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A Fisheries Investigation of the Previously Un-Surveyed Little Bear River

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Chapter 8
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SUMMARY

To evaluate the effects of human impacts on the composition and abundances of fishes on the Little Bear River, the 2012 Aquatic Ecology Practicum class conducted backpack electrofishing surveys in four sites of the river on 29 September and 4 October 2012. At these sites, species composition, biomass, and abundances were documented utilizing 2-pass electrofishing. In total, ten species were captured, with native species being represented by Bonneville cutthroat trout (*Oncoryhnchus clarki Utah)* and mottled sculpin (*Cottus* bairdii). Mottled sculpin comprised the majority of native fish captured (n= 241), while brown trout accounted for the majority of nonnatives (n= 129). Brown trout abundance was highest at the most upstream site (Station 2) and decreased going down the longitudinal gradient. Regression analysis revealed that larger average pebble size at Station 2 could be a factor in determining the observed higher brown trout abundance at this site, although the small sample size warrants further investigation. At the lowest site (Station 11) with poor water quality, only introduced species were present: green sunfish (*Lepomis cyanellus*), common carp (*Cyprinus carpio*), largemouth bass (*Micropterus salmoides*) and sand shiner (*Notropis stramineus*). Recommendations for future fisheries investigations on the Little Bear River include the sampling of additional sites, inclusion of more passes per site, and additional invertebrate and pebble sampling. Management recommendations include assessment of the potential value of a fisheries management program on the Little Bear River.

INTRODUCTION

The Little Bear River drains the southern portion of Cache Valley, which is located in northern Utah. Similar to most streams in populated regions, the Little Bear River has been altered by anthropogenic influences, including diminished water quality, impoundment, and channel modifications. The Utah Department of Water Quality (UDWQ) investigated some of these impacts in an effort to determine the Total Maximum Daily Load (TMDL) of nutrients. Data analyzed in that study were compiled from water quality monitoring in the Little Bear River from 1976 through 1999. After determining that total phosphorous (TP) levels exceeded UDWQ criteria at five of the ten sites sampled on the Little Bear River, remediation efforts were suggested and outlined (UDWQ 2000).

Subsequent studies conducted by Utah State University scientists further investigated sediment loading and biological isotope indicators of heightened nutrient loads (Jones et al. 2011; Luecke and Messner Unpublished). Additional investigation of the Little Bear River and its watershed include studies performed by two upper-level undergraduate courses in the Watershed Sciences department at Utah State University during Fall semester of 2012.

Fisheries monitoring can provide much insight to the status of a stream's ecological integrity (Schmutz et al. 2000). Except for some Utah DWR data on the East Fork of the Little Bear River, there appears to be little information regarding fish abundance and taxonomic composition in the Little Bear River. This eliminates the possibility of comparing data collected in this study to those in the past, yet underscores the importance of developing some form of baseline study which could be referenced in the future.

METHODS

Study Area

Fish sampling at four sites along the Little Bear River conducted by the 2012 Aquatic Ecology Practicum class occurred on 29 September and 4 October and was initiated at the furthest downstream site (See site map in Executive Summary). Sampling locations were selected relatively evenly along the longitudinal gradient, but only four stations could be sampled due to time constraints. Reaches were 100 meters in length, as this maintained consistency with previous local depletion estimates and promoted the benefits of regional standardization (Bonar et al. 2009). Two elsctrofishing passes were conducted at each reach. A class member, Chance Broderius, collected GPS information at the bottom of each reach, which included station waypoints and elevation.

Station elevation where fish sampling occurred ranged from 1699 meters at the uppermost site (Station 2) to 1347 meters at Station 11 near Cutler Reservoir. The character of the river valley changed from a relatively narrow canyon at Station 2 to a somewhat typical mid- to lower-order stream of the intermountain west at Station 11. Hyrum reservoir is located between Station 4 and 11 and can be viewed as a discontinuity within the Little Bear River continuum and an assumed barrier to fish migration (Ward and Stanford 1983). Selecting two sampling locations above Hyrum Reservoir and two below allowed investigation of the possible influence of Hyrum reservoir on the Little Bear River fish assemblage.

Fish Collection

A Smith Root LR 24 backpack electrofisher was used to collect fish, and settings were calibrated with the automatic setup feature (Photo 1). Fish sampling occurring on 4 October 2012 at Station 2 was done by three students with dip nets, while sampling on 29 September 2012 at Stations 4, 7, and 11 required an additional netter due to higher average surface area. Electrofishing seconds were monitored to achieve consistency between the individual passes within a reach. Fish-abundance estimates were performed by the depletion method, with the upper and lower boundaries of the reach blocked by seines to prevent fish from escaping (Li and Li 2006). Captive fish were placed in a holding bucket and taxanomic identification, total length (mm), and total wet weight (g) were recorded on data sheets. Additional information was provided by photographs of different taxa, which were taken at Stations 7 and 11 as noted in Photos 1 and 2 in the Appendix. Species not photographed include Bonneville cutthroat trout and green sunfish.

Average Width, Biomass, Catch per Unit Effort, and Abundance Estimate Calculation

Average width of Stations 2, 4, and 7 were calculated by measuring five wetted-widths with a surveying tape. Average width of Station 11 was determined by the Google Earth® measuring tool, which was possible due to the channelized character and relative lack of riparian canopy at this site. Calculation of average width allowed for determination of reach surface area, which was subsequently used to quantify biomass of fish species captured and comparison of reach spatial characteristics.

Abundance estimates in this study were performed with the same approach utilized in an investigation on the Logan River which calculated abundance estimates with the simple linear regression method and the modified Zippin method for comparative purposes (Budy et al. 2002, Zippin 1958). The modified Zippin method was also used by Utah Department of Wildlife Resources (UDWR) surveys on the Logan River (Budy et al. 2002). The modified Zippin estimate of fish abundance is calculated as follows:

$$\boldsymbol{N = \frac{C_1^2}{C_1 - C_2}}$$

Where,
N = estimated fish population reported in units of fish per 100 meters, C_1 = number of fish captured on the first pass, and C_2 = number of fish captured on the second pass.

Additionally, standard error can be calculated with the modified Zippin method as:

$$\textit{Standard Error: } S.E.(N) = [\frac{C_1 - C_2}{(C_1 - C_2)^2}]^* \sqrt{C_1 + C_2}$$

The value of fish abundance estimates arguably supercedes other fisheries research results. Abundance estimates can provide managers with quantifiable results, which include biomass and population estimates, both of which are highly beneficial in determining resource allocation and measures of ecological integrity. As with most estimates, an increased sample size typically results in greater precision.

Statistical Analysis
Statistical analyses were conducted with Microsoft Excel 2010. Statistical analyses consisted of simple regression between variables of fish abundance, observed fish biomass, and catch per unit effort (CPUE), with each fish-related variable pertaining to an individual taxa. Small sample sizes of the majority of species captured precluded statistical analyses, particularly noticeable at Station 11. Variables analysed included location (river kilometer), monthly and annual temperature, monthly and annual dissolved oxygen concentration (percent of saturation), average pebble size (millimeters), turbidity (nephelometric turbity units), and EPT (*Ephemeroptera, Plecoptera, and Trichoptera*) to Chironomid ratios. Annual temperature, dissolved oxygen concentration, and turbidity data were obtained from the Utah State University "Little Bear River WATERS Test Bed" website (http://littlebearriver.usu.edu/sites/ Default.aspx 15 November 2012), which provides access to automated water quality monitoring stations. Information from these automated stations directly pertained to five of the eleven stations sampled by the Aquatic Ecology Practicum class, with two out of four being present at fish sampling reaches. Additionally, a two-sample t-test was used to compare length-frequency distributions between reaches for brown trout and mottled sculpin.

RESULTS

Ten species and a total of 408 fish were caught in the Little Bear River, with 80 percent of the total catch occurring at the two sites above Hyrum Reservoir (Table 1). As predicted, a cold-water fish assemblage was found in reaches further upstream, whereas the lowest reach sampled revealed a warm water assemblage. Mottled sculpin constituted 59 percent of fish captured in the Little Bear River, and brown trout comprised the largest proportion of fish biomass (Figure 2A) among our sample. Specific catch results at the four stations are provided below.

Common name & Abbreviation	Latin name	Station 2	Station 4	Station 7	Station 11	Total
Bonneville cutthroat trout (BCT)	*Oncorhynchus clarki utah*	2	1			3
Brown trout (BNT)	*Salmo trutta*	64	34	31		129
Common carp (CC)	*Cyprinus carpio*				7	7
Green sunfish (GS)	*Lepomis cyanellus*				15	15
Largemouth bass (LM)	*Micropterus salmoides*				2	2
Mottled sculpin (MS)	*Cottus bairdii*	63	164	14		241
Rainbow trout (RBT)	*Oncorhynchus mykiss*			1		1
Sand shiner (SS)	*Notropis stramineus*				1	1
Tiger trout (TT)	*Salmo trutta* ♀ × *Salvelinus fontinalis* ♂			1		1
White sucker (WS)	*Catostomus commersoni*			8		8
	Total Fish	129	199	55	25	408

Table 1. *Fish taxa identified and corresponding total catch in the Little Bear River, Utah, 29 September 2012 and 4 October 2012.*

Station 2: In the Headwaters

Two Bonneville cutthroat trout, 64 brown trout, and 63 mottled sculpin were captured at Station 2, which produced the highest trout densities (individuals per 100 meters) and biomass among the reaches sampled (Figure 1). Although brown trout only outnumbered mottled sculpin by one fish, brown trout biomass at Station 2 vastly exceeded the other two taxa observed (Figure 1). Overall fish biomass at Station 2, which was 28.8 g m^{-2}, was markedly higher than any other reach. Depletion of brown trout and mottled sculpin was achieved by catching fewer individuals of each taxa during the second pass, which allowed for estimation of abundance. Brown trout abundance at Station 2 was estimated to be 100 individuals per 100 meters, with an estimated standard error of +/- 30. Estimated mottled sculpin abundance was 124 individuals per 100 meters with an estimated standard error of +/- 63. Although total fish biomass and estimated brown trout abundance were higher at Station 2 than any of the other reaches sampled on the Little Bear River, total fish catch per unit effort was highest at Station 4 (Figure 2).

Station 4: Near Avon

At Station 4 we captured one Bonneville cutthroat trout, 34 brown trout, and 163 mottled sculpin. More mottled sculpin were caught on the second pass than the first at Station 4, which eliminated the possibility of producing an abundance estimate for this species in this reach. Brown trout biomass decreased markedly from 27.6 grams per square meter at Station 2 to 5.0 grams per square meter at Station 4, despite maintaining the highest relative biomass (cf. Figure 1 and 2). Mottled sculpin biomass (g/m^2) decreased as well despite the increased catch. This reduction in fish biomass resulted from the increased surface area at Station 4, not from the total catch for the site. Estimated brown trout abundance in Station 4 was 67 fish, with a standard error of +/- 45 (Figure 3).

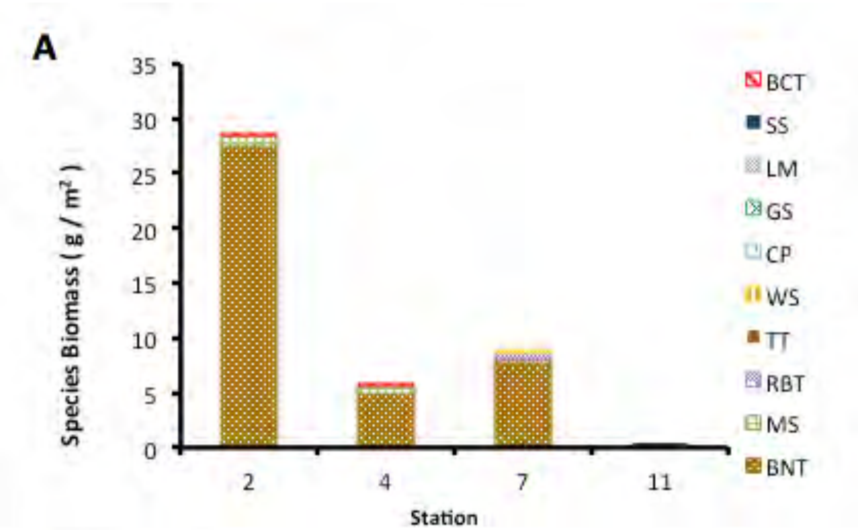

Figure 1. A. Biomass (g / m2) of all fish species collected in the Little Bear River. Note the general decrease in total fish biomass observed from Station 2 to Station 11. Total biomass at Station 11 was 0.17 g / m^2.

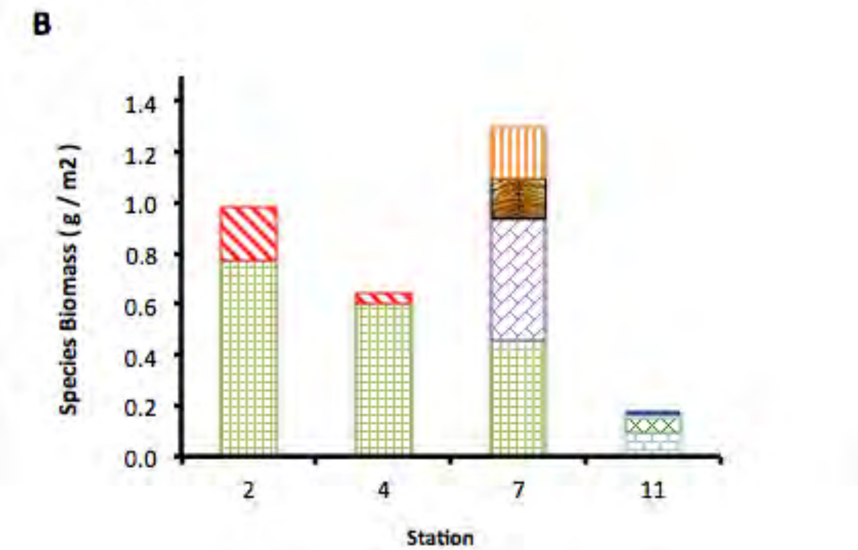

Figure 1. B. Biomass of fishes other than brown trout (Salmo trutta). Coldwater species dominated the assemblage at Stations 2 through 7, while at Station 11 the fish assemblage shifted to warm water species. Species codes are shown in Table 1.

Station 7: Below Hyrum Reservoir

The fish assemblage at Station 4 displayed the highest species diversity (five species) of any reach electrofished on the Little Bear River. However, the only native species captured at Station 7 was the mottled sculpin. Thirty-one brown trout and fourteen mottled sculpin were caught. The remainder of species captured were only observed at Station 7. These include tiger trout, rainbow trout, and white suckers (Table 1). Similar to Station 2, brown trout dominated the observed fish assemblage at Station 7 (Figures 2 and 3). Brown trout abundance in Station 7 was estimated as 33 individuals per 100 meters, with an estimated standard error of +/- 2.31, which was a reduction from densities in Station 4 (Figure 3). Station 7 was, however, considerably narrower than Station 4 (see Physical chapter), and consequently had less surface area.

Station 11: Mendon Bridge

An evident shift in the fish assemblage occurred at Station 11, wherein the cold-water species observed in upstream sites were no longer present (Table 1; Figure 2). Fish taxa captured in Station 11 were common carp, green sunfish, largemouth bass, and one sand shiner, and these were only present at this site.

Station 11 had the lowest observed fish biomass and densities of the four sites sampled. However, the backpack electrofisher did not appear to be stunning larger (> 200 mm) carp that were spotted by netters. Consequently, fish biomass may have been underestimated at this site.

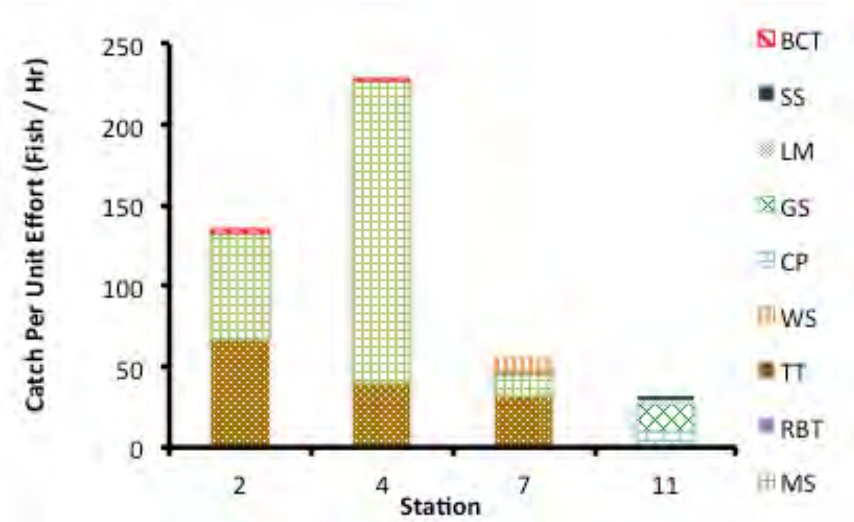

Figure 2. *Catch per unit effort (fish/hour) of each fish species captured at each station sampled during a backpack electrofishing survey of the Little Bear River, 29 September 2012 and 4 October 2012.*

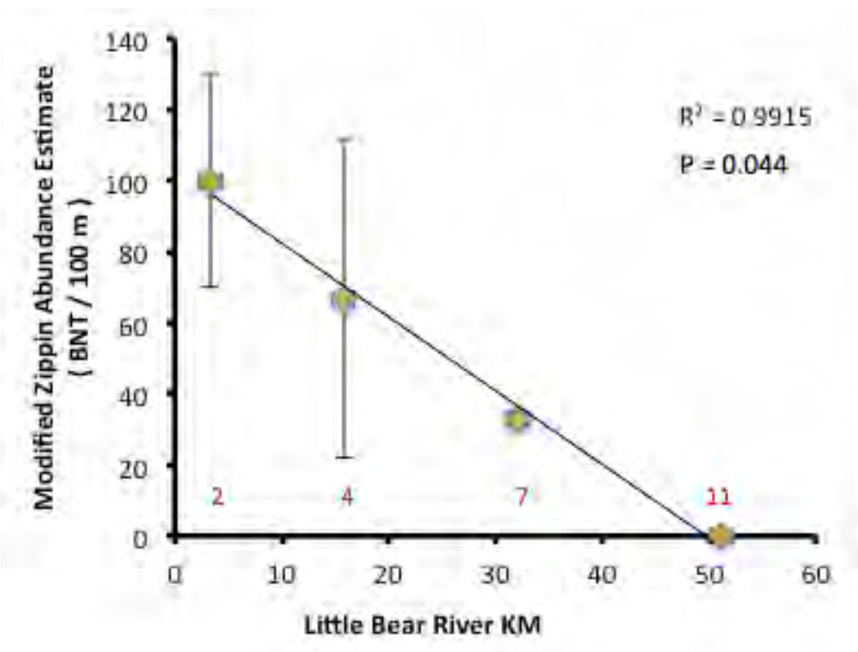

Figure 3. *Brown trout (Salmo trutta) abundance estimates at four sites along the Little Bear River longitudinal gradient. Abundance estimates were determined with the modified Zippin estimate. Station numbers are represented in red text above the horizontal axis. Location data courtesy of Marc Weston.*

Larger Scale Results

The Little Bear River fish assemblage was observed to undergo a shift from species that preferred cold water at Stations 2 through 7, to a warm water species composition at Stations 11. Identification of statistically significant relationships between habitat limiting factors, location, estimated fish abundance (fish 100 m^{-1}), and observed fish abundance ($hour^{-1}$) was limited to brown trout and mottled sculpin due to the higher observed abundance of these species. Linear regression of estimated brown trout abundance and position along the Little Bear River longitudinal gradient provided a statistically significant relationship ($R^2 = 0.99$, $p = 0.04$, Figure 3). This significant decline in trout density is consistent with the River Continuum Concept (RCC), which states that as rivers transition from low order headwater streams to higher order streams, the fish community is expected to change from "cool water species low in diversity to more diverse warm water communities" (Vannote et al. 1980). The presence of Hyrum Reservoir presents a discontinuity (*sensu* Ward and Stanford 1983) along the Little Bear River system, but its thermal influences to the river were not particularly evident (see chapter by A. Pappas). However, even at Station 11 mean July temperatures were <20°C, suggesting that trout could have inhabited the lowest reaches of the river. Consequently I attempted to determine other factors that might be influencing brown trout abundance in the Little Bear River.

Brown trout CPUEs at the four stations were negatively correlated with pebble sizes (Figure 4; $R^2 = 0.97$, $p = 0.014$). Corresponding average pebble size at each reach was 62, 45, 37, and 0.1 mm. The presence of spawning gravels is essential to the success of all salmonids (Spence and Hughes 1996), and gravels typically used for spawning range from 0.6 to 10.2 centimeters in size (Bjornn and Reiser 1991). The error bars displayed in Figure 5 indicate an increasing amount of variance that correlates higher CPUE with average pebble size, and suggest that while average pebble size is increasing at higher elevations in the watershed, there were many different sized pebbles within the sample.

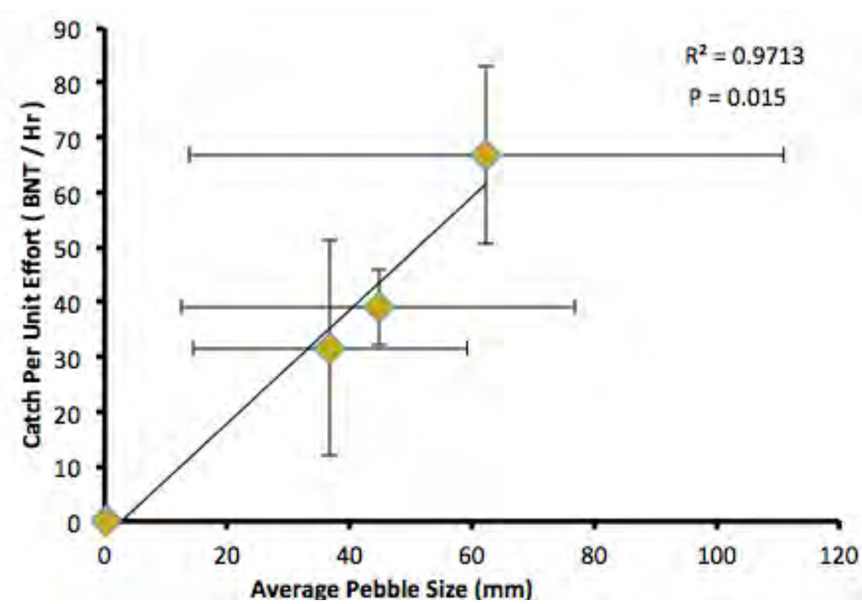

Figure 4. *Relationship between average pebble size and Brown trout (Salmo trutta) catch per unit effort. Pebbles were randomly collected then measured by Marc Weston at Stations 2, 4, 7, and 11. Corresponding average pebble size at each reach was 63, 45, 37, and 0.1 millimeters.*

DISCUSSION

The high proportion of nonnative fish observed in our sampling effort is a direct result of anthropogenic impact to the Little Bear River system, with only two of the ten species collected existing within their native range (Sigler and Sigler 1996). The 241 mottled sculpin caught comprised the majority of native fish observed in the Little Bear River, and neither native species captured in this study were observed at Station 11.

Brown trout are native to Europe and were introduced to the intermountain region in the late 1800s (Varley and Schullery 1998), however the source of introduction to the Little Bear River is unknown. If fisheries monitoring of the Little Bear River continues, the determination of source populations of nonnative fishes would help researchers determine important information pertaining to aquatic ecology, such as resource allocation and food web dynamics. Given the observed abundance, it could be assumed that brown trout are well established in the Little Bear River; however other sources could include the East Fork of the Little Bear River (http://www/ waterquality.utah.gov/watersheds/lakes/PORCUPIN.pdf).

Despite the observed low native trout densities, the brown trout abundances at Station 2 to Station 7 could indicate that the Little Bear River is not overly polluted (Elliot 1994). Additionally, the Little Bear River from Station 2 to Station 7 is an example of an unmanaged trout fishery that could be viewed as a reference for other streams where management has been intensive. Regional efforts to recover declining populations of native Bonneville cutthroat trout could benefit from information regarding this fish's presence in what appears to be a brown trout-dominated system.

Tiger trout, rainbow trout, and white suckers were only observed at Station 7 (Table 1), which as mentioned earlier, displayed the highest fish species diversity of any site on the Little Bear River. While the source of these species is unknown, the presence of white suckers is a possible sign of a transition to a warm water fish assemblage given this fish's wide range of thermal tolerance (Sigler and Sigler 1996). If deemed necessary and appropriate to future management, digging deeper into Utah Division of Wildlife Resources fish stocking report archives and possibly interviewing local fishermen and landowners might aid the determination of sources of nonnative trout introductions to the Little Bear River.

As with nonnative species at other sites investigated in the Little Bear River, the sources of introduction to Station 11 are unknown at this point in time. However, relatively extensive documentation of other warm water species in Cutler Reservoir suggest that fish may have moved upstream from this impoundment into Station 11 (Budy et al. 2011). Along with warm water fishes, cool water species such as walleye (*Sander vitreus*) are established in Cutler Reservoir and brown trout have also been collected there (Budy et al. 2011).

A notable absence in the observed fish assemblage was that of mountain whitefish (*Prosopium williamsoni*), which are commonly found in trout streams throughout the intermountain west. This might have been a result of our relatively small sample size. Other limitations that affected this study appear to be related to the backpack electrofisher. Multiple large common carp were missed at Station 11, with some spotted in congregations at the block nets by non-fishing students. If these fish were visible in the turbid water at this site, it seems likely that the electrofishing equipment might have missed more. I assume this reduction in gear efficiency was a result of the increased surface area, moderately high depth, and sandy substrate at Station 11.

Time limitations to this study allowed only two electrofishing passes per reach, which allowed us to sample more reaches. The consequence of this approach was the inability to estimate abundances for most species. However, sampling more reaches was assumed to provide a better indication of taxonomic presence or absence, wherein sampling the two sites below Hyrum Reservoir revealed seven additional taxa that had not been observed at Stations 2 and 4. If the goals of future research include quantification of these different species, I would recommend conducting at least three passes per reach, and sampling as many reaches as possible.

If fisheries investigation of the Little Bear River continues in the future, the sampling of stream macroinvertebrates to identify potential type and abundance of food sources for fish should be viewed as an important component. The positive relationship between larger average pebble size and higher brown trout abundance that I determined has also been observed with increased numbers of invertebrates in a Colorado stream (Allan 1975). Additionally, the increased assessment and quantification of stream macroinvertebrate communities in the Little Bear River would provide another biological indicator of overall stream health (Rosenberg et al. 1986). Future researchers are also encouraged to further investigate pebble size and other stream morphology parameters, including pool and riffle frequency. If the influence of pebble size and other morphological factors upon fish and macroinvertebrate abundance and species diversity in the Little Bear River could be determined and isolated, assessment of the potential effects of perturbations to fish and invertebrate communities in the Little Bear River by other sources such as increased nutrients would likely become more evident.

These findings also suggest that the Little Bear River has the potential to be viewed and managed as a trout fishing stream. Although the high proportion of private land along the river might limit the possibility of public access, the benefit of a healthy and productive trout stream to landowners and their property values could promote cooperative efforts with aquatic resource managers. Perhaps more important than the potential for recreational fishing, the close proximity of the Little Bear River to the Utah State University campus provides students and educators an ideal opportunity to apply science and sampling methods learned in the classroom to a stream ecosystem with a preexisting network of water quality monitoring stations and a noticeable level of human impact.

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APPENDICES

Photo 1. *Fish species captured at Station 11 on the Little Bear River. Starting at the top and moving counterclockwise the species are largemouth bass (Micropterus salmoides, common carp (Cyprinus carpio), and Sand shiner (Notropis stramenius).*

Photo 2. *Fish species captured at Station 7 on the Little Bear River. Clockwise from top-left: brown trout (Salmo trutta); mottled sculpin (Cottus bairdii); white sucker (Catostomus commersoni), and; rainbow trout (Oncorhynchus mykiss).*