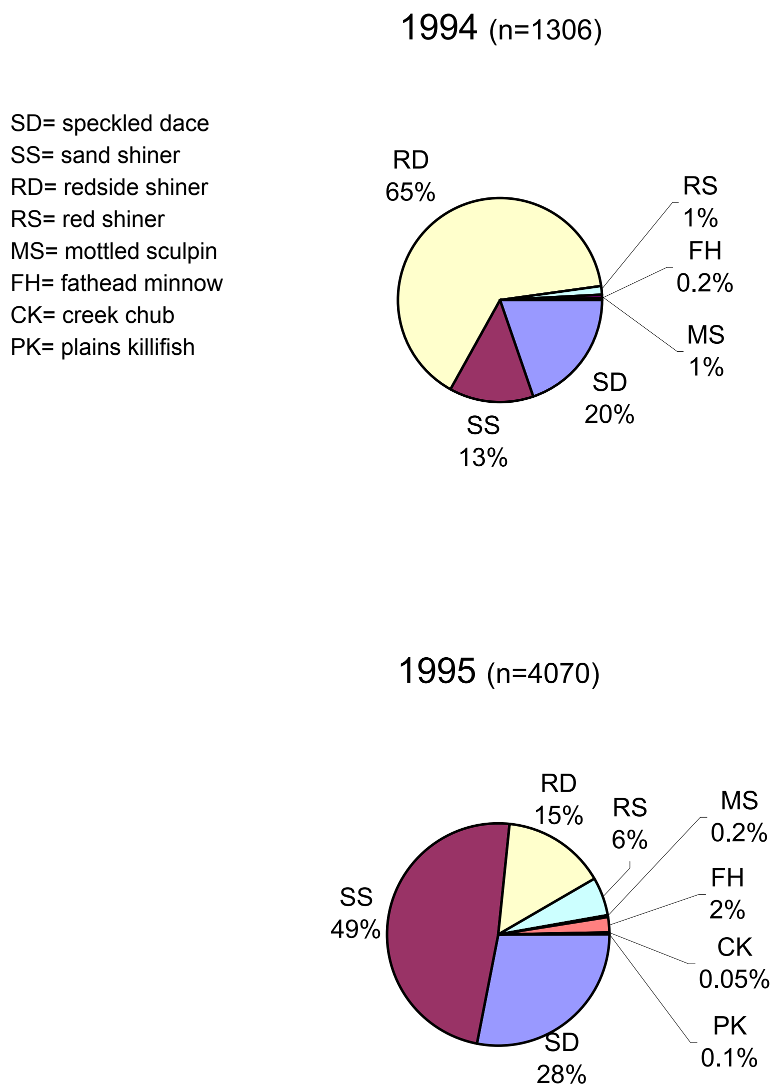

Figure 9. Percent composition of juvenile and adult small-bodied species collected in the Little Snake River in 1994 and 1995. Data for 1994 from Hawkins et al. (1997).

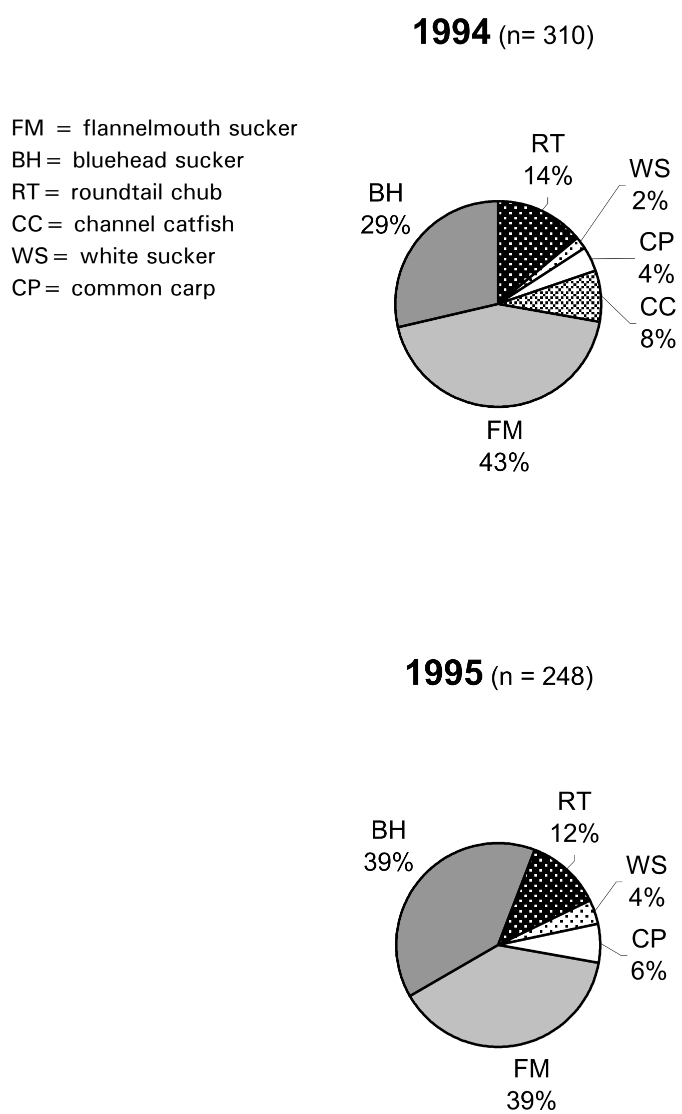

Figure 10. Percent composition of large-bodied species based on abundance estimates of fish captured in a baseflow refugia pool in the Little Snake River, 1994 and 1995. Data for 1994 from Hawkins et al. (1997).