Temperature and Discharge on a Highly Altered Stream in Utah's Cache Valley

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SUMMARY

To study the River Continuum Concept (RCC) and the Serial Discontinuity Hypothesis (SDH), I looked at temperature and discharge changes along 52 km of the Little Bear River in Cache Valley, Utah. The Little Bear River is a fourth order stream with one major reservoir, a number of irrigation diversions, and one major tributary, the East Fork of the Little Bear River. Discharge data was collected at six sites on 29 September 2012 and temperature data was collected hourly at eleven sites from 1 October to 20 October 2012. Discharge and temperature both increased as elevation declined to Hyrum Reservoir. After which point, temperature increased slightly and discharge dropped sharply for a period and then returned to similar patterns occurring above the reservoir. In addition to the data collected during our sampling efforts, a long-term temperature dataset available from the Internet was used to observe seasonal temperature changes. While seasonal temperature patterns were variable above the reservoir, the site below Hyrum Reservoir exhibited the strongest increase in temperature from winter lows to summer highs.

INTRODUCTION

Flowing from the southern edge of Cache Valley to Cutler Reservoir, the Little Bear River is a fourth order stream which has been modified for agriculture and to prevent flooding. Hyrum Reservoir is a 450 acre reservoir at 4,700 ft, located southwest of Hyrum, UT, and is the only major reservoir disrupting the flow of the Little Bear River (although another major reservoir lies upstream on the East Fork of the Little Bear River).

The River Continuum Concept (RCC, Vannote et al. 1980) is a framework for unmodified river systems (Statzner 1985) and the framework suggests that with downstream movement, rivers will increase in both discharge and temperature. Past work suggests that reduced riparian vegetation increases the amount of solar radiation penetrating the water column, and subsequently increases water temperature (Mohseni 1999). Additionally, stream discharge, also affected by downstream movement, can alter stream temperature (Beschta 1997). Along the Little Bear River, riparian vegetation has likely been reduced as agricultural use increased subsequent to settlement of the valley in the mid-1850s.

To test the predictions of the RCC, I looked at changes to water temperature and discharge along the longitudinal gradient of the Little Bear River. According to Statzner (1985), the changes predicted by the RCC might not fully explain the changes occurring along the longitudinal gradient of the Little Bear River because of the disruptions of Hyrum Reservoir and water diversions. To address this issue, another working hypothesis is often used, the Serial Discontinuity Hypothesis (SDH, Ward et al. 1983). The SDC specifically focuses on the effects of reservoirs and other disruptions to flow on temperature, discharge, pebble size, nutrients and others (Ward et al. 1995). The SDC suggests that reservoirs act to disrupt the otherwise normal changes to parameters as water moves downstream, and that after a transitional period
(distance downstream form the disruption), rivers should return to follow the predictions of the RCC. I utilized both conceptualizations of river function to interpret the physical parameters of the Little Bear River.

**STUDY AREA AND METHODS**

Our study area of the Little Bear River starts on the border of U.S. Forest Service land, south of Avon, UT, and extended to a site located just above Cutler Reservoir, near Mendon, UT. Sites were chosen to best be able to describe the influences of tributaries, water diversions and Hyrum Reservoir.

**Temperature Analyses**

I used both short-term and long-term temperature data to observe potential changes along the longitudinal gradient of the Little Bear River. To measure short-term temperature data, I used Onset’s Hobo Pro v2 Data loggers with an accuracy of plus or minus 0.21°C, which proved very good for this study. I placed six temperature loggers in mid-stream using rebar and two zip ties. The remaining four sites have data loggers in place for a study conducted independently by Utah State University. These stations were installed by USU many years ago to record long-term changes in water chemistry, temperature and other parameters. The first day of October, I placed temperature loggers at all the sites without temperature sensors in place from the USU study. My temperature loggers were left in the river for 20 days. During this period, air temperatures ranged from -5 to 10 °C, which is typical October weather in Cache Valley. Data from all of the temperature loggers were then uploaded using Hoboware into an Excel Database. I then collected the remaining data from each of the USU stations (http://littlebearriver .usu.edu/current/Default.aspx) and found that these data had been collected at 30 minute intervals, opposed to the 1 hour time intervals set on the HOBO loggers I had used. I then removed all of the appropriate half hour intervals to form a matching dataset. Maximum, minimum, and average daily temperatures were calculated and distance downstream of each sample location was calculated (See Chapter 1). To see if the RCC is valid from Station 1 to Station 11, I did a two tailed t-test to see if they were statistically different. This was done using Excel’s data analysis pack. I also repeated this process to see if Stations 6 and 7 were statistically different.

For the long-term temperature data from USU, I used Stations 3, 4, 5, and 11, as they were the only sites that had temperature data year round, for 2011. I used monthly average temperatures for these sites. Three of the four sites were located above Hyrum Reservoir while the forth site, the furthest downstream, was near the town of Mendon (see Figure 1 in Executive Summary). A two-tailed t-test was done to determine whether Stations 3 and 11 were similar in temperature. I then repeated this process to compare Station 3 to 4.

**Discharge Measurements**

Discharge in the Little Bear River varies from the headwaters to the entrance of Cutler Reservoir. I sampled six sites along the river: three sites above and three sites below Hyrum Reservoir. To measure flow I used the standard protocol of the USGS (Dickinson 1967). First I measured the wetted width of the steam. Depending on the width of the steam we took 25 to 10 velocity measurements at set intervals (Figure 1). Normally USGS uses a minimum of 15 velocity measurement but at Station 7 we were unable to take 15 velocity readings because the river was too narrow. When taking the velocity measurements,
the probe was placed at 60 percent of the waters depth to obtain a representative reading. In other words, if the water depth was 100 cm we would take the velocity reading at 40 cm off the bottom. For calculating discharge, I first found the cross sectional area of each square we produced by doing multiple velocity measurements. Then I calculated discharge by multiplying the cross sectional area by the average velocity of that section. To get the total discharge I then summed the discharges for all the cross sections.

Current-meter discharge measurements are made by determining the discharge in each subsection of a channel cross section and summing the subsection discharges to obtain a total discharge.

RESULTS

The short-term temperature data increased from Station 1 to 2 (Figure 2). From Station 1 to 6, temperature increased consistently. At Station 7, the first site downstream of Hyrum Reservoir, the average and minimum temperatures increased while the maximum stayed relatively consistent with Station 6. From Station 7 to 8 all temperature parameters dropped sharply, and then increased from there to Station 11. Diel fluctuations in temperature were large (Figure 3), with 4-5°C day-night changes at Station 1, and 5-6°C changes at Station 10.

Figure 1. Descriptive diagram of how discharge measurements were collected (http://ga.water.usgs.gov/edu/streamflow2.html).

Figure 2. Average, maximum and minimum daily temperature changes along the Little Bear River measured for a 20-day period from October 1 to 20, 2012. Station numbers are labeled above the X-axis. The grey bar shows the approximate location of Hyrum Reservoir along the gradient.
The long-term data showed a similar trend to that of the short-term data, in that temperature generally increased with downstream movement and increased most dramatically at Station 11 during summer months (Figure 4).

Discharge appeared to be negatively influenced by Hyrum Reservoir (Figure 5). From Station 6, the closest site upstream of Hyrum Reservoir, to Station 7, the first site below, discharge dropped from 0.58 to 0.03 cubic meters per second. Discharge then increased from Stations 7 to 11.

**DISCUSSION**

The short-term data from October suggest that both the RCC and SDH are appropriate theories for explaining trends in the Little Bear River. The increasing trend in temperature is typical of streams where there is a reduced ration of riparian cover to stream size. Additionally, the disruption of Hyrum Reservoir caused a sudden change in both temperature and discharge, followed by a slow reset period, and then these factors take on trends once seen above the reservoir. Other factors that could have played a part in temperature variation would be clear cutting of riparian vegetation for agricultural purposes, which causes
the solar input into the stream to increase and temperatures to increase (Beschta 1997; Mohseni 1999). The maximum and minimum temperature below Hyrum Reservoir, at Station 7, were closer together then the rest of the sites, indicating less diel variability in temperature. This could be due to were the water is discharged from the reservoir which could cause the water temperature to not vary throughout a day. This section also had a good canopy, at least where we sampled (see photo in Executive Summary). Similar to temperature, discharge increased with distance downstream, was disrupted by Hyrum Reservoir inducing an alteration from the increasing trend then returned to similar trends taking place above the dam. The exact source of the river recharge is unknown, but a small tributary enters the river near the city of Wellsville, and agricultural return flows also likely contributed.

In the evaluation of the long-term temperature data I found that each Station followed normal seasonal trends. To see if RCC was valid for long-term temperature data I compared Stations 3 to 11. I got a p-value of 0.049, indicating a significant increase in temperature. I then wanted to see if Station 3 was similar to Station 4 and they were also significantly different (p-value 0.016). The long term data must have other influence such as a diversion dam or other water inputs that causes the temperature to vary per month and per station. Having less water in the stream influences the water temperature (Mohseni 1999). With less water there are higher water temperatures, but as stated earlier, 2011 had higher than normal flows. This causes the river to have more normal flows, which in turn causes temperatures to be lower than during low-water years. Also with more snow pack we get more runoff from areas that do not normally have overland flow (Gebert et al. 1987). This could cause the statistics to show no relation from site to site. For 2011 we show that the RCC was not valid for long-term dataset because it’s a modified stream with many influences.

Some variability in these results may be attributed to inconsistencies in data collection. The online USU dataset was not consistent from month to month with the same number of readings. This could have been caused by errors with temperature readers, altered flows, or probes being fouled by debris. Working directly with the other researchers at USU would have helped to minimize some of these errors.

![Figure 5. Discharge along a longitudinal gradient of the Little Bear River measured on September 29, 2012. Station numbers are shown above the X-axis. Y-axis is discharge in cubic meters per second. The grey bar shows the location of Hyrum Reservoir.](image)
REFERENCES


