The California State University
COUNCIL ON OCEAN AFFAIRS, SCIENCE & TECHNOLOGY (COAST)

Graduate Student Research Award Program
AY 2019-2020 Application Form

Application Deadline: Thursday, January 30, 2020, 5:00 p.m. PST

Save as both a Word document and a PDF file named as follows:
***LastName_FirstName_App.docx* and *LastName_FirstName_App.pdf*.**
Submit both files as email attachments to graduate@share.calstate.edu.

Student Applicant Information

First Name:	Jasmine	Last Name:	Shen
CSU Campus:	Humboldt State University	Student ID#:	
Email:		Phone:	
Degree Program:	Natural Resources	Degree Sought (e.g., MS, PhD):	MS
Matriculation Date (mm/yy):		Anticipated graduation date (mm/yy):	
GPA in Major Courses:		Thesis-based? (Y/N):	Y

Advisor Information

First Name:	Alison	Last Name:	O'Dowd
CSU Campus:	Humboldt State University	Department:	Natural Resources
Email:		Phone:	

Research Project Title: Pulse flow releases and inundation of marginal habitat: responses of drift and benthic macroinvertebrate forage concentration downstream of Lewiston Dam on the Trinity River, CA

Project Keywords (5-7 keywords related to your project): Benthic macroinvertebrates, drift forage, aquatic ecology, streamflow management, Chinook salmon, Trinity River

Budget Summary (must add up to $3,000)

Award amount directly to awardee:	$3,000
Award amount to Department:	$0

Please refer to the Award Announcement for detailed instructions on the information required for each of the following sections.

Project Description (60 points total)-1,500 word maximum; any text over this limit will be redacted

Introduction

Trinity River Watershed

The Trinity River is the largest tributary of the Klamath River, running through Trinity and Humboldt counties in northern California. Historically, the Trinity River provided a bountiful supply of natural resources to indigenous groups, but as European colonizers arrived, natural resources were exploited for profit and the scale of exploitation intensified (Adkins 2007). Human impacts increased further following construction of the Trinity River Division (TRD) in 1963 as part of the Central Valley Project (USDOI 2000), exporting nearly 90% of the upper Trinity Basin annual inflow to the Sacramento River (TRBFWTF 1977). Insufficient streamflows, coupled with earlier anthropogenic modifications, compounded impacts of habitat degradation to salmonid populations (Nehlsen et al. 1991; Moyle 1994) and was identified as the most limiting factor of salmonid production (USFWS 1980). This recognition catalyzed efforts to restore the anadromous fishery resources of the Trinity River and led to the formation of the Trinity River Restoration Program (TRRP) to oversee river rehabilitation projects from Lewiston Dam downstream to the confluence with the North Fork Trinity River (hereafter referred to as "restoration reach").

Importance of Benthic Macroinvertebrates

In order to assist in the TRRP's goal to increase salmonid production, it is crucial to understand the factors that affect salmonid survivorship from a rearing juvenile to reproducing adult. Juvenile rearing was determined as the limiting life stage for Chinook salmon on the Trinity River (USFWS and HVT 1999), with evidence suggesting prey availability as the predominant factor influencing growth rates of juvenile salmonids (Beauchamp 2009; Lusardi et al. 2019). Juvenile salmonids are strongly dependent on benthic macroinvertebrates (BMIs) as a food source, which can become available as prey items from different sources. Individual fish may utilize different foraging strategies, with the size of the fish and social hierarchy of the community affecting foraging behavior (Waters 1972; Nielsen 1992; Harvey and Railsback 2014). Due to this diversity in foraging strategies, both BMIs living on the benthos and drifting BMIs suspended in the water column can serve as important prey subsidies and have direct impacts on the growth and survival of young salmonids (Rosenfeld et al. 2005; Weber et al. 2014).

Importance of This Study

Despite the importance of BMIs as key contributors for juvenile salmonid production, little work has been done to understand the effects of flow releases from Lewiston Dam on drift forage dynamics in the Trinity River. Streamflow has been described as a "master variable" in lotic systems that may limit and reset river populations on scales as large as drainage networks (Power et al. 1995; Caldwell et al. 2018) and hydrologic alteration can detrimentally impact ecosystem function (Pyne and Poff 2017). It is therefore paramount to rigorously examine the relationship between streamflow and BMI drift forage. This study aims to answer such unknowns and provide information for flow managers with the goal of promoting salmonid production. The research objectives for this project are to investigate the impacts of streamflow on BMI drift composition, concentration, and biomass before and during pulse flow releases from Lewiston Dam (hereafter referred to as "Pulse Flow Drift Study"), and explore if the duration of inundated marginal habitat has an effect on BMI benthic colonization, composition, concentration, and/or biomass (hereafter referred to as "Marginal Habitat Study").

Methods

Study Site

The restoration reach of the Trinity River is approximately 65 river-kilometers and runs through forested, mountainous terrain, characterized by channelized sections as well as mechanically restored sections (Ock et al. 2015). In order to characterize the Trinity River longitudinally, four sites were selected throughout the restoration reach: Sawmill (SM), Steel Bridge (SB), Evans Bar (EB), and Junction City (JC) (Figure 1).

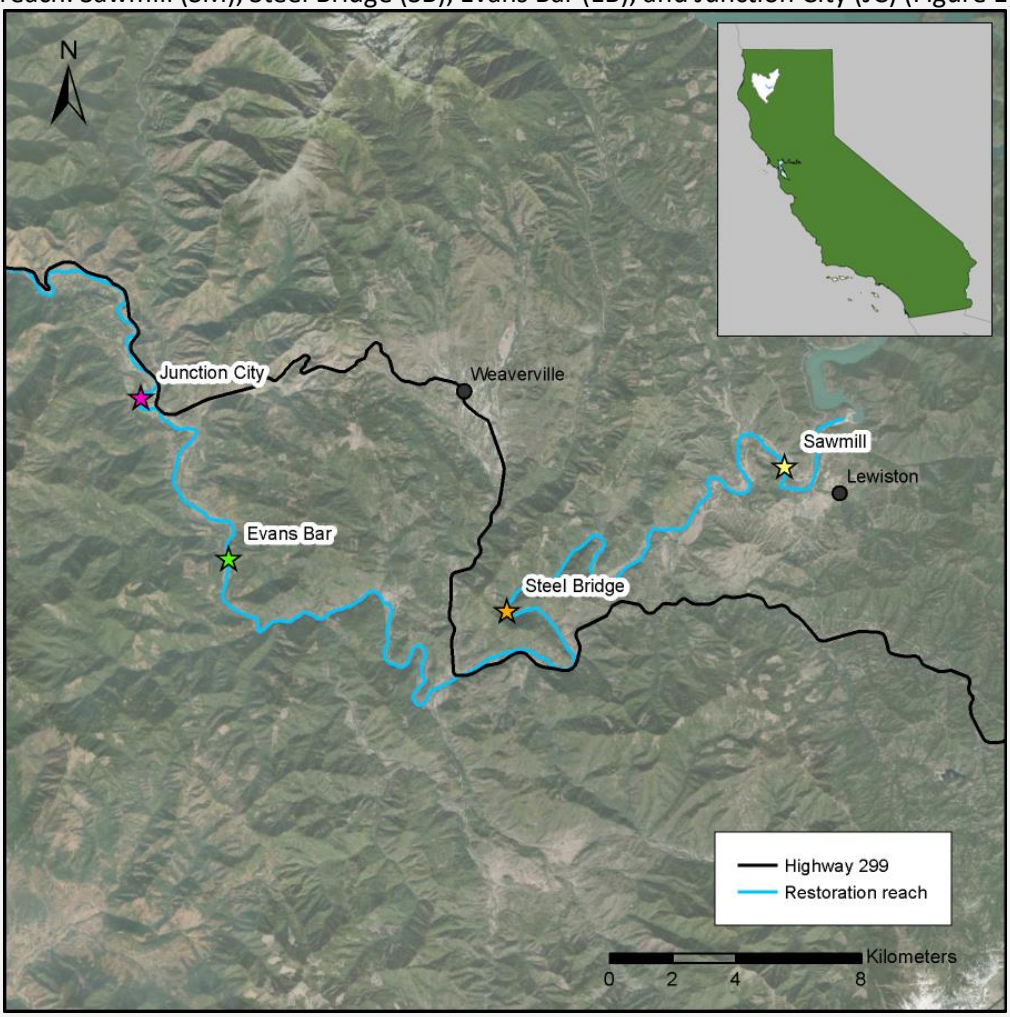

Figure 1. The Trinity River restoration reach with locations of the four study sites. The inset map indicates where the Trinity River Watershed is located within California. Basemap by Esri et al. (2009).

Pulse Flow Drift Study

Sampling will occur on four occasions during pulse flow events. Due to the far longitudinal distance between the upstream (SM and SB) and downstream sites (EB and JC), only two sites will be sampled during each pulse flow (Figure 2). We will confine our sampling window to daylight hours. Pulse flow drift samples will be collected at five times throughout the ascending limb of every pulse (every 2 hours for 30 minutes to capture flows between 600-1500 cfs). The first pulse will be sampled an additional time at 450 cfs for the upstream sites and will only be sampled once at the downstream sites. Baseline drift sampling will occur the week prior to the pulse flows and will follow the same sampling schedule as during the pulse flows so baseline samples are collected during the same time of day with the same temporal distribution. A total of 176 drift samples will be collected.

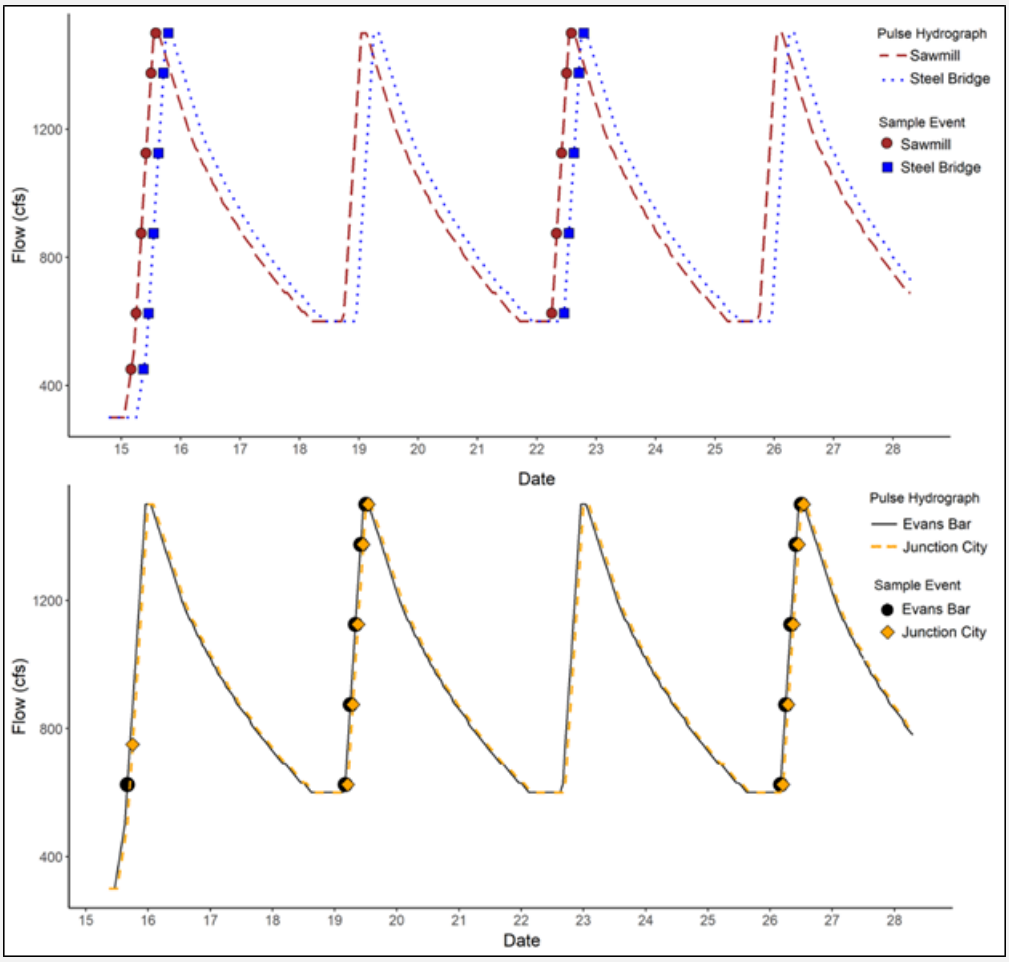

Figure 2. Sampling schedule for pulse flow releases in April 2020. Top panel illustrates the sampling schedule for the upstream sites (SM and SB); bottom panel illustrates the sampling schedule for the downstream sites (EB and JC). Lag time of pulse flow occurrence among sites will result in a slightly different distribution of sampling timing during the pulse among the four sites.

For each sampling occasion, two drift nets will be deployed at each site in riffle habitats. The drift nets will be positioned so the top of the net is 3 cm above the water surface and the bottom of the net is 3 cm above the substrate, as studies have shown that BMI drift concentrations differ between the surface and the lower water column (Shearer et al. 2002). Sampling effort will be standardized to the volume of water that is sampled. Each sample will be preserved in a 90% ethanol solution. Physical parameters including water temperature, dissolved oxygen, turbidity, dominant substrate type, depth, and water velocity entering the drift nets will be measured.

Marginal Habitat Study

During the early rearing period for Chinook salmon (January – April), paired benthic samples will be collected at the two downstream sites (EB and JC) in perennially wetted areas and in areas that have inundated durations of <3 weeks, ~6 weeks, and ~9 weeks. Benthic samples will also be collected before inundation occurs (week 0) to gain a sense of baseline conditions. For each sampling occasion, two benthic samples will be collected at each location using a Hess sampler for a total of 32 benthic samples. An illustration of what the sampling might look like at EB and JC are portrayed in Figure 3 and Figure 4, respectively. Sampling effort will be standardized to the circumference of the Hess sampler and a depth of 10 cm. Each sample will be preserved in a 90% ethanol solution. Water velocity, depth, and dominant substrate type will be recorded at each Hess sample location. Water temperature, dissolved oxygen, and turbidity will also be measured. A tablet and a GPS unit will be used to delineate the water's edge during each sampling event to most accurately determine inundation area and duration.

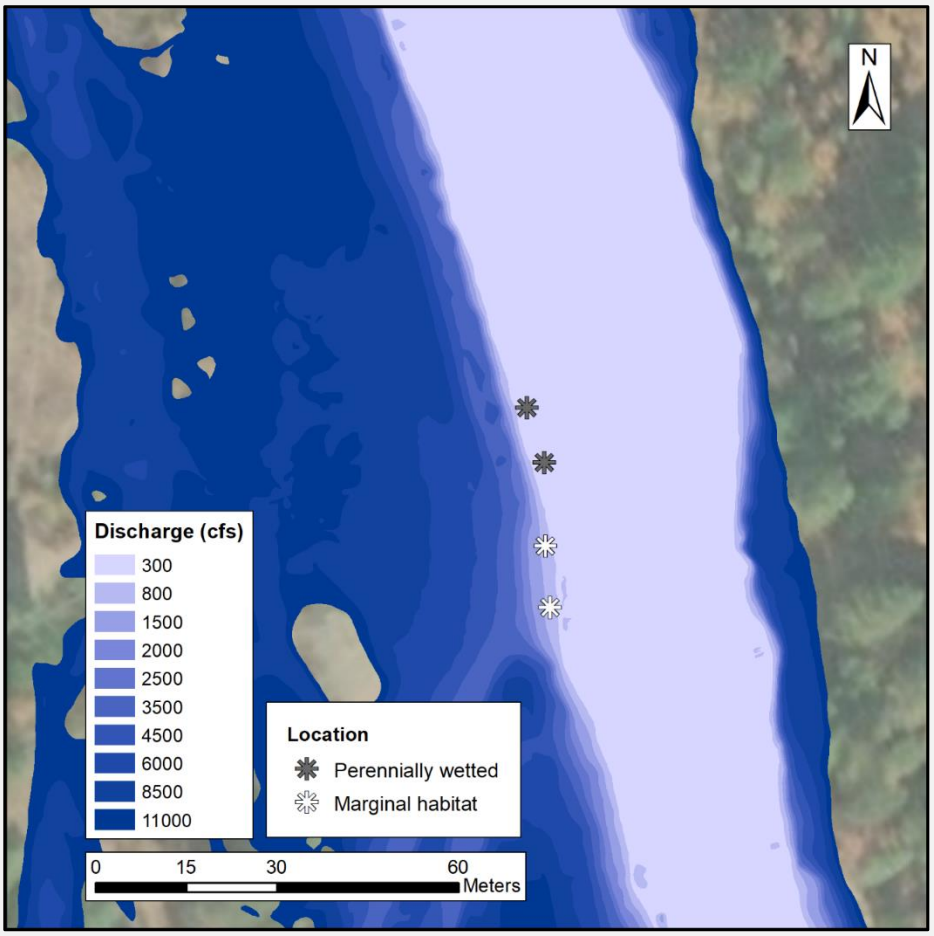

Figure 3. Wetted areas at Evans Bar (EB) during different discharge levels. Hypothetical sampling locations are shown for perennially wetted (gray stars) and marginal habitat (white stars). Basemap by Esri et al. (2009).

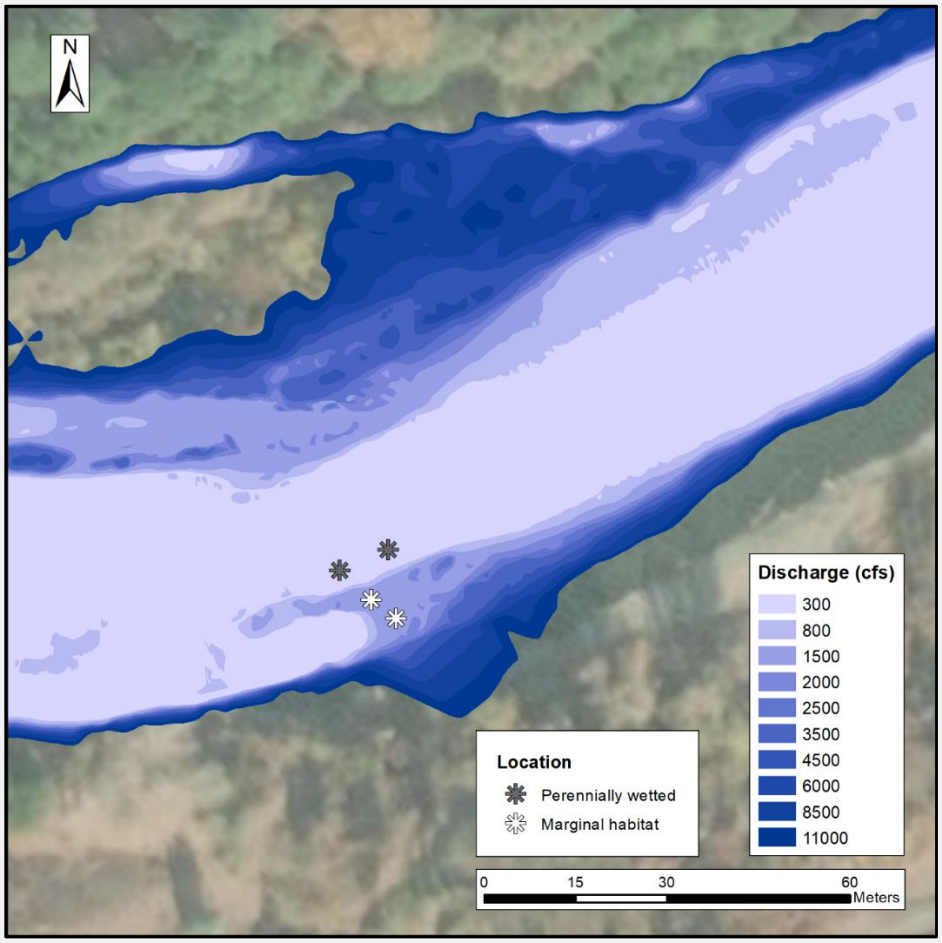

Figure 4. Wetted areas at Junction City (JC) during different discharge levels. Hypothetical sampling locations are shown for perennially wetted (gray stars) and marginal habitat (white stars). Basemap by Esri et al. (2009).

Sample Sorting and Characterization

Drift and benthic samples will be processed using dissecting microscopes. Each organism will be identified to Family for insects and Class or Order for non-insect and terrestrial taxa. The life stage (e.g., larva, nymph, adult) and size measurement will be recorded for each organism to attain a biomass estimate using published length-weight regression formulas.

Anticipated Analyses

For the Pulse Flow Drift Study, I plan to incorporate a mixed effects model where each net and location of sites will be random effects, streamflow levels will be the fixed effect, and BMI drift results will be the response variable with time of day as a covariate. This method should account for the inherent, non-independence between samples to provide a reasonable estimate of the response of BMI drift at differing streamflows.

For the Marginal Habitat Study, a mixed effects model may also be used. Treatment type will be a fixed categorical effect that interacts with inundation period, and sites will be a random effect. This method should assist in quantifying the effects of inundation period on BMI concentration and biomass. Multivariate analysis models will also be incorporated to investigate differences in taxa composition and colonization rates.

Potential Management Implications

The results from this study have the potential to provide a deeper understanding of how altering streamflows affect processes that support important biota. The allocation of freshwater is a sensitive topic, so researching ways to optimize water use for ecosystem health is of interest to many stakeholders. If flow regimes can be positively manipulated using the very impounding structures that initially harmed aquatic systems, then freshwater, a limited resource, may be utilized more efficiently by all organisms.

References (0 points)-no limit

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Timeline (10 points total)-250 word maximum

Fall 2019 – Wrote thesis proposal, met with thesis committee and received approval of proposed research by committee members.

Spring 2020 – Collect benthic and drift samples. The exact timing of field work will largely depend on the occurrence of natural rain events and flow releases from Lewiston Dam that are determined by the TRRP Flow Workgroup.

Spring 2020 - Fall 2020 – Process samples.

Summer 2020 - Fall 2020 – Analyze data.

Spring 2021 – Complete thesis, defend research, and graduate.

Summer 2021 – Prepare manuscript for publication.

Relation to COAST Goals (15 points total)-300 word maximum

The advent of widespread dam construction dramatically altered aquatic ecosystems by disconnecting riverine habitat and disrupting the life histories of native species that evolved with the river's natural flow regime (Benejam et al. 2010). Anadromous fishes lose access to spawning and rearing habitat upstream of impassable dams, limiting the upstream transport of marine nutrients from salmon carcasses (Cederholm et al. 1999) and negatively impacting salmonid populations.

A goal of COAST is to advance knowledge of coastal and marine resources and the processes that affect them – this study aligns with that goal by elucidating hydrologic mechanisms that can bolster food availability to enhance salmonid production. Anadromous salmonids are a remarkable group of animals that bridge freshwater and marine ecosystems, making them one of the most treasured group of fishes in the state. The results of this study can be used to improve our knowledge of anadromous salmonids and the complex processes that affect their growth and survival. Additionally, this study supports another goal of COAST, developing innovative solutions to challenges that our coastal zone faces through its emphasis on streamflow effects. The altering of natural flow regimes often has detrimental impacts on ecosystems, but dams can be viewed as an opportunity to support conservation goals by designing functional flow regimes to mitigate dam-related impacts (Chen and Olden 2017; Sabo et al. 2017). I hope to contribute knowledge in deciding how to balance the many different sociological, ecological, and economic needs of the natural and urban environment through this study.

Budget and Justification (15 points total)

Item/Description	**Unit Price**	**Quantity**	**Amount to Awardee (via Financial Aid)**	**Amount to Department**
Living expenses (rent)	$500/month	6 months	$3000.00	-
		Subtotals:	$3000.00	-
		Grand Total	**$3,000.00**	

Justification (250-word maximum):

This study is laboratory intensive and will require many hours of microscope work. It would be impossible to process all the samples myself in a reasonable time period, so I will need to hire student research assistants to expedite the sample processing. While the Trinity River Restoration Program (TRRP) has generously provided funding for this project, the budget is not large. Between purchasing supplies, traveling to the field sites, and hiring research assistants, there is not much left to cover elevated basic living expenses in the remote town of Arcata. I am grateful that my school has a program that provides a food subsidy for students, but the cost of rent is still high, despite already moving from a single person studio to a shared living space.

If I were to receive this COAST Graduate Student Research Award, it would greatly alleviate financial stressors and grant additional time for me to focus on my graduate studies. I appreciate your time and thank you for considering my application.

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