Impacts of diet on cutthroat trout growth in selected streams of similar size in the Big Creek drainage.

Undergraduate Research

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Abstract

Fish populations experience a number of natural and anthropogenic disturbances. Because of the tremendous impact that humans can have on aquatic systems, it is likely that their disturbances can play a major role in the decline of wild fish populations. In order to understand the magnitude of human impacts on fish populations, it is necessary to study fish in settings that have been relatively unimpacated. I conducted my research in a wilderness setting that provided an opportunity to study the variability of fish population dynamics under natural conditions. My research addressed the temporal and spatial variability in diet composition of cutthroat trout (Oncorhynchus clarki lewisi) in Big Creek, Frank Church River of No Return Wilderness Area (FCRNRW). Data collection for my research included night-time snorkeling to capture fish, 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 streams within the Big Creek drainage near Taylor Ranch Research Station. Analyses of my data showed that there was no significant change in fish size over the summer growing season in any site. I found that there was no relationship between the terrestrial contribution to fish, and fish size. Terrestrial diet items represented a relatively uniform and significant contribution to fish forage. Terrestrial insect contribution to westslope cutthroat diets increased over the course of the growing season in only one of three sites. My diet research showed that both terrestrial and aquatic insects were important components of westslope cutthroat trout diets throughout the summer. 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 researchers 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

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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, behavior and trophic relationships 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 review*). One summer of investigation could not address all of these factors, so I chose to look explicitly at food consumption 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

The overall objectives of my research were:

1) To quantify changes in the size structure of cutthroat trout populations over time.
2) To describe the spatial and temporal variation in cutthroat trout diets in different streams of the Big Creek basin.
3) To compare the relative importance of aquatic or terrestrial diet items for cutthroat trout.
4) To quantify changes in trout diet as a function of time and fish size.

My testable hypotheses are:

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

H2: Fish diets will vary spatially to reflect distinct and different food webs at different streams.

H3. Larger fish will depend more on terrestrial resources in their diet than small fish.

H4. As fish grow and terrestrial insects become more abundant later in the growing season, diets will shift to reflect a larger contribution of terrestrial inputs.

Study Area

I conducted this research on tributaries of Big Creek near Taylor Ranch Field Station, which is located in the middle of the Frank Church River of No Return Wilderness. This wilderness comprises nearly 2.4 million acres, making it the largest wilderness in the lower 48 states. Taylor Ranch Field Station is located at about 3800 ft. This country is steep with deeply dissected and complex terrain with relatively low annual precipitations at 37cm (14.5 inches). My study sites occurred in areas with deciduous riparian vegetation. Upland plant communities included Douglas fir (*Pseudotsuga menziesii)*, Ponderosa pine (*Pinus ponderosa)*, mountain mahogany (Cercocarpus ledifolius), and bunch grass. This pristine environment supports a diverse community of native fish species including anadromous Chinook salmon and steelhead as well as rainbow trout, bull trout, mountain whitefish, and sculpin. Nonnative fish species currently are not present in the system. My research was conducted in 3 independent second order stream reaches, Pioneer Creek, Cliff Creek and Cougar Creek. A 100 meter reach was sampled in each creek.

Methods

In order to accomplish the study objectives, the following methods were employed.

1) Fish were captured randomly by night snorkeling and netting fish in the order in which they were encountered. 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 were 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 in Big Creek. With the combination of increased sighting of fish at night and fish seizing in place in the water column when shined with the headlamp rather than spooking, my catch success was high.

2) While fish were anesthetized diet samples of fish were obtained from each fish during the same times that length and weight measurements were recorded. Diet samples were collected by using gastric lavage, a nonlethal method for pumping stomachs. For this procedure I used a 10 cc syringe with a short piece of soft plastic tubing extending off of the end to carefully slide down the throat of the fish and force water into their gut cavity causing stomach contents to be regurgitate. Samples were stored 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 and fish. A regression was used to assess the relationship between fish length and weight. A 95% confidence interval was used for both statistics.

Results

The fish sampled had an average weight of 26.37 grams (± 16.35g.) and an average length of 133.42 mm (± 26.13mm). 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.

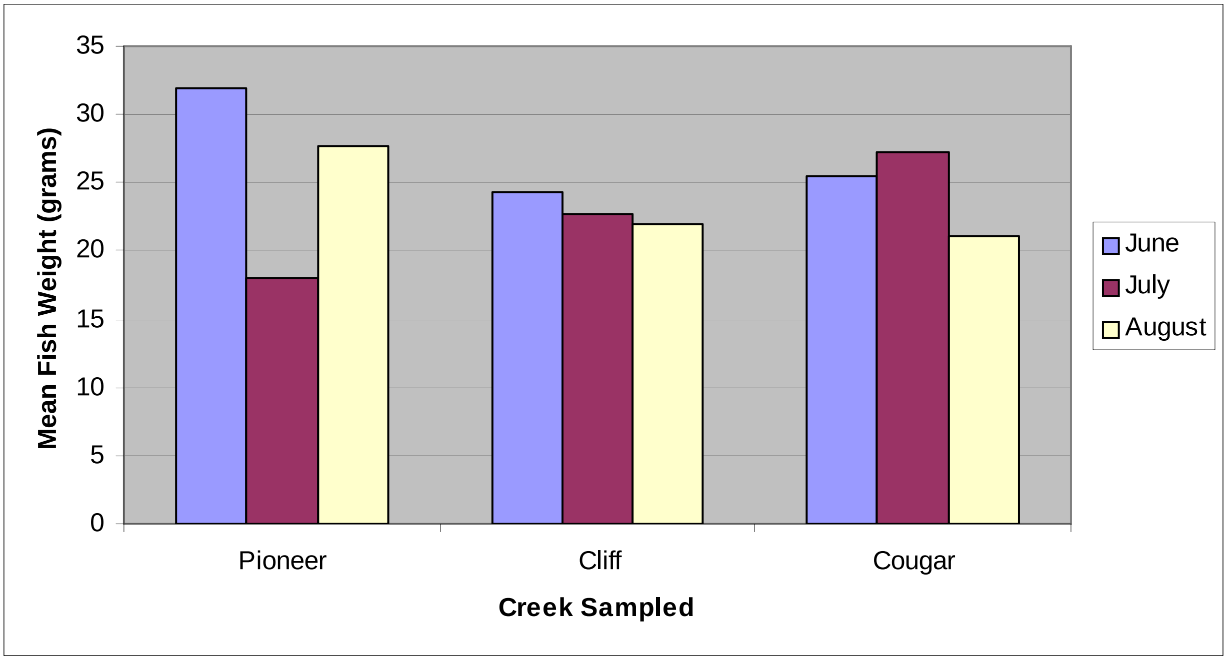

Figure 1. Average weights (grams) for fish sampled each month in each sample site.

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 were expected to grow and terrestrial insect abundance increase, I 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 suggests that terrestrial inputs are likely to always (across the summer growing season) represent a significant contribution to the energy budgets of cutthroat trout in this system.

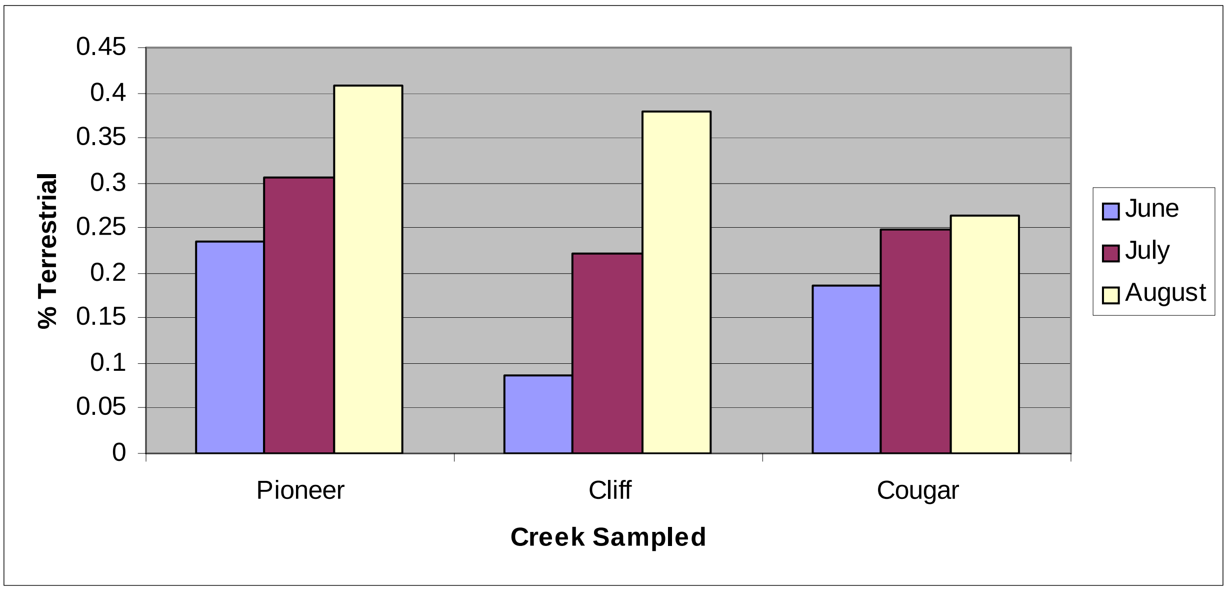

Figure 2. Average percent terrestrial contribution in diets sampled each month at each site.

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 in any of the three streams ($p>0.05$, 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). Statistical regression was 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.

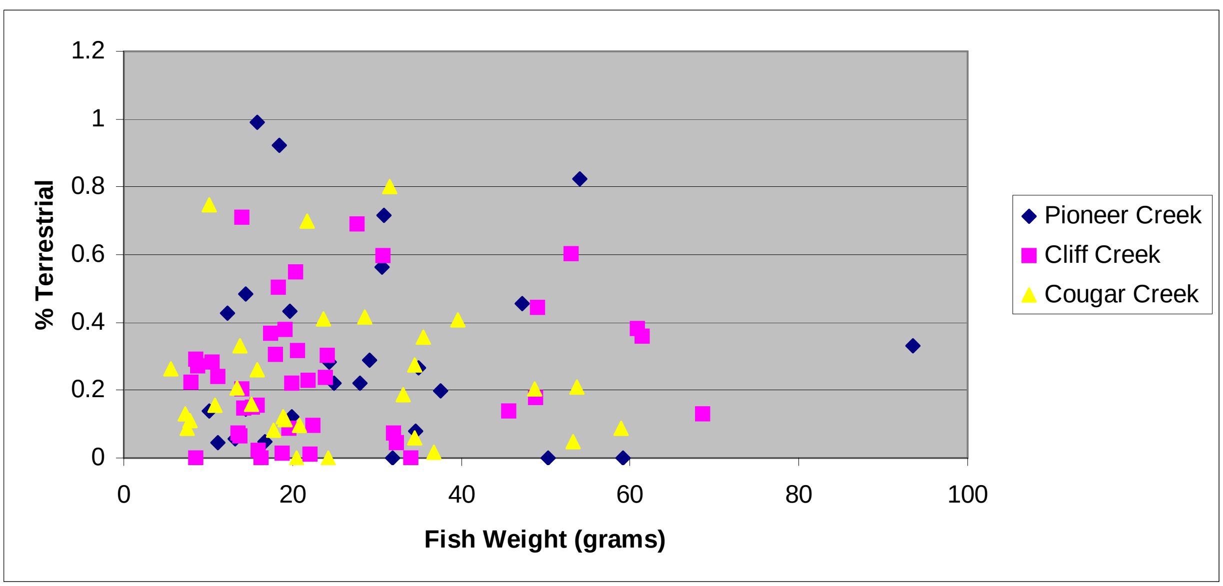

Figure 3. Percentage of terrestrial contribution in diets and weights for corresponding fish.

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. Statistics for Regression of percentage of terrestrial contribution in diets and weights for corresponding fish.

Discussion

A major objective of the study was to assess whether the relative importance of terrestrial resources for cutthroat diets changed across the growing season. Without the ability to mark and follow individual fish we could not study the relationship between fish growth and diet change on the same fish throughout the study. Additionally, changes in the demographics of the cutthroat populations within our study area precluded our ability to test these relationships at a reach scale. Over the course of my study, fish size did not change, so it could be argued that terrestrial inputs not changing is a function of always having the same size fish in the stream. No change in fish size may lead to the conclusion that emigration/immigration may be more important than growth in determining the size structure of a cutthroat trout population. Patterns of immigration and emigration would occur as major changes in the physical habitat change throughout the growing season. 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 may be biased 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 at sites.

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 stronger relationship may have been expressed in both Pioneer and Cougar Creek

My personal observations while in the field were that there should have been an increase in terrestrial inputs through the summer. An example would be the increase in grasshopper abundance and size 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.

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