Impacts of food availability on cutthroat trout growth and density in selected streams of similar size in the Big Creek drainage.

Undergraduate Research
Presented to: Charles DeVlieg Award Committee

Prepared by:
Jesse Davis

Department of Fish and Wildlife Resource
College of Natural Resources
University of Idaho
Moscow, ID 83843

Mentored by: Brian Kennedy, Ph.D.

September 24, 2006

Abstract

Throughout the years fish populations have been experiencing increased disturbances. Human impact plays a major role in the depredation of wild fish populations. I chose to conduct my research in a wilderness setting removed from human impacts. This setting provided an opportunity to study the variability of fish population dynamics under natural conditions.. Data collection for my research included sampling diet content using gastric lavage techniques and taking fish size measurement (weight and length). Data were collected at three different time periods (June, July, and August) in three independently selected streams Within Idaho's Frank Church River of No Return Wilderness. Analyses of my data showed that there was no significant change if fish size over the summer, growing season. My data also found one stream to have a significant difference in terrestrial insect contribution to westslope cutthroat diets with terrestrial insect consumption increasing later in the growing season. I found that there was no relationship between the amount of terrestrial insects consumed and fish size. This implies that terrestrial inputs represent a significant but variable contribution in fish diets. This research may help with Quantifying the effects of changing resources on a population which can allow us to understand and predict not only a focal species' *response* to depressed or elevated resources in the future; but also how shared resources are partitioned in a fish community and how that species or community may be impacted by a non-native invader. From a management perspective, this research may prove useful since studies of salmonids are frequently interested in the question of whether increasing food resources leads to bigger fish or more fish. It is crucial to understand the production level at which native fish populations, such as those populations evaluated by this study in a pristine environment, are able to thrive and maintain such a healthy status

TABLE OF CONTENTS

Introduction

With limited space, limited food resources and broad overlap in diet, competition among juvenile salmonids is inevitable (Hilderbrand and Kershner 2004). When species distributions overlap and there is competition for resources, there are consequences both for the individuals and the populations (Allan 1995). At the scale of the individual, direct competition for limited resources can lead to depressed growth, higher risk of mortality, and increased emigration from a site. At the scale of the population, competition can lead to higher variation in growth and depressed overall abundance (Begon et al. 1986). As an important first step in understanding the impacts of competition on a species, the relationship between a species and its resources in the environment must first be understood and whether changing amounts of resources in the environment elicits a functional (e.g. changes in individual size) or numerical (e.g. changes in density) response.

Throughout the Pacific Northwest, native salmon and trout species have coexisted in streams and rivers for thousands even tens of thousands of years (National Research Council 1996). During this time regional populations of salmon and trout have adopted behavioral and life history mechanisms for sharing space and resources. Few aquatic environments exist where we can study the undisturbed results of evolution and coexistence that have been shaped by the impacts of competition that are not confounded by impacts of humans.

Much of the trout habitat in the Middle Fork of the Salmon River represents an isolated patch of resistance from these impacts. As such, tributaries of the Middle Fork represent one of the best places in which to study the extent to which native trout species track their resources. In Big Creek, that drains into the Middle Fork of the Salmon River, westslope cutthroat trout (*Oncorhynchus clarki lewisi*) (WCT) share habitats with anadromous Chinook salmon and steelhead as well as rainbow trout, bull trout, mountain whitefish, and sculpin. Long term studies of anadromous salmon in this region have identified spatial and temporal trends in population sizes through passive-integrated transponder (PIT) tags (Achord et al. 2003, Zabel and Achord 2004), however much less is known about the dynamics of native trout in this area. In general, there are few published studies that seek to understand the abiotic and biotic factors, such as temperature, spawning habitat, food availability and competition that limit the distribution of WCT and control their abundance across their entire range (Platts 1979, Rieman and Dunham 2000). Westslope cutthroat trout feed primarily on macroinvertebrates, particularly immature and mature forms of aquatic insects as well as terrestrial insects. Much exemplary work has been done on the macroinvertebrate community in this region (e.g. Minshall and Robinson 1998, Minshall et al. 2001).

Along with food availability there are many factors that may influence the growth and density of individual fish and fish populations (Diana 2004, Young 2001). Other growth limiting factors may include; temperature, cover habitat, competition, and predators (Young 2001, Kennedy et al. *In prep*). One summer of investigation could not address all of these factors, so I chose to look explicitly at food availability because a) food is often considered a limiting factor for recruitment in fish populations (Boss and Richards 2002), b) the impacts of food resources can be modified or integrated with other factors (e.g. if competition is highest in resource poor environments), and c) current food resources can be effectively linked to historical data from Big Creek tributaries and ongoing research in the area.

Objectives and hypotheses

1) Quantify diet of cutthroat trout.
2) Measure length and weight of cutthroat trout in sampled streams
3) Determine if aquatic or terrestrial macroinvertebrates are more important in cutthroat trout diets
4) Quantify changes in size of cutthroat trout inhabiting stream through out the sample period.

My testable hypotheses are:

H1: Fish size will increase over the course of the growing season

H2. As fish grow and terrestrial insects become more abundant, diets will shift to reflect a larger contribution of terrestrial inputs.

H3 Terrestrial contribution is larger for bigger fish both spatially and temporally.

Study Area

The area in which I conducted this research is the Big Creek drainage near Taylor Ranch Field Station, which is located in the middle of the Frank Church River of No Return Wilderness. This wilderness comprises of nearly 2.4 million acres, making it the largest wilderness in the lower 48 states. My research was conducted in 3 independent stream reaches, Pioneer Creek, Cliff Creek and Cougar Creek. A 100 meter reach was sampled in each creek. Due to the small amounts of human activity in this wilderness area it provides for an excellent comparison to more human dominated or managed environments. Due to the nearly untouched ecosystem this wilderness has to offer, this research is vital in understanding such a wild population that does not encounter any non-native competitors. Habitat quality of native salmonids is an area of concern due to the higher rates of decline seen in many fish populations worldwide.

Methods

My methods for objectives were:

1) In order to gather measurements of individual fish they were captured by night snorkeling and netting the fish. After fish were collected they were anesthetized using tricaine (MS-222), so length and weight measurements could be taken. Weights were recorded using an electronic balance and measured to the nearest 0.01g, and length measurements were recorded to the nearest millimeter using a standard metric ruler (Hilderbrand and Kershner, 2004). These procedures will be performed three different times over the course of the study (June, July, and August). Night snorkeling was selected for collection because of the increased sight and capture success. Della Croce (2005) found that more fish were seen at night Big Creek. With the combination of increased sighting of fish at night and fish "freeing" in place in the stream when shined with the headlamp rather than spooking, my catch success high and few fish were not sampled due to errors in my capture technique.

2) Diet samples of fish were taken during the same times that length and weight measurements were recorded. While fish were anesthetized gut samples were obtained from each individual captured. Gut samples were collected by using gastric lavage techniques, a form of noninvasively pumping stomachs, and then storing the contents in a 70% ethanol solution for later identification under a dissecting microscope. Diet samples were conducted three times throughout the study (June, July, and August).

3) The importance of terrestrial macroinvertebrates in cutthroat trout diets was determined by sorting through diet samples. Diet matter was separated into three categories (aquatic, terrestrial and unidentifiable matter). Each separate category of the diet content was

then placed on pre-weighed tinfoil and placed in a drying oven. The dried samples were then weighed to the nearest .0001g to determine the biomass of each category for each diet sampled.

4) Changes in size of cutthroat trout were determined from the weights and lengths of all fish sampled. By looking at variation in size of cutthroat trout sampled it was determined if there was any changes in average fish size throughout the sample period.

Analyses

An Analysis of Variance (ANOVA) was used to determine the significance of any change in weight of fish throughout the growing season, as well as the change in terrestrial insect abundance in diets throughout the growing season.

A regression was used to determine the significance of the relationship between terrestrial insect contributions being larger in bigger fish. A 95% confidence interval was used for both statistics.

Results

There was no significant change in fish size over the course of the growing season ($p>.05$, Table 1). This was determined by comparing fish size across each sample period (May, June, and July) within each sample site (Figure 1). Fish weight was used for analyzing changes in fish size. Since there was a strong relationship with weight and length data for the fish sampled ($R=0.9370$, $p= 3.0293E-85$) choosing one over the other for analysis would not influence my data.

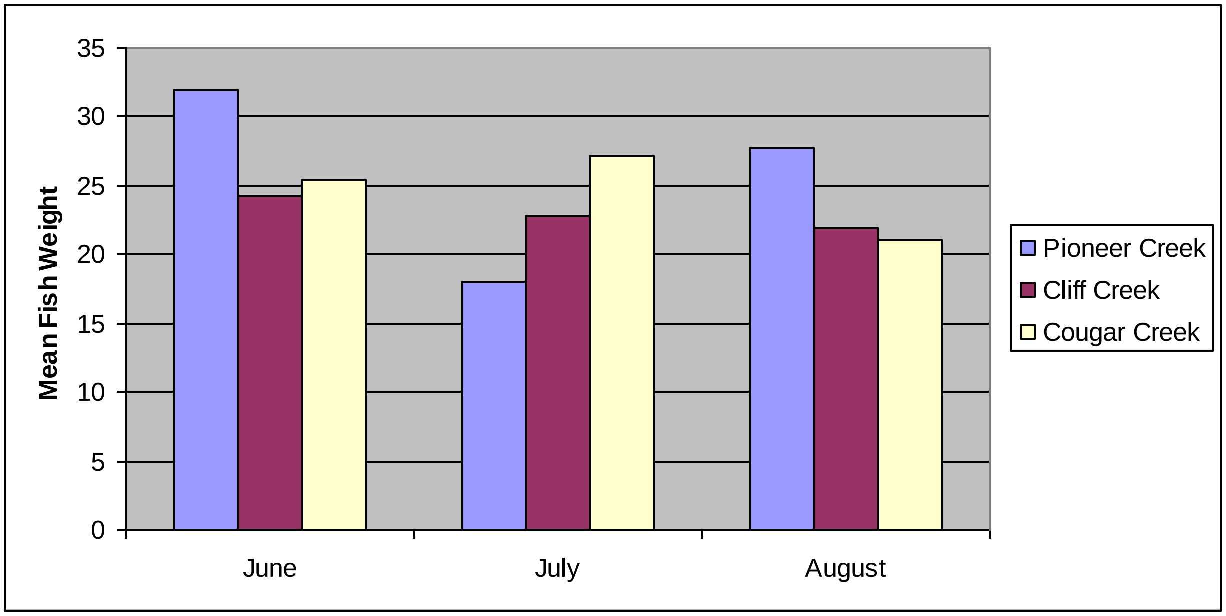

Figure 1. Average weights for fish sampled each month in each sample site.

ANOVA: Change in fish weight over the summer

Pioneer Creek	
F	1.3259
p-value	0.2812
Cliff Creek	
F	0.0811
p-Value	0.9222
Cougar Creek	
F	0.5518
p-value	0.5808

Table 1. Average weights for fish sampled each month in each sample site.

Later in the growing season as fish are expected to grow and terrestrial insect abundance increases, it was predicted that fish diets would shift to reflect a larger contribution of terrestrial inputs. The ANOVA tests expressed no significant increase in terrestrial contribution to fish diets throughout the sampling period for Pioneer Creek (p=.4246) and Cougar Creek (p=0.6736). There was, however, a significant increase in terrestrial contribution in diets sampled from Cliff

Creek (p=0.0003, table 2). This implies that terrestrial inputs always, across sample points, represent a significant but variable contribution in fish diets.

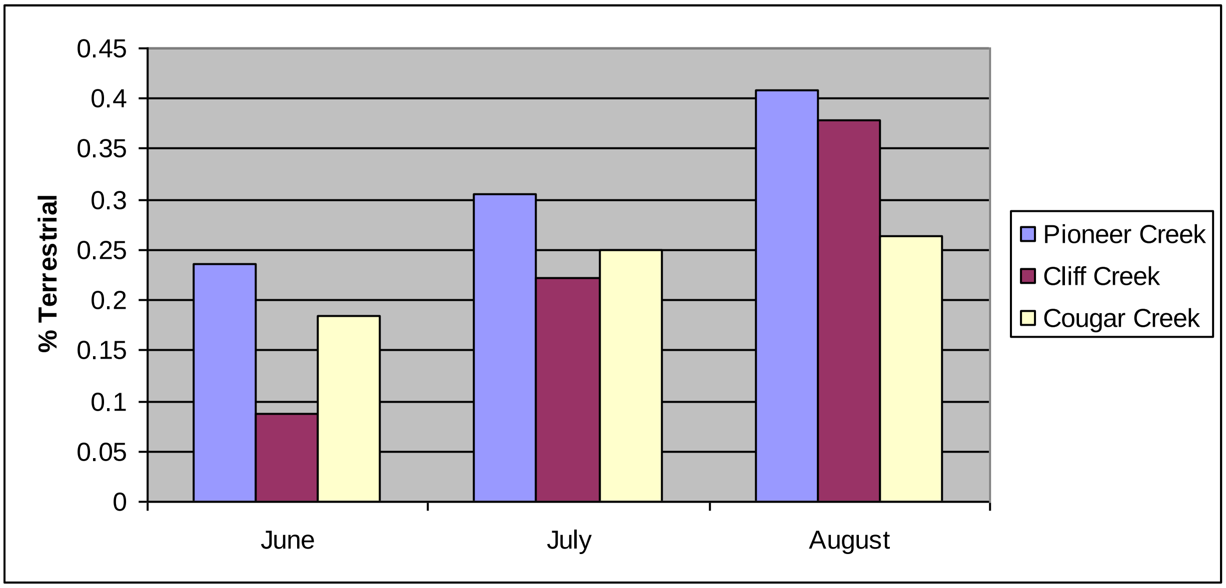

Figure 2. Average percent terrestrial contribution in diets sampled each month at each site.

ANOVA: Change in % Terrestrial consumption over summer

Pioneer Creek	
F	0.8894
p-value	0.4246
Cliff Creek	
F	10.1569
p-value	0.0003
Cougar Creek	
F	0.4010
p-value	0.6736

Table 2. Average percent terrestrial contribution in diets sampled each month at each site.

When trying to determine whether terrestrial contribution is larger for bigger fish my tested hypothesis was proven false. Terrestrial contribution was not larger for bigger fish (p>0.05, Table 3). This was determined by doing a regression of the percentage of terrestrial contribution in the diet against the weight of each fish (Figure 3). Regressions were done for each sample date at all sites. My results expressed that proportionally there was no significant difference in the percentage of terrestrial consumptions between different sized fish. However, statistical analyses for August in Cougar creek proved there to be a significant relationship between terrestrial consumption and fish size (p=0.0329, Table 3). The sample from July in Cliff Creek was close to expressing a relationship between terrestrial consumption and fish size (P=0.0550, Table 3). These statistical values represent the predicted relationship of terrestrial contribution being greater for larger fish.

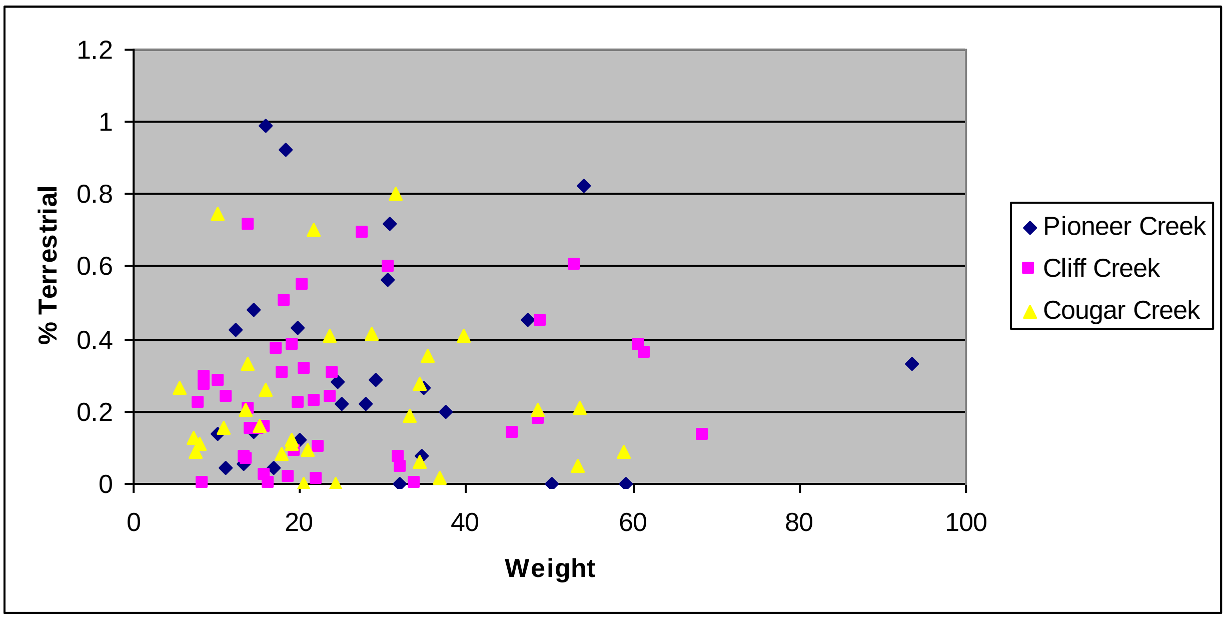

Figure 3. Percentage of terrestrial contribution in diets and weights for corresponding fish.

Regression: Weight vs. Terrestrial

	June	July	August
Pioneer Creek			
F	0.2085	0.0116	0.0014
p-value	0.2088	0.4715	0.1112
Cliff Creek			
F	0.3599	6.6994	1.6900
p-Value	0.3408	0.0550	0.0829
Cougar Creek			
F	0.1122	0.2816	0.0123
p-value	0.2619	0.2484	0.0329

Table 3. Percentage of terrestrial contribution in diets and weights for corresponding fish.

Discussion

The limitation on my hypotheses is that fish size did not change, so it could be argued that terrestrial inputs not changing is a function of always having large fish in the population. No change in fish size may lead to the conclusion that emigration/immigration may be more important as habitat changes. Influential habitat changes would occur as a result of seasonal disruptions such as flooding during runoff or ice formation in winter.

While night snorkeling I did not observe significant changes in fish size or numbers. In Cougar Creek, however, I did notice three individuals that were of spawning size during the sample periods of June and July but they were not present during the August sample period. This was the only observation of any significant change in my sites. My data is may be bias by the length of my study sites in each stream sampled, which was only 100 meters. Due to the size of my study site my data may not account for any possible in-stream movement in and out of my study sites. My sampling techniques may also have produced some bias toward fish size data. Due to my techniques for capture and the size of fish I was targeting for sampling gut content I avoided large fish (>200 mm) and smaller fish (<100). Therefore individuals falling in these categories generally were not accounted for. However, during my snorkeling surveys I did not observe any significant difference in the presence of individuals greater than 200 mm and smaller than 100 mm across each sample date and site. Therefore my data is a good representation of the fish populations present in site.

Although there was not a level of significant difference expressed by the P-values for Pioneer Creek and Cougar Creek the averages for the percentage of terrestrials consumed expresses an increasing relationship. A reason for this relationship not being significant may be a result in my small sample size. If my sample size was larger a a stronger relationship may be expressed in both Pioneer and Cougar Creek

My personal observations while in the field were that there was an increase in terrestrial inputs. An example would be the increase in grasshopper abundance as the summer months passed, with the least amount present in June and the most in August. To better support my data drift and benthic sample data will be acquired from a project still in progress to get a better understanding of food availability. This will allow for a comparison of what food was available and what was consumed.

Acknowledgements

Brian Kennedy, Jim and Holly Akenson, Colden Baxter, Cinnamon Robinson, Rachel Wilkinson, Neal Richards, Sara Jones and Melissa Lamb.

Literature Cited

Achord, S., Levin, P.S., and Zabel, R.W., (2003). Density dependent mortality in Pacific salmon: the ghost of impacts past? *Ecology Letters*, Issue 6, Pages 335-342.

Adams, S.B., Frissell, C.A., and Rieman, B.E., (2002). Changes in the distribution of nonnative brook trout in an Idaho Drainage over two decades. *Transactions of the American Fisheries Society*, Volume 131, Pages 561-568.

Allan, J.D., (1995). Stream Ecology. *Structure and Function of Running Waters*. Chapman & Hall Publishing.

Begon, M, Harper, J.L. and Townsend, C.R., (1996). Ecology: Individuals, Populations and communities, Third ed. Blackwell Scientific Publications.

Boss, S.M., Richardson, J.S., (2002). Effects of food and cover on the growth, survival, and movement of cutthroat trout (Oncorhynchus clarki) in coastal streams. *Canadian Journal of Fisheries and Aquatic Sciences*, Volume 59, Issue 6, Pages 1044-1053.

Bryant, M. D., Zymonas, N. D., Wright, B.E., (2004). Salmonids on the fringe: Abundance, species composition, and habitat use of salmonids in high-gradient headwater streams, southeast Alaska. *Transactions of American Fisheries Society*, Volume 133, Issue 6, Pages 1529-1538.

Della Croce, P., (2005). Unpublished Document.

Diana, J., (2004). *Biology and Ecology of Fishes, Second ed*. Cooper Publishing LTD.

Hilderbrand, R.H., Kershner, J.L., (2004). Are there differences in growth and condition between mobile and resident cutthroat trout? *Transactions of American Fisheries Society,* Volume 133, Issue 4, Pages 1042-1046.

Hilderbrand, R. H., Kershner, J. L., (2004). Influence of habitat type on food supply, selectivity, and diet overlap of Bonneville cutthroat trout and nonnative brook trout in Beaver Creek, Idaho. *North American Journal of Fisheries Management*, Volume24, Issue 1, Pages 33-40.

Kennedy, B. P., Klaue, B., Blum, J. D., and Folt, C. L., (2004). Integrative measures of consumption rates in fish: expansion and application of a trace element approach. *Journal of Applied Ecology*, Issue 41, Pages 1009-1020.

Kennedy, B.P., Nislow, K.H., and Folt C.L., (2004). *In preparation for Ecology (manuscript available).* Establishing the links between consumption, growth and survival for juvenile Atlantic salmon (*Salmo salar*).

Minshall, W.W. and C. T. Robinson., (1998). Macroinvertebrate community structure in relation to measures of lotic habitat heterogeneity. Archiv fur Hydrobiologia 141: 129-151.

Minshall G.W., Robinson, C.T., Lawrence, D.E., Andrews, D.A., and Brock, J.T., (2001). Benthic macroinvertebrate assemblages in five central Idaho (USA) streams over a 10-year period following disturbance by wildfire. *International Journal of Wildland Fire*, Volume 10, Issue 2, Pages 201-213.

National Research Council, (1996). Upstream: Salmon and Society in the Pacific Northwest. National Academy Press, Washington, D.C.

Rieman, B.E., and Dunham, J.B., (2000). Metapopulations and salmonids: a synthesis of life history patterns and empirical observations. *Ecology of Freshwater Fish*, Issue 9, Pagees 51-64.

Rosenfeld, J. S., Boss, S., (2001). Fitness consequences of habitat use for juvenile cutthroat trout: energetic costs and benefits in pools and riffles. *Canadian Journal of Fisheries and Aquatic Sciences*, Volume 58, Issue 3, Pages 585-593.

Young, Kyle A., (2001). Habitat diversity and species diversity: testing the competition hypothesis with juvenile salmonids. *Oikos*, Volume 95, Issue 1, Pages 87-93.

Zabel, R.W., and Achord, S., (2004). Relating size of juveniles to survival within and among populations of chinook salmon. *Ecology*, Issue 85, Pages 795-806.