**Semester Project Progress Report**

1. **Problem:**

Our project is to model ways to improve Bonneville Cutthroat Trout (BCT) populations and habitat within the Little Bear River from Porcupine Reservoir, through Hyrum Reservoir, and to the river’s terminus into Cutler Reservoir. This project will analyze how reservoir releases affect the temperature suitability of BCT habitat.

1. **Literature Review:**

**Executive Summary: A River Continuum Analysis of an Anthropogenically-Impacted System: The Little Bear River, Utah**

Wayne A. Wurtsbaugh, Nick Heredia, Patsy Palacios, Jared Baker, Chance Broderius (2013)

<https://digitalcommons.usu.edu/cgi/viewcontent.cgi?article=1777&context=nrei>

Review of Resource: This study provided important insight into the physical and biological characteristics of the river and the impacts of surrounding agricultural and urban development. The development surrounding the Little Bear River has augmented its natural terrain and chemical attributes. The study focused on the variation in water temperature at key points or stations along the river. Additionally, the distribution of different fish species throughout the river was documented, highlighting the rarity of native species.

Our work aims to better understand the connection between water temperature variation along the river due to human interaction and the diversity of the fish community. Additionally, our work will focus on analyzing the urban and agricultural inflows and how to reduce their impacts. The chemical characteristics of the river directly impact Cutler Reservoir which eventually enters the Great Salt Lake. By studying this portion of this flow path to the Great Salt Lake, we will be able to better understand how to carry higher quality water to the lake and preserve the ecology of the Little Bear River.

**A Study of the Spawning Ecology and Early Life-History Survival of Bonneville Cutthroat Trout**

Phaedra Budy, Sara Seidel, David Koons, and Brett Roper (2012)

<https://digitalcommons.usu.edu/cgi/viewcontent.cgi?referer=&httpsredir=1&article=1394&context=wats_facpub>

Review of Resource: The study outlined in this report was done through Utah State University and was performed largely during the 2008 spawning season for Bonneville Cutthroat Trout (BCT). The study was performed on the Logan River and its major tributaries in Logan Canyon. The researchers were able to study impacts of water temperature on BCT during different stages of development. They found that the characteristics of BCT spawning such as magnitude, duration, and frequency were controlled by river hydrology. They saw responses in spawning depending on temperature fluctuations as well.

Even though this research was performed on the Logan River, since our project is in the same region and deals with the same species, we hope to use some of the information they found in creating our model. We hope to create a relationship between releases of water from Hyrum Reservoir and the hydrology/temperature of the river between there and the Great Salt Lake. We can then tie the reservoir releases and river conditions to predicted impacts on fish in the system.

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

Andy Pappas (2013)

<https://digitalcommons.usu.edu/cgi/viewcontent.cgi?article=1780&context=nrei>

Review of Resource: This literature focused on temperature and discharge variation along the Little Bear River, from its headworks to its entrance into Cutler Reservoir. Discharge and temperature in the river increased as elevation declined to Hyrum Reservoir. The strongest increase in temperature was recorded at a point below the reservoir across all seasons. Another important finding from this study was the impact of flow levels on water temperature. The diversions along the river and the interruption of Hyrum Reservoir cause unnatural characteristics in the Little Bear River.

Our research and work will focus on understanding what flows and characteristics must be maintained in the river to restore it to a more balanced state. By analyzing the impact of diversions, interruptions, and releases in the river, progress can be made toward creating a stabilized habitat for aquatic species within this stretch of the Little Bear River.

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

Christian Smith (2013)

<https://digitalcommons.usu.edu/cgi/viewcontent.cgi?article=1786&context=nrei>

Review of Resource: This Utah State University study, performed in 2012, investigates the impacts that human activities have had on the Little Bear River. They captured fish at different stations along the river, as well as took samples of the pebbles and other aggregates at each location. They included sample locations above and below Hyrum Reservoir, noting that Hyrum Reservoir presents a significant barrier to fish passage. The report notes that up to that point, there was not much documentation on fish populations on the East Fork of the Little Bear River and that their study in part aimed to be a baseline study that could be referred back to in the future.

Our model would hope to use the data on fish populations in the reaches downstream of Hyrum Reservoir. When we run the model and see the results of water releases from the dam, we can compare these new data to the old data from this study and measure the impact that the releases have on the ecosystem of the Little Bear River. These comparisons would show if certain changes in releases and/or management are “worth it” or not based on the changes they cause.

**Algal Nutrient Limitation throughout the Little Bear River Watershed**

Jared Baker (2013)

<https://digitalcommons.usu.edu/cgi/viewcontent.cgi?article=1783&context=nrei>

Review of Resource: This study was completed by Jared Baker as part of the broader study “A River Continuum Analysis of an Anthropogenically-Impacted System: The Little Bear River, Utah”. This portion of the study focuses on the water chemistry of the Little Bear River and the reasons for algal growth within the river. Based on the testing, it was determined that “anthropogenic” activities, such as wastewater discharge and agricultural runoff, within the watershed were the greatest contributors to nutrient levels and algal growth in the river.

Both nitrogen and phosphorus were identified as limiting components of algal growth. If water managers understand the nutrient levels present in the river, then land use practices could be adjusted to change the productivity of the stream. These processes would improve the quality of water being sent from the Little Bear River Watershed into Cutler Reservoir; thus, the fish population and habitat would be directly affected by these water quality improvements.

Our project seeks to better understand the watershed inflows to the Little Bear River and how they are affecting the quality of the water being sent to Cutler Reservoir. Fish ecology is directly affected by water quality, thus identifying points of pollution in the watershed will aid in our goal of improving the fish habitat. The results of this study will help us to recommend solutions to reduce eutrophication and algal growth through better management of urban, wastewater, and agricultural flows into the river.

**Systems modeling to improve river, riparian, and wetland habitat quality and area**

Ayman H. Alafifi, David E. Rosenberg (2017)

<https://www.sciencedirect.com/science/article/pii/S1364815218305309>

Review of Resource: This study looks at the impacts of water releases and revegetation on aquatic and wetland habitats. They saw that there were other impacts on habitat that came from more than just additional water releases. The study found winter releases (from December to March) to be especially important. These releases make room for capture in the spring runoff, minimizing spill. This also protects from flooding events in the spring runoff that could kill fish eggs or fry.

Our model can build on the initial findings of this study, by attempting to specifically quantify the impacts of winter releases of water on the fish population. The model we create will also indicate how meeting and/or exceeding minimum requirements of delivery to Cutler Reservoir/GSL will aid the fish population and create other benefits. Our scope is more limited and will not be looking at vegetated areas/wetland habitats and instead will focus strictly on the aquatic ecosystem.

1. **Model Formulation:**

***Model Decisions Variables***

1. Water Releases from Porcupine Reservoir (acre-ft per time)
2. Water Releases from Hyrum Reservoir (acre-ft per time)
3. Irrigation Drainage into River – Runoff from irrigation chosen to re-enter the river (acre-ft per time)
4. Irrigation Water Removed from River (acre-ft per time)
5. Industrial/Sewer Releases into River – Treated waste water allowed to re-enter the river (acre-ft per time)
6. Water Sent to the Great Salt Lake from the Cutler Reservoir (acre-ft per time)

***Model Objectives***

1. Decrease Water Temperature below Porcupine and Hyrum Dams in Summer Months (Degrees Fahrenheit)

***Model Constraints***

1. Reservoir Capacity - Capacity in Hyrum Reservoir and Porcupine Reservoir (acre-ft)
2. Reservoir Retention – Minimum required amount of water to be retained in Hyrum Reservoir and Porcupine Reservoir (acre-ft)
3. River Water Levels/In-Stream Flow – Minimum flow requirement in Little Bear River (cfs)
4. Irrigation Demands (acre-ft per time)
5. Industrial Demands (acre-ft per time)
6. Municipal Demands (acre-ft per time)
7. Nutrient Levels in Water – Maximum safe levels of nutrients in water (mass per volume)
8. GSL Water Demand from Bear River – Minimum releases from Cutler Reservoir to GSL (acre-ft per time)
9. Inflows to Reservoirs (acre-ft per time)
10. **Major Findings to Date**

One important consideration we discovered was that Porcupine Reservoir is owned and managed by the Porcupine Reservoir Company. This is important information when considering stakeholder and water manager objectives within the project’s scope. These objectives will help us understand when and why reservoir releases are performed.

Another important finding for our project was information on the water temperature of BCT habitats in the Little Bear River. Alafifi and Rosenberg (2020) state that “the lower elevation Bear River main stem has warmer summer water temperatures that reach 26 degrees Celsius. The higher elevation Little Bear and Blacksmith Fork rivers have cooler water temperatures that do not exceed 22.5 degrees Celsius (Watershed Sciences, 2007). Johnstone and Rahel (2003) report that water temperature at or above 25 degrees Celsius could be lethal for BCT...Currently, BCT is only abundant in the headwaters of the Blacksmith and Little Bear rivers (DeRito, pers. comm., 2016).” This information will allow us to formulate our objective function to minimize the number of times the water temperatures downstream of Hyrum and Porcupine reservoirs exceed 25 degrees Celsius.

1. **Steps To Finalize Project**
2. Formulate Model In GAMS
3. Run Model and Iterate to Check Correctness
4. Model Verification with Dr. Rosenberg
5. Summarize model formulation in writing and describe the results and recommended solutions.
6. **Potential Challenges**
7. Correct Model Formulation in GAMS
   1. Objective Function
   2. Covering all necessary constraints
   3. Using accurate data to simulate reservoir operation
   4. Reservoir Mass Balance Equation for Multiple Reservoirs
8. Understanding How to Model Water Temperature Variation – X amount of release causes Y change in water temperature. How do we establish this relationship? Is it linear? What sort of database could we access to select the relationship?
9. Correctly Interpreting the Changes in Reservoir Operation in terms of BCT Habitat Benefits
10. Representing Human Water Demands in Model
11. Finding accurate water temperature data for river and reservoirs. USGS gage stations provide discharge information and no temperature data.