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

Prepared by: Jesse Davis

Presented to: DeVlieg Undergraduate Research Scholar Award Selection Committee

Budget: $4,250

Mentored by: Brian Kennedy, Ph.D.

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Abstract

Optimal feeding conditions are required by stream dwelling fishes in order to sustain maximum growth potential. Little work has been done relating the growth potential and densities of native trout to the macroinvertebrate populations in the local streams near Taylor Ranch. In the proposed research, I will be analyzing how food availability influences cutthroat trout growth and densities in tributaries of Big Creek at Taylor Ranch Research Station. I propose to compare westslope cutthroat trout (*Oncorhynchus clarki lewisi)* growth and densities across selected sites of the Big Creek drainage and quantify the relationship between food availability, diet contents, and cutthroat growth and abundance. In order to achieve this proposed study, I will (1) sample the macroinvertebrate populations that potentially comprise cutthroat diets, (2) analyze the diets of cutthroat trout to establish the degree of selectivity of foraging cutthroat and whether this varies by location, size and density, (3) measure growth rates throughout the summer to assess how growth is affected by both food resources and conspecific densities, and (4) quantify fish densities in stratified habitats across 3 or more independent stream reaches. These data will be collected by means of snorkeling surveys, electroshocking, stomach samples, and aquatic invertebrate samples within the selected streams.

Introduction and Background

With limited space and 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, one must first understand the relationship between a species and its resources in the environment 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. Quantifying the effects of changing resources on a population 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.

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. Throughout much of the trout habitat in the northwestern U.S., human impacts have included excessive harvest, urban development, agricultural practices, grazing, mining, historic and ongoing stocking of nonnative fish species that compete with or prey upon native salmonids or jeopardize the genetic integrity of the subspecies through hybridization.

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, 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 in 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 (see Platts 1979, Rieman and Dunham 2000).

Spawning of WCT occurs primarily in small tributary streams between March and July, when water temperatures reach about 50 F. Fertilized westslope cutthroat eggs are deposited in stream gravels where they incubate for several weeks, the actual period of time dependent upon water temperature. Several days after hatching from the egg, when about one inch long, the fry emerge from the gravel and disperse into the stream. WCT 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). The proposed research will build upon what is know about the spatial variability in macroinvertebrate populations and attempt to link this knowledge to fish populations. Wherever possible I will coordinate my work with ongoing studies of primary and secondary productivity in the Taylor Ranch ecosystem.

This study will attempt to integrate the long term studies of anadromous salmon and macroinvertebrate populations near Taylor Ranch since the late 1980's by directly linking the response of a fish population to its food resources. The proposed research is timely and important in Big Creek and the Middle Fork system as a whole for several reasons: 1) it is far removed from human impacts and therefore represents an opportunity to study variability in fish population dynamics in response to food availability under pristine conditions and a natural disturbance regime, 2) spatial variability in other salmonid species have been attributed to hypothesized depressed productivity in this region as a result of declining adult salmon returns, thereby limiting nutrients, primary productivity and insect production over the last two decades (Achord et al. 2003), 3) the slow encroachment of brook trout up the Salmon River system has potentially important consequences for future food web interactions in the Middle Fork watershed (Adams et al. 2002), and 4) from a management perspective, studies of salmonids are frequently interested in the question of whether increasing food resources leads to bigger fish or more fish. We hope to be able to address this question at two spatial scales in a natural setting.

Along with food availability there are many other factors that may influence the growth and density of individual fish and fish populations (Diana 2004). Other growth limiting factors may include; temperature, cover habitat, competition, and predators (e.g. Young 2001, Kennedy et al. *In prep*). One summer of investigation cannot address all of these factors, so I have chosen to look explicitly at food availability because it can integrate or identify some of the important ecological processes occurring among fishes and because it can perhaps most productively tie together historical information that we have about these streams. However, whenever possible, we will monitor other potential influences on cutthroat foraging (e.g. temperature and competitor density) and at least consider this, if not include it explicitly, in the final analysis.

When analyzing the growth of trout, food played a stronger influential role than any other factor (Boss and Richards, 2002). Food availability has been considered a population limiting factor for years. The amount of food available has an influence on fish survival, growth, and population density and abundance (Boss and Richards, 2002). There are other limiting factors of a population's success; however, without food the ability to survive would be impossible. Therefore, it is crucial to understand the abundance and availability of food sources for fish populations within a stream. Past research has been done which expresses a positive correlation of food availability with fish density and growth during the summer growing season (Boss and Richards, 2002). Food availability is limited by the productivity and resource diversity of a stream which can vary among the habitats present within that stream (Young, 2001). These factors will affect the competitive interactions and growth rates of fish by having this influence on food resources that will be recorded hourly using hobo temperature probes and analyzed as a covariate in the relationship between growth and food availability.

Being an avid fisherman myself, I have come to realize the importance of having a stable and healthy native fish population. Over the years fish have been introduced worldwide which has produced a competitive interaction between native and non-native species. This competition has been known to dwindle the population numbers of the native populations which once thrived. It is crucial to understand the production level at which native fish populations, such as those seen in the big creek drainage, are able to thrive and maintain such a healthy status. This healthy population status is what attracts fisherman to put forth the time and money needed to enter the Franck Church Wilderness in order to experience such wild wilderness. The thought of fishing in a secluded wilderness where the fish are native and wild is a strong factor which influences the economic importance of the Big Creek drainage in the Frank Church Wilderness.

Study Area

The area in which I will be conducting this research is the Big Creek drainage near Taylor Ranch, which resides 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. The river systems that are present in this wilderness are home to many native fish populations and no nonnative fish species. For the proposed research I will select 3 independent stream reaches that are large enough and provide enough habitat that a complexity is present which contains replicable habitat units within the study design. 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 of high concern these days due to the high amounts of decline seen in many fish populations worldwide.

Objectives

The overall objective of this study is to determine how food availability influences westslope cutthroat trout growth and density. In order to accomplish this goal we will quantify benthic, drift and terrestrial invertebrate densities in three different stream reaches near Taylor ranch. Each stream reach will be long enough (~200 m) to incorporate 2 – 3 distinct habitat types (e.g. riffle, run and pool) in roughly equal proportions such that our experimental design will be stratified and habitat can be analyzed independently from each stream reach. Throughout the growing season we will quantify the growth and abundance of all cutthroat trout in the study areas at multiple time points (probably 3). Simultaneously we will also quantify the abundance of other species of fish so that are analysis of food abundance on density can explicitly address the potentially confounding factor of total neighbors. Lastly, a randomly chosen subset of all fish within each study reach will be non-lethally sampled for gut content analysis in order to compare our sampled invertebrates ("available diet items") to what is represented in the cutthroat diets ("preferred diet items"). This analysis is necessary in order to ground truth for our invertebrate samples to be sure that what we are sampling in the environment is actually what is represented in the diets of individual fish.

Questions and hypotheses

The proposed research attempts to answer four basic questions relating trout diet, size, and abundance to aspects of its food availability at two different scales: 1) habitat scales – defined primarily by depth and current velocities, are replicated within stream reaches, and 2) stream reach scale – a randomly chosen collection of contiguous habitat patches that are intended to represent the stream as a whole.

<u>Question 1</u>: Does food availability differ consistently within similar habitats (defined by depth and current velocity) across each of the three steams sampled?

<u>Question 2</u>: Do cutthroat trout randomly sample the diet items in their environment or is there a preference for certain diet items?

<u>Question 3</u>: Do differences in food availability correlate positively with fish size in the three streams sampled?

<u>Question 4</u>: Are there spatial differences in fish densities among habitat and reaches that are inversely correlated with fish growth in these sites?

My testable hypotheses for each of these questions are:
Hypothesis 1: Densities of aquatic invertebrates will vary spatially and temporally, with highest invertebrate densities/fluxes in riffles surrounded by riparian vegetation and lowest densities/fluxes in open pool habitats.

Hypothesis 2: Cutthroat trout are selective feeders that do not sample randomly in their environment, where selectivity implies that they are taken in greater proportion than they are represented in the environment.

Sub-hypothesis 2a: At the stream scale, drifting invertebrates are more likely to end up in Cutthroat diets than nondrifting diet items

Sub-hypothesis 2b: At the habitat scale (within any given habitat), larger invertebrates are more likely to be taken in cutthroat diets.

Sub-hypothesis 2c: At temporal scales, drifting organisms at dusk or dawn are less likely to be taken than drifting invertebrates at any other time of day.

Hypothesis 3: For a given age class of cutthroat trout, size & growth in each stream is positively correlated with the overall amount of food available.

Sub-hypothesis 3a: Within stream reaches fish will be larger in those habitats where food availability is greater.

Sub-hypothesis 3b: Across stream sites, fish will on average be larger in those stream reaches that contain more of the habitat type (as a % of total habitat) with increased macroinvertebrate production.

Hypothesis 4: For a given age class of cutthroat trout, trout density in habitats and stream reaches will be inversely correlated to the average size of that age class.

Sub-hypothesis 4a: Larger fish (or higher growth rates) of a given age class of cutthroat trout will result in decreased densities as fish territories expand and reach carrying capacity.

Sub-hypothesis 4b: In habitats that support smaller fish, densities will be higher.

Slopes of density changes through time, with confidence intervals calculated from within reach replicates, we will be able to estimate whether mortality and emigration is significantly higher in some reaches than others.

Methods

The overall objectives of the proposed research are:

1) Identify 3 different streams of similar size and similar habitat complexity in the Big Creek drainage to sample.
2) Quantify food available in sampled streams.
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3) Quantify diet of cutthroat trout.
4) Measure length and weight of cutthroat trout in sampled streams.
5) Quantify cutthroat trout and other fish species densities in each stream
6) Analyze data and write paper to be published in a peer-reviewed journal.

1) In order to determine what streams will be designated for the research I will send a day or two familiarizing myself with the study area. Three streams will be chosen that are similar in size (~200m), preventing the size of the stream from influencing the issues being observed and analyzed. Hobo temperature loggers that record at sub-hourly intervals will be installed immediately.

2) Food availability with in a stream will be determined by measuring drift samples. Drift samples will be collected by placing mesh nets (mesh diameter = 250 µm), in an area where fish are observed, for a standard set time (t = 3h). Collected drift samples will also stored in a 5% formalin solution for later identification (Boss and Rosenfeld, 2001). Aquatic invertebrate samples can then be taken to determine if the food abundance is greater in certain streams and how this may effect the growth of cutthroat trout (Kennedy et al. 2004). Collecting stomach samples and invertebrate drift samples from each stream will provide a means of comparison between WCT consumption and available drift for all samples streams. These procedures will be performed three different times over the course of the study (May/June, July, and August).

3) Diet samples for fish will be taken during the same times that length and weight measurements are recorded. While fish are anesthetized gut samples will be obtained from each individual captured. Gut samples will be collected by noninvasively pumping stomachs and then storing the contents in a 5% formalin solution for later identification under a dissecting microscope. The diets analyzed from each stream will then be compared to correlated drift samples. Diet samples will be conducted three times throughout the study (May/June, July, and August).

4) In order to gather measurements of individual fish they will be captured by electroshocking. Electroschocking will be used due to its effectiveness in past research (Hilderbrand and Kershner, 2004). After fish are collected by electroshocking they will be anesthetized using tricaine (MS-222), so length and weight measurements can be taken. Weights will be recorded using an electronic balance and measured to the nearest 0.1g, and length measurements will be 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 (May/June, July, and August).

5) To quantify fish densities snorkeling surveys will be conducted in selected streams. When snorkeling and fish are observed the species will be recorded on a PVC armband with a pencil and their general location and behaviors will be noted. This will be performed three different times (May/June, July, and August).

6) Drift density for each stream will be calculated by measuring the velocity with an electronic flowmeter at the mouth of the net. This recorded velocity will then be multiplied by the area being filtered by the drift net (Hilderbrand and Kershner, 2004). Selection indices (e.g. Ivlev's electivity index) will be used to test whether diet choice is random or biased for certain invertebrate taxa. Abundance estimates will be derived independently by snorkeling surveys two days before electroshocking throughout entire stream reach. Electroshocking will be performed using a three pass removal method with stream reaches blocked by nets when possible. Data will be analyzed using appropriate statistical analysis. Invertebrate abundance and cutthroat size will be analyzed using ANOVA with posterior multiple comparisons test. For the purposes of fish size and density, ANOVA tests will be stratified with habitats nested within reaches. Reaches will incorporate enough habitat types to achieve proper replication. Each time point will be analyzed independently.

Faculty support

Dr. Brian Kennedy, a new faculty member in the Department of Fish and Wildlife Resources has pledged his support for me, Jesse Davis, and the proposed research project. The research topic is an area in which Brian has experience and interest in pursuing future work. The field work will be labor intensive and will require two people for much of it. Brian will use some of his time in this academic year and summer toward meeting the objectives of the proposal. He will oversee me in the beginning, during critical times and whenever backpack shocking or dangerous activities will be involved. Because Brian is interested in initiated stream studies at the Ranch, he will use some of his start-up money to fund the research equipment that I would need to accomplish the research goals. Additionally, Brian will oversee the successful completion of this project by mentoring my invertebrate analysis, gut content analysis, data analysis, and manuscript and talk preparation.

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Appendix I: Timetable

Date	Activity
April 1st -May 1st	Begin gathering tools for research
May 1st -May 15th	Prepare camping and research gear, and travel arrangements
May 18th	Depart for Taylor Ranch
May 19th	Arrive in Taylor Ranch
May 20th -May 22nd	Familiarize myself with study area and specify sampling sites
May 23rd -June 10th	Collect 1st set of samples
June 11th -June 20th	Analyze data from 1st set of samples
June 21st -July 9th	Collect 2nd set of samples
July 10th -July 19th	Analyze data from 2nd set of samples
July 20th -August 7th	Collect 3rd set of samples
Aug 8th -August 16th	Analyze data from 3rd set of samples
August 17th	Prepare gear
August 18th	Depart Taylor Ranch
August 19th	Arrive in Moscow
September 1st -December 1st	Analyze any data not yet completed
January 1st -February 1st	Write Report and prepare presentation of study results
March 1st –April 1st	Present final research report and presentation

Appendix II: Project Budget

DeVlieg – Taylor Ranch Undergraduate Research Scholar
Budget Year (05/01/2005 - 04/30/2006)

Salary, Wages and Stipend	*Award*	*Kennedy matching with startup & time*	*Total*
Undergraduate salary (~10 weeks, 40hrs/week @ $7.50/hr)	3,000/summer		3,000
Salary (Brian Kennedy) (2005 ~2.0 – 3.0 weeks)		2,750 – 4,000	2,750
Total Salary/Wages	*3,000*	*2,750*	*5,750*
Supplies, Services and Travel			
Research Supplies (invertebrate nets & snorkeling gear)	1,000		1,000
Research Supplies (backpack shocker with permitting)		6,000	6,000
Travel	250	250	500
Housing and board at Taylor Ranch	0	200	200
Publication/Page Reprint/Postage Charges		200	200
Total Operating Costs	*1,250*	*6,650*	*7,900*
TOTAL DIRECT COSTS	**4,250**	**9,400**	**13,650**

Jesse Davis

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Permanent Address: 2105 NE Cherry Lane, Madras, Oregon 97741 (541) 475-6320

Objective

I am seeking a job that will provide experience in the fields of fish and wildlife along with other skills that may prove useful in life and a future career. I have chosen to submit this resume and proposal because I feel that having the opportunity to spend a summer on Taylor Ranch would be once in a lifetime experience as well as a great way to begin my career in the fish and wildlife profession.

Educations

University of Idaho, Moscow, ID (Junior)
Major: Fish Resources
Minor: Wildlife Resources
Expected Graduation Date: May 2006
GPA: 2.97/4.0
Fall Semester GPA (2004): 3.66/4.0
Earned 75% of college expenses through scholarships, summer employment, and raising 4-H lambs.

Course Highlights

Fish Ecology	Biological Structure and Function
Wildlife Ecology I	Organisms and Environments
Ichthyology (spring 2005)	Evolution and Diversity of Life
Wildlife Ecology II (spring 2005)	Scuba

Special Skills

Having the ability to work well independently as well as in team environments is a key skill of mine. Not only am I comfortable working in leadership position, but I also possess the ability to understand and be able to follow directions clearly. With the combination of the skills listed above and my concern of being particular about my work I am always ready to take on a challenge.

Computer Skills

Microsoft Word, Excel, PowerPoint, and Internet research

Work Experience

Portland General Electric, Madras, OR (Summer 2004)
Fisheries Technician. Worked with both screw and merwin traps. Snorkeled at night to net juvenile bull trout. Performed telemetry work using a hand held antenna and a fixed antenna on a truck and boat. Checked creel stations. Performed water quality surveys with supervisor using Hydrolab. Removed coded wire tags from snouts. Scuba dived in reservoir. Worked with bull trout by taking weights, lengths, and checking for pit tags and floy tags. Worked with hobos and tidbits. Assisted with kokanee beach seaning for population productivity estimates.

University of Idaho, Moscow, ID (October 2003-May 2004)
Limnology Lab Assistant. Sorting substrate to collect and identify microinvertebrate insects from Snake River dredging samples.

US Forest Service, Avery, ID (September 2003)
Volunteer. Hiked up tributaries of the St. Joe River to identify and count bull trout redds.

Madras High School Forestry Class, Madras, OR (2000-2001)
Student/Volunteer. Participated in stream surveys, which included electrofishing and water quality measurements, on several local streams.

Honors/Services/Activities

Services
Member of American Fisheries Society (2004-2005)
Participated in University of Idaho intramural football, soccer, hockey, basketball and water polo (2002-2005)
Refereed for U of I intramural sports (2004-2005)
Volunteered at University of Idaho's Lionel Hampton Jazz Festival (2004)

Honors (High School)
U of I Deans List (Fall 2004)
Outstanding Forestry Student (1999, 2001)
Outstanding AP Biology Student (2001)
Citizenship Award (2001)

Recreational Activities
Camping, Fly-Fishing/Tying, Rafting, Backpacking, Hiking, Sports

References

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Dr. Scarnecchia is my advisor and I have discussed Taylor Ranch with him.

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February 8, 2005

DeVlieg Undergraduate Research Scholar Selection Committee
College of Natural Resources
University of Idaho
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Dear Committee,

I am happy to support Jesse Davis in his candidacy as an undergraduate research scholar at Taylor Ranch in the summer of 2005. I first met Jesse a day before I was leaving the University of Idaho campus on my first visit of this spring term. At that time it seems he had been unsuccessful at finding a mentor with whom to work at Taylor Ranch on fisheries and aquatic projects. Knowing of my interests in working up at Taylor Ranch, Dennis Scarnecchia gave me his name and within a couple of hours he was in my office discussing possible projects to be conducted at the Ranch. At this point the pre-proposals for the DeVlieg Undergraduate Scholar Award were due in 4 days.

Without too much help from me, Jesse got something turned in on Feb. 1, and since then he has worked extremely hard and collaboratively to get a research proposal together that simultaneously captivates his interests in salmonid fisheries, articulates with my increasing interests in aquatic research at Taylor and builds upon some of our knowledge of Taylor Ranch streams from the long-term work of ISU and NMFS scientists.

What immediately struck me about Jesse were his genuine interests in fisheries research, Taylor Ranch and aquatic conservation issues. His research experience seems very good and well-suited for the challenging work that he has proposed. I cannot speak personally for his academic achievement as I have known him for less than two weeks, but he seems engaged and motivated and his record suggests a strong commitment to improvement. I am optimistic that he will produce a successful scientific study of cutthroat trout populations in Big Creek and that he will be a benefit to the Taylor Ranch community as a whole.

Sincerely yours,

Brian Kennedy