Contact Information

2024 Upper Columbia Regional Project Pre-Application

* Pre-applications due March 11, 2024 (COB)

*Complete applications due in PRISM April 19, 2024 (COB)

*Revised proposals due in PRISM May 24, 2024 (COB)

*Final revised applications due in PRISM June 24, 2024 (noon)

Project Title	Bioenergetics modeling and restoration effectiveness: Pilot study.
Sponsor	Chelan County Natural Resource Department
Primary Contact	Matt Holland
E-Mail Address	matt.holland@co.chelan.wa.us

Budget Request

Values MAY be duplicative and do not have to equal TOTAL anticipated budget in pre-application.

Anticipated Request - SRFB (standard round)	$50,000
Anticipated Other Funding	$60,000
Anticipated TOTAL Budget	$50,000

Other Funding Source(s)

Pacific Northwest Research Station (USDA Forest Service), 2024 work already funded; 2025 request pending 2024 results

Project Location

Briefly describe the location of the project	This monitoring project would occur throughout the Middle Enitiat and Upper Wenatchee sub basins on recent restoration projects, largely within Gray/Stormy reaches and the lower 12 miles of Nason Creek..
Latitude (decimal degrees)	47.837315

Longitude (decimal degrees) -120.417016

Project subbasin Multiple Subbasins

Please explain why there are multiple subbasins

Entiat and Wenatchee sub-basins. Several large, coordinated, reach scale projects were recently implemented in the middle Entiat, making it ideal for restoration effectiveness monitoring. Expanding the study to the Wenatchee sub-basin can enable the incorporation of spatial variability in fish populations and river basins.

Does the proposed project span multiple assessment units? Yes

List the additional assessment units directly impacted by this proposal. Entiat River-Potato Creek, Lower Nason Creek

Reach(es) Name Entiat River-Potato Creek, Lower Nason Creek

Identify the reach(es) priority/ reach ranking. Note: If the project involves work in multiple reaches, select "Multiple" and include details in the text box that will appear below. Please reference the Prioritization Web Map: https://prioritization.ucsrb.org/. Multiple reaches (provide details below)

Please detail the reach-ranking of the reaches below

Reach: Entiat River Potato 05 - Rank 3
Reach: Entiat River Potato 06 - Rank 2
Reach: Entiat River Potato 07 - Rank 1
Reach: Nason Creek Lower 02 - Rank 3
Reach: Nason Creek Lower 03 - Rank 2
Reach: Nason Creek Lower 10 - Rank 1

Project Information

1. What are the project objectives? Objectives support and refine biological goals, breaking them down into small steps. Objectives are specific, quantifiable actions the project will complete to achieve the stated goal. Each objective should be SMART (Specific, Measurable, Achievable, Relevant, and Time-bound). Note: This exact question is included in the PRISM application. Example format: The project seeks to address [specify limiting factor(s)] for [limiting life stage(s)] by [specific actions proposed] to create an estimated [include specific target metrics, as described below] upon implementation in [estimated year].

This project seeks to augment an existing research and monitoring program (focused on river restoration effectiveness) in two subbasins of the Upper Columbia by monitoring the food availability for juvenile salmonids in restored floodplain and mainstem reaches compared to unrestored control reaches and putting it in context of fish growth and density measured in the same reaches. We will quantify the average abundance of zooplankton and drifting and benthic macroinvertebrates at random sampling sites in perennially inundated floodplains, seasonally inundated floodplains, restored mainstems and unrestored mainstem control reaches. We will also measure the average growth rates of juvenile Chinook salmon and steelhead fry and parr in these reaches as part of a larger study to understand how growth correlates to food availability. Furthermore, we will measure temperature, flow and depth and classify the habitat type of each sampling replicate into account to better understand what habitat types within each reach are most productive and can provide for the highest number of individuals. We will then apply bioenergetic

modeling to predict growth, habitat selection by fish and population carrying capacity, and compare actual fish data to these predictions.

2. What species will the project benefit? Spring Chinook | Steelhead | Summer Chinook

3. Select the project's objectives and the associated tracking metrics Design, Monitoring or Assessment

4. Does this project already exist in Salmon Recovery Portal or PRISM? No

5. Has this project been submitted previously for funding through the SRFB and/or other process(es)? No

6. What category is the project? Monitoring

If applicable, what is the secondary project category? N/A

Is the project eligible for Riparian Funding? No

Design and Restoration Proposals

Assessment Proposals

Protection Proposals

Monitoring Proposals

7. Does this project address a Tier 1 data gap in the MaDMC Regional Data Gaps List? Yes

8. To what extent does your project address a regional data gap?

This project addresses the following data gaps:
Data Gap ID - 3.1 (Tier 1): Effectiveness of habitat projects incorporating spatial and temporal influences on results and at the appropriate scale (e.g., project, reach, assessment unit, population).

Data Gap ID - 3.3 (Tier 2): Certain project types are missing robust effectiveness monitoring (e.g., floodplain, off-channel, riparian, upland water storage, beaver reintroduction, BDAs).

Data Gap ID - 2.12 (Tier 1): Habitat requirements and limiting factors by life stage.

The overall study design involves monitoring floodplain fry density, estimating survival via growth and mark-recapture experiments, and collecting stranding data, thereby addressing all three data gaps.

The work proposed here will add a bioenergetic component to the study by quantifying food availability based on the biomass of zooplankton and drifting and benthic macroinvertebrates.

These studies will address the two Tier 1 data gaps mentioned above regarding the spatial scale of monitoring and limiting factors (food availability) by life stage, while also investigating the effectiveness of

different project elements (Tier2).

9. What is the scale of inference? Multiple Populations

10. Purpose - How will the monitoring complement, enhance, or leverage ongoing monitoring efforts?

This study would compare the biomass of important food resources for fish under river restoration to determine whether restored areas increase foraging opportunities in restored habitats. We propose this project as a pilot study that complements objectives of a larger regional monitoring program implemented in 2023 and 2024. In that work, we are determining the patterns of fish habitat use during high flows that inundate floodplains, and whether growth and survivorship of Chinook Salmon fry are enhanced by floodplain reconnection. Because that monitoring work is ongoing, there is the opportunity to add collection of pilot data on the availability of food resources to fish and conduct preliminary bioenergetics modeling.

The ongoing work also seeks to collect accurate fry-to-parr and parr-to-smolt abundance and survival data in floodplains, tributaries, and restored and unrestored reaches of the Entiat River to parameterize and evaluate a Life Cycle Model (LCM) for the Entiat River with productivity (e.g., abundance or growth) and survivorship data. Bioenergetics modeling would complement the LCM effort in that both provide estimates of carrying capacity. With two modeling efforts, the extent to which carrying capacity is enhanced by restoration will be more accurately estimated.

11. Methods - Briefly describe the methods and how they are appropriate to the monitoring question

To compare zooplankton and macroinvertebrate abundance, we will utilize spatially randomized sampling of zooplankton in comparison to growth rates and fish density within reference and restored floodplain reaches and in different habitat types. In addition, we will compare fish densities and growth rates with food abundance at the same sampling replicates. This will provide insights into food availability in different habitat types and floodplain reaches. Environmental data will be collected at each sampling replicate and event to analyze which factors have the greatest impact on zooplankton abundance. This analysis will help us to quantify the benefit of restored floodplains compared to unrestored mainstem control reaches for juvenile salmon regarding food availability, growth and survival (Corline et al. 2017).

12. Describe how the data (raw and processed), results, and other information will be disseminated and accessed once the project is complete

All data will be archived with the Principal Investigator, with project sponsor Chelan County Natural Resource Department, and with the project partner Hinchinbrook, Inc. The quantitative ecologist from Hinchinbrook, the principal investigator, and the project sponsor will prepare at least one publication for distribution and present study results at regional meetings and conferences.

13. Explain why SRFB project funds are being requested rather than funds from other sources

This project is a component of a larger regional monitoring program started in 2022 with SRFB funds being instrumental to its development. Expanding upon success in 2022, we secured funding in 2023 and 2024 from the SRFB, HCP Tributary committees, and project partners. Those additional partners include Pacific Northwest Research Station (USDA Forest Service), NOAA Fisheries, Cascadia Conservation District, U.S. Forest Service, Yakama Nation, and Hinchinbrook, Inc. The SRFB is viewed as an essential partner for the ongoing success of this program, and the requested funds would augment existing funding and are directed toward a specific component of the project.

Project Risk and Economic Benefits

1. What is the landownership? Chelan-Douglas Land Trust, USFS, some private

2. Have you secured landowner participation in or acceptance for this project?

Yes

Please explain

Monitoring sites would take place on recent restoration projects completed on either USFS land or CDLT properties, whom we have an ongoing relationship with regarding other project related monitoring actions. However, if one of the landowners revokes their consent, we will choose a different study site or locate alternative access routes.

3. Describe any land owner requirements (e.g., design elements, right-of-ways, access agreements, liability waivers, etc.) and if/how they could affect the project

N/A

4. Will the project raise potential concerns for interest groups (e.g., recreational users) or the community at large (including upstream/ downstream/ adjacent landowners)?

As a monitoring proposal this question is not generally applicable, however it is worth mentioning that restoration work, especially floodplain reconnection, can be contentious in our region with many documented concerns from the stakeholder community. We hope that our monitoring program can help mitigate some of these concerns by demonstrating a benefit to the fish populations.

5. Who will have the responsibility to manage and maintain the project? What is the responsibility of current or future landowners?

Project Sponsor: Chelan County Natural Resources Department, Matt Holland - Natural Resource Specialist

Principal Investigator: Pacific Northwest Research Station – USDA Forest Service, Carlos M. Polivka, Ph. D.

Co-Investigators: Keith van den Broek, Stine Griep – Hinchinbrook, Inc.

6. Are other projects being proposed immediately upstream or downstream of worksite?

No

7. Please describe the risk of failure associated with this project.

Our work assumes that we can access floodplains during high flows; however, some high-flow situations may preclude the ability to access the sites at the scheduled time. In that case, our timeline will be modified to begin sampling when water conditions allow field procedures to be carried out safely.

Some of the work proposed to study habitat selection and fry-to-parr/parr-to-smolt survival in floodplains relies on the ability to mark fry, either with FRy ID and PIT tags or VIE marking. If fish are too small to ensure their survival during marking, we will use density values to analyze habitat selection and a size-over-time model to estimate growth as described above. This approach is less accurate than the one we plan to use if marking is possible but enables us to derive a rough estimate of fry-to-parr survival without marking.

Both the Wenatchee and Entiat sub-basins are prone to wildfires that typically occur during the same months as much of our proposed sampling. Such wildfires often lead to debris flows that adversely affect the ability to observe and capture fish. Sometimes access to the river is prevented by the fire itself or by the need to keep access areas clear for emergency responders. If wildfires preclude a year of data, we will move the field activities to the following year.

8. Is there any public outreach planned during and/or after implementation? Does the project build community support for salmon recovery efforts?

Our project partners are active participants at several regional stakeholder groups including the Regional Technical Team, Watershed Planning Units, and Habitat Subcommittees. All project results will be

presented at these various forums with opportunities for public outreach and development of community support for salmon recovery efforts.

9. Does the project represent an opportunity for economic benefit? How much benefit does the project create for the dollars invested?

We will hire local staff as field work technicians as possible and have already developed strong partnerships with many local organizations. All permanent staff associated with the program are Washington residents.

10. Describe any partnerships, their experience, and types of contributions supporting the project.

Pacific Northwest Research Station – USDA Forest Service, Carlos M. Polivka, Ph. D. - Research Fishery Biologist
Hinchinbrook, Inc., Keith van den Broek – Senior Fish Biologist

Partnering with the County in 2022, PNWRS and Hinchinbrook have already produced one publication highlighting the effectiveness on some restoration elements throughout the Entiat watershed and presented study results at several meetings/conferences. Under proposed work, similar methods would be employed and expanded to additional restoration elements, and potentially to a greater spatial, and temporal coverage.

Optional Section - Preparation for PRISM

The following questions are identical to the questions RCO requires in the PRISM application. If desired, sponsors can complete associated questions early and copy responses into PRISM during the "Complete Application" phase due on April 19, 2024.

Do you want to review and/or pre-populate PRISM questions? No

Supporting Documents

Upper Columbia Process Guide 2024

SRFB Manual 18 (2024)

RCO Application Resources (2024)

PROJECT: 24-1856 MON, FOOD WEB MONITORING, BIOENERGETICS AND RESTORATION

Sponsor: Chelan Co Natural Resource Program: Salmon Federal Activities Status: Application Submitted

Parties to the Agreement

PRIMARY SPONSOR

Chelan County Natural Resources Department
Address 411 Washington St Ste 201
City Wenatchee **State** WA **Zip** 98801
Org Type County-Open Space/Nat Resources
Vendor # SWV0001231-12
UBI
Date Org created
Org Notes

link to Organization profile
☐ Org data updated

SECONDARY SPONSORS

No records to display

MANAGING AGENCY

Recreation and Conservation Office

LEAD ENTITY

Upper Columbia Salmon Rcy Bd L

Project Contacts

Contact Name Primary Org	Project Role	Work Phone	Work Email
Jeannie Abbott Rec. and Conserv. Office	Project Manager	(360) 480-2701	Jeannie.Abbott@gsro.wa.gov
Matt Holland Chelan Co Natural Resource	Project Contact	(509) 679-0085	matt.holland@co.chelan.wa.us
Ariel Edwards Upper Columbia Salmon Rcy Bd L	Lead Entity Contact	(208) 540-2691	ariel.edwards@ucsrb.org
Sofia Bjorklund Chelan Co Natural Resource	Billing	(509) 667-6324	sofia.bjorklund@co.chelan.wa.us

Worksites & Properties

#	Worksite Name
#1	Gray & Stormy Reaches, Entiat River

Worksite Map & Description

Worksite #1: Gray & Stormy Reaches, Entiat River

WORKSITE ADDRESS

Street Address

City, State, Zip

Worksite Details

Worksite #1: Gray & Stormy Reaches, Entiat River

SITE ACCESS DIRECTIONS

From Wenatchee, drive North on State Hwy 97A towords Entiat. Turn left onto Entiat River road and then drive 18.5 miles to Stormy Reach, Area B Parking area, on the left.

TARGETED ESU SPECIES

Species by ESU	Egg Present	Juvenile Present	Adult Present	Population Trend
Chinook-Upper Columbia River Spring, Entiat River, Endangered		✓	✓	
Steelhead-Upper Columbia River, Entiat River, Threatened		✓	✓	

Reference or source used

TARGETED NON-ESU SPECIES

Species by Non-ESU	Notes
None	

Project Location

RELATED PROJECTS

Projects in PRISM

PRISM Number	Project Name	Program Name	Current Status	Relationship Type	Notes
21-1184 M	RegM-Entiat River Fish Monitoring	Salmon Federal Activities	Closed Completed	Earlier Phase	Previous work focused on monitoring habitat utilization in mainstem large wood structures/engineered log jams, whereas the proposed project would focus on utilization a broader set of floodplain features located at various recent restoration projects.
23-1283 M	Floodplain Restoration Effectiveness Monitoring	Salmon Federal Activities	Active	Current Phase	Current work focuses on utilization a broader set of floodplain features located at various recent restoration projects, building upon earlier work focusing on the utilization of larger wood structures. The proposed study would further build upon this wo

Related Project Notes

Project Proposal

Project Description

This project seeks to complement an ongoing study on monitoring the fish response to floodplain restoration in different tributaries, by initiating methods for monitoring the total biomass and complexity of the food web that supports fish foraging and growth in one major sub basin of the Upper Columbia River. We will identify and quantify the abundance of food relevant for juvenile Chinook salmon and steelhead in form of drift samples collected in different habitat types within restored and unrestored control floodplain reaches. We will identify the sampled invertebrate species and compare them to those identified in gut content, sampled from juvenile salmonids captured in the same habitats. We will also measure fish density and the average growth rates of juvenile salmon fry and parr in these habitats as part of a larger study to understand how growth correlates to food availability. Furthermore, we will measure temperature, flow and depth and classify the substrate type of each sampling replicate to better understand what habitat types and environmental conditions within each reach are most productive and can provide for the highest number of individuals. We will then apply bioenergetic modeling to predict growth, habitat selection by fish and population carrying capacity, and compare actual fish data to these predictions.

Project Questions

#1: Who will be responsible for administration, design, and/or implementation of this project (i.e. in-house staff, paid consultants, contractors, volunteers, other agency staff, etc.)? Explain.

In-house staff (CCNRD) will be responsible for administration of this grant, with study design and implementation of the project being carried out by a paid contractor (Hinchinbrook) and our partnership with the Pacific Northwest Research Station (USFS).

#2: Is this project located at a hatchery or hatcheries? If so, provide the hatchery name(s):

No.

#3: What type of contract is this: Purchased Service, Personal Service, Interagency Agreement?

Interagency agreement between Chelan County, Hinchenbroook Inc., and the Pacific Northwest Research Station.

#4: Is this a sole source contract?

No

#5: Does this contract have to be filed with OFM?

No

Monitoring Metrics

Worksite: Gray & Stormy Reaches, Entiat River (#1)

Priority in Recovery Plan	MaDMC Data Gaps List
Number of Reports Prepared (E.0.e.1)	1
Name Of Report (E.0.e.2)	Food web monitoring, bioenergetics and restoration effectiveness - Pilot study
Project Identified in a Plan or Watershed Assessment (E.0.c)	MaDMC Data Gaps List
Number of Cooperating Organizations (E.0.d.1)	3
Name Of Cooperating Organizations (E.0.d.2)	Chelan County Natural Resources, Pacific Northwest Research Station, Hinchinbrook Inc.
Complement Habitat Restoration Project (E.0.b)	Middle Entiat: Stormy Reach Area B, Gray Reach Areas D/F.

MONITORING

Acres of watershed area monitored (E.1.b.2)	20.8
Record Name Of Strategy/Program (E.1.d)	UCRTT (Upper Columbia Regional Technical Team). 2021. A Biological Strategy to protect and restore salmonid habitat in the Upper Columbia Region. Report to the Upper Columbia Salmon Recovery Board, Wenatchee, WA.
Stream Miles Monitored (E.1.b.1)	1.80

Restoration effectiveness monitoring (E.1.c.13)

Total cost for Restoration effectiveness monitoring	$93,000 **Note:** Would like to pursue additional funds from other regions unused monitoring funds, if available.
# acres (to nearest 0.1 acre) monitored for Restoration effectiveness (E.1.c.13.c)	20.8
# miles (to nearest 0.01 mile) of stream monitored for Restoration effectiveness (E.1.c.13.a)	1.80

Overall Project Metrics

COMPLETION DATE

Projected date of completion	04/30/2026

Monitoring Cost Estimates

Worksite #1: Gray & Stormy Reaches, Entiat River

Category	Work Type	Estimated Cost	Note
Monitoring	Restoration effectiveness monitoring (E.1.c.13)	$93,000	Would like to pursue additional funds from other regions unused monitoring funds, if available.
	Subtotal:	$93,000	
	Total Estimate For Worksite:	$93,000	

Summary

Total Estimated Costs:	$93,000
Total Estimated Monitoring Costs:	$93,000

Project Application Report - 24-1856

Cost Summary

	Estimated Cost	Project %	Admin/AA&E %
Monitoring Costs			
Monitoring	$93,000		
SUBTOTAL	$93,000	100.00 %	
Total Cost Estimate	$93,000	100.00 %	

Funding Request and Match

FUNDING PROGRAM

Salmon Federal Activities	$50,000	53.763441

SPONSOR MATCH

OTHER IN-KIND CONTRIBUTIONS	DONATED SERVICES
Amount	$43,000.00
Funding Organization	US Forest Service Pacific Northwest Research Station

Match Total:	$43,00046.236559
Total Funding Request (Funding + Match):	$93,000100.000000

Project Application Report - 24-1856

Attachments

Required Attachments	2 out of 2 done
Monitoring Study Plan	✓
RCO Fiscal Data Collection Sheet	✓

PHOTOS (JPG, GIF)

Photos (JPG, GIF)

608376

PROJECT DOCUMENTS AND PHOTOS

Project Documents and Photos

File Type	Attach Date	Attachment Type	Title	Person	File Name, Number Associations	Shared
	04/19/2024	Monitoring Study Plan	2024SAL-RegMonitoringStudyPln-1.docx.DOCX	MattH	2024SAL-RegMonitoringStudyPln-1.docx.docx, 608732	✓
	04/18/2024	Map	MidEntiat_Map.jpg	MattH	MidEntiat_Map.jpg, 608376	✓
	04/18/2024	RCO Fiscal Data Collection Sheet	draft 2024 SRFB_CCNRD_FiscalDataCollectionShee	MattH	draft 2024 SRFB_CCNRD_FiscalDataCollection… 608370	
	04/10/2024	Project Review Comments	Project Review Comments Report, 24-1856M (04/10/24 13:50:59)	JeannieA	Project Review Comments Report - 24-1856 (04-10-2024_13-50-59).pdf, 606542	✓
	04/10/2024	Project Application Report	Project Application Report, 24-1856M (04/10/24 13:50:59)	JeannieA	Project Application Report - 24-1856 (04-10-2024_13-50-59).pdf, 606541	✓

Application Status

Application Due Date: null

Status Name	Status Date	Submitted By	Submission Notes
Application Submitted	04/19/2024	Matt Holland	
Preapplication	04/08/2024		

I certify that to the best of my knowledge, the information in this application is true and correct. Further, all application requirements due on the application due date have been fully completed to the best of my ability. I understand that if this application is found to be incomplete, it will be rejected by RCO. I understand that I may be required to submit additional documents before evaluation or approval of this project and I agree to provide them. (Matt Holland, 04/19/2024)

Date of last change: 04/19/2024

Regional Monitoring Study Plan

Project Number	24-1856
Project Name	Food web monitoring, bioenergetics and restoration effectiveness - Pilot study
Sponsor	Chelan County Natural Resources Department

Please attach a detailed study plan in PRISM titled "Study Plan" that includes the elements below. Present the information in any order.

1. **Purpose.** Describe the information needs and how these data will be used.

    A. Describe how the proposed monitoring will provide data essential for advancing salmon recovery. What high priority information needs or data gaps identified within the regional recovery plan and/or associated regional research, monitoring, and evaluation plan (or lead entity strategy in areas without a recovery region) will the study address? What salmonid fish species will benefit?

This project seeks to complement an ongoing study on monitoring the fish response to floodplain restoration in different tributaries, by initiating methods for monitoring the total biomass and complexity of the food web that supports fish foraging and growth in one major sub basin of the Upper Columbia River. Monitoring studies are typically focused on studying the direct association between fish density and the modifications made to the physical habitat. However, studying such responses can overlook whether overall fish productivity has improved, which can depend not only upon the total biomass, but the structure of the aquatic food web. Food web analysis therefore can complement inferences about the fish response to habitat restoration projects.

Restoration of river habitat to benefit threatened species of salmonids is widespread in the Pacific Northwest. One emerging large-scale approach is floodplain reconnection intended to activate off-channel areas during high flows. Recently, a framework was developed in part of the Upper Columbia (Methow sub-basin) to evaluate habitat-specific food webs and their relative flow of nutrients to fish (Bellmore et al. 2013). Here, we propose to apply this framework via a pilot study of restoration in the Entiat River. The Entiat River has served as a model system for the study of fish responses to physical habitat features implemented in restoration efforts (Polivka 2022). Associated food web monitoring will test the relative extent to which habitat selection is driven by resource availability and physical habitat features.

In the Upper Columbia region, the Upper Columbia Regional Technical Team has identified three significant data gaps pertaining to restoration targeted at Chinook Salmon (spring run) and steelhead:

Data Gap ID 3.1 (Tier 1): Effectiveness of habitat projects incorporating spatial and temporal influences on results and at the appropriate scale (e.g., project, reach, assessment unit, population).

Data Gap ID 3.3 (Tier 2): Certain project types are missing robust effectiveness monitoring (e.g., floodplain, off-channel, riparian, upland water storage, beaver reintroduction, BDAs).

Data Gap ID 2.12 (Tier 1): Habitat requirements and limiting factors by life stage.

All three of these data gaps can be addressed by monitoring studies that evaluate the effectiveness of floodplain reconnection and other restoration measures at multiple spatial and temporal scales.

The proposed food web monitoring will evaluate habitat scale and reach scale effects in restored floodplains vs. unrestored floodplains and how observed differences in fish responses at both scales are driven by total biomass and food web complexity. The data will complement our results from ongoing studies, focusing on fish response to restoration and habitat preferences. This will further enable us to determine whether capacity and productivity in floodplains habitats for juvenile Chinook and steelhead has been augmented by restoration .

B. Explicitly identify the geographic scale of data collection and conclusions referred to within the data. Describe if the design and analyses allow for generalized results beyond the initial geographical scale of the project. If the project is a part of a larger overall monitoring project or strategy, describe the goal of the overall strategy, explain individual sequencing steps, and which steps are included in this application for funding. Attach a map in PRISM that illustrates how this project fits into the overall strategy, if relevant.

This proposed pilot study will provide habitat and reach scale information within the Entiat sub-basin about how overall food biomass and food web structure drive habitat selection in restored vs. unrestored reaches of the river. As part of a larger monitoring project (see below), such mechanistic studies will enable improved estimates of capacity and productivity at the habitat and reach scales via the use of bioenergetics models. Combined with previous studies in the Methow sub-basin (Bellmore et al. 2013, own data), capacity and productivity estimates can potentially be generalized across a larger extent of the Upper Columbia.

Capacity and productivity values derived from bioenergetics models can be compared with values estimated from fish distribution and abundance data (see below). The resulting inferences can then contribute to life cycle models (LCMs) being generated for the three major Upper Columbia sub-basins (Wenatchee, Entiat, Methow). Ultimately, LCMs will allow for predictions to be made at the population scale.

This project is part of a larger, multi-year monitoring strategy that began in 2022 with SRFB support, with the overall goal of evaluating fish abundance, habitat selection behavior, capacity, and productivity in all three sub-basins mentioned above. Those responses are being evaluated

relative to floodplain reconnection and other habitat treatments (addition of engineered log jams, beaver dam analogs, etc.). Monitoring of fish density and habitat distribution spans the fry and parr life stages and food web monitoring will take place on the same temporal scale. This proposal describes work that will therefore build on SRFB and HCP Tributary committee funded fish habitat studies conducted between 2022 and 2024.

C. Are these data available from other sources (literature, other SRFB monitoring, etc.) or being adequately addressed by prior or ongoing studies or existing literature? Describe any previous or ongoing assessment or inventory work in the project's geographic area and describe how this project will build upon, rather than duplicate, the completed or ongoing work. Include detail about other monitoring efforts that complement or could help accomplish the overall objective, so that readers can understand the gaps, if any.

Prior food web analyses in the Upper Columbia Region in the context of floodplain reconnection have been conducted in the Methow sub-basin (Bellmore et al. 2013, Bellmore et al. 2017). Those studies provided an advanced, mechanistic approach to evaluating productivity of the fish assemblage and capacity estimates for important salmonids such as steelhead and Chinook salmon. Importantly, the inferences in those studies were applied to side channel reconnection in floodplains. One key result was that food availability across habitats suggested that the Chinook population was persisting below the predicted capacity whereas fish abundance data suggested that the population was closer to capacity (Bellmore et al. 2013). Fish abundance data that we collected in 2023 in the Entiat River, Nason Creek and Twisp River, suggested that there could be capacity differences among tributaries and sub-basins. This proposed study builds upon that work and the food web study in the Methow by determining whether food resource biomass can explain capacity differences between restoration and reference reaches and between sub-basins.

D. How will the study contribute to validating or revising current management strategies or assessing progress toward delisting the focal species? Include explicit ties of the proposed monitoring to advancing our knowledge of viable salmonid populations (VSP) parameters (abundance productivity, spatial structure, diversity) of the focal species.

The proposed work combines a more rigorous estimate of productivity in restored and unrestored floodplains through bioenergetics modeling with a larger project to collect abundance data for fry and parr life stages, which will directly assess the effectiveness of floodplain restoration as a management strategy to lead to the recovery of the focal species. It furthermore allows for the comparison of productivity between different habitat types and temporarily and perennially inundated floodplains to inform management about what habitat/floodplain types are most beneficial for target species. The data will also contribute to life cycle models (LCMs) that are the latest tools in assessing population viability.

E. Does this study have specific regional importance and provide a regional benefit? Has the appropriate region shown its support for this project by signing and submitting regional certification?

This study specifically covers a response to floodplain restoration in one major sub-basin of the Upper Columbia region and will be used as a pilot study to identify methods that can be applied in other sub-basins and tributaries. Therefore, it is of direct regional significance. The regional monitoring certification form is included in this application.

2. Project Goals, Objectives, and Hypotheses.

A. What are the project's goals? The goal of the project should fill specific gaps in information essential to salmon recovery efforts. The goal statements should broadly articulate desired ecological outcomes of the proposed activity.

The project goals are to identify and establish bioenergetic data collection and modeling methods that can be applied in other sub-basins. With SRFB funding we will address the following research goals:

a. Determine whether key fish prey items/food resources are distributed according to restoration type (perennial floodplain connection, seasonal connection, disconnected/reference condition).
b. Determine whether fish prey biomass is distributed according to habitat type.
c. Quantify the extent to which resources drive density dependent habitat selection (i.e., the relationship between density and productivity), using habitat selection theory.

With additional (pending) funding we will add the following goals:

d. Determine whether food web complexity varies according to habitat type.
e. Predict fish biomass and production from food web structure using bioenergetic models

B. What are the project's objectives? Objectives support and refine the goals, breaking them down into smaller steps. Objectives are specific, quantifiable actions the project will complete to achieve the stated goal. Each objective should be SMART (Specific, Measurable, Achievable, Relevant, and Time-bound). State SMART objectives as expected "outcomes" rather than "output." Monitoring project objectives should tell a reader what the sponsor wants to learn rather than what they will do. The description should include clearly stated, testable hypotheses.

Project objectives addressed with SRFB funding will provide information on the habitat and reach scales:

a. We will test the hypothesis that food quantities vary across habitats within restored floodplain reaches and across restored and unrestored reaches. To achieve this, we will measure the biomass of important food resources for Chinook and steelhead fry and parr across different habitat types in restored and

unrestored floodplains. This will complement observations of fish density and biomass across habitats and floodplain reaches and help determine whether any correlation exists between food availability and fish habitat use.

b. We will test the hypothesis that higher quality food affects fish densities and/or fish condition on different scales. Total resource biomass may not vary significantly across habitat types and reaches, but food web structure may show that taxa most frequently consumed by fish are most abundant in certain habitats or reaches. We will identify the preferred food items by sampling gut contents from fish captured in different habitat types in restored and unrestored floodplains and determining the relationship between preference and availability from sampled food resources (see a. above). We will then test if the abundance and quantity of preferred food correlates with fish density/condition and/or with possible behavioral responses such as quitting harvest rates (Malone and Polivka 2022).

Larger scope project objectives beyond those for which we seek SRFB funding - and for which we anticipate funding from PNW Research Station and other sources - will provide information on the sub-basin/population scale (see Methods below):

c. We will test the hypothesis that restored floodplains increase productivity and capacity on the sub-basin scale. From growth rates measured on fish in different habitat types and in restored and unrestored floodplains, we will ultimately be able to estimate the productivity of habitat types within floodplains and among different floodplain reaches. We will use bioenergetic models to predict total production and capacity at the population scale as a result of restoration by analyzing differences among habitat types.

d. Estimates of productivity and capacity at larger spatial scales will eventually enable us to contribute further to the parameterization of life cycle models such as the HARP model (Jorgensen et al., 2021 & Beechie et al., 2021)) being applied across the region.

3. Methods.

A. Sampling design. Provide a written description and map of the sampling locations. If locations are not yet defined, describe the process by which the sponsor will identify sampling locations.

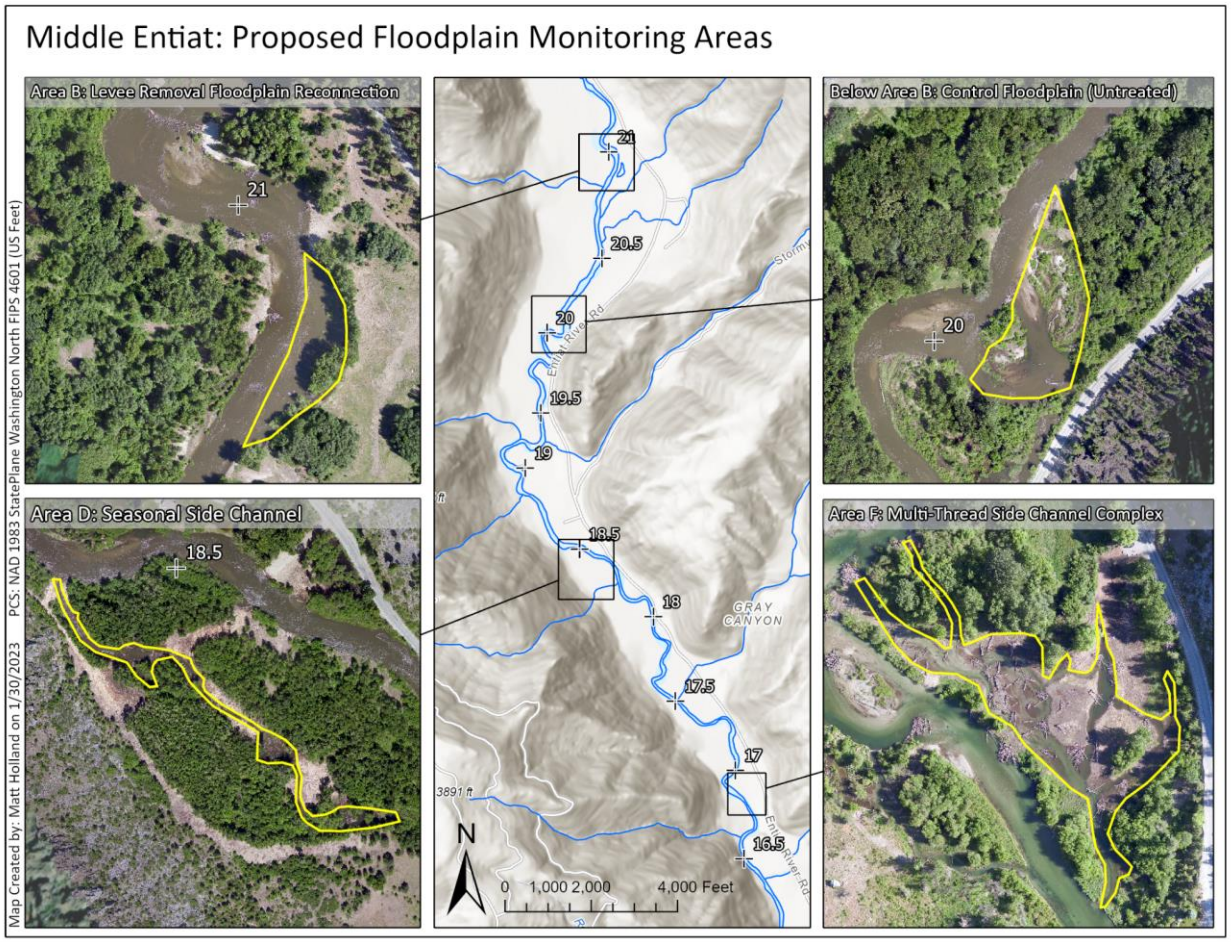
The Entiat River is a major subbasin of the Upper Columbia River. Its headwaters are in the Cascade Mountains and run ~57 river miles to its confluence at (49.6567 N, 120.2244 W). The river consists of three major geomorphic valley segments: (1) The lower segment extends from River Miles 0-16.1. The river is primarily single-threaded in that segment with a high gradient and low sinuosity. (2) The middle segment extending to River Mile 21.1 has a lower gradient and a multi-thread channel with high sinuosity meanders. (3) The upper segment is a higher gradient segment that ends at River Mile 26. It has a meandering channel steepened and straightened for short lengths by alluvial fans (Godaire, 2010).

Floodplain restoration sites on the Entiat River are located in the middle valley segment, and are described below (see map 1). The described floodplains were/will be sampled as part of a monitoring study in 2023 and 2024. The data collected in this study will use the same sampling sites to complement existing and future monitoring data:

Area B (RM 19.4 – 20.1): "Stormy B." Restored in 2019, Stormy Reach Area B involved removing 1,000 feet of a left bank levee, reconnecting floodplain and wetland habitat, enhancing a right bank side channel, installing 24 large wood structures, and restoring wetland and upland vegetation communities. This project intends to increase cover, forage, rearing, and resting habitat for Upper Columbia River spring Chinook Salmon and steelhead. Creation and reconnection of side channels provide juvenile rearing habitat and the construction of large wood structures increases pool-holding habitat and cover (see map 1, upper left).

A control area in the form of a natural floodplain exists immediately downstream of Area B (see map 1, upper right). If the scope of crews and equipment for which we applied allows and if not prevented by limited accessibility to the low number of natural floodplains, we will identify and sample a second natural floodplain in the Entiat, or one of its tributaries as a control reach to increase our sample size.

Map 1:



Area D (RM 17.5-17.8): "Gray D." Installed during 2020, Gray Reach Area D (Cottonwood Flats) involved creating a 1,300 foot long floodplain side channel, enhancing side channel roughness and habitat with 14 large wood structures placed throughout, removing several thousand cubic yards of anthropogenic wetland fill and historical bridge abutments in the mainstem, and the restoration of wetland and upland vegetation communities. The purpose of the project is to restore hydraulic connectivity between the Entiat River and its floodplain, to improve instream habitat for salmonids, and to restore wetland function in the floodplain (see map 1, lower left).

Area F (RM 16.15-16.7): "Gray F." Restored during 2020, Gray Reach Area F involved the placement of over 40 mainstem and floodplain habitat structures, right and left bank side channel enhancements, fill/floodplain bench removal, and the restoration of wetland and upland vegetation communities. This project was designed to re-engage disconnected floodplain habitats and increase main stem channel complexity, primarily for the benefit of Chinook Salmon and steelhead throughout various life stages. The project design relies on the placement of large woody material (LWM) structures to alter local hydraulics, minor grading to encourage side channel activation at lower stream flows, and enhancement of naturally occurring log jams to improve fish habitat cover and complexity (see map 1, lower right).

B. Data collection methods. Describe or reference the response variables or metrics evaluated, the rationale for their selection, field methods, protocols, and essential equipment. Are the selected metrics consistent with ongoing monitoring efforts in the region? If not, provide justification for the departure.

Field collection of meiofauna and macroinvertebrates

We will conduct extensive sampling of the macroinvertebrate and meiofaunal communities to estimate the flow of energy to fish (specifically juvenile Chinook salmon and steelhead). For our eventual application of bioenergetic models, food availability and consumption are increasingly seen to be the most important driving mechanisms (Railsback 2022).

During high flows we will sample fish food resources in three restored and one control floodplain in the Entiat River (see above). In each floodplain reach, we will sample fish food resources in habitat types defined in ongoing monitoring studies of fish habitat distribution, including open areas, vegetation (terrestrial or aquatic), artificial channel, ELJ, and NLJ. At each habitat type, we will measure current velocity (m/sec), depth (m), and temperature (°C). In addition, we will classify the substrate (mud, sand, gravel, rocks) to understand the extent to which it affects productivity of primary consumers and food web structure. We will sample each floodplain twice per week during inundation on two consecutive days every other week for at least four consecutive weeks in order to detect short term temporal variability in productivity. With pending funding from the project partner (PNW Research Station) and potential funding from other sources (e.g., HCP Tributary Committees), we will add monthly sampling events to also incorporate longer term variability.

We will focus on drifting food resources because they are the primary component affecting productivity and habitat selection by Chinook and steelhead, and compare them to samples of diets taken from fish. With pending funding we will add samples of benthic and terrestrial infall to provide insight into the overall productivity of the system (Bellmore et al., 2013).

Drift samples will be taken with 250-µm mesh nets attached to one end of a 30-cm long · 12-cm high · 12-cm deep rectangular plastic pipe frame that rests on the stream bottom. Past work has shown that this mesh size is sufficiently fine to capture both drifting meiofauna (cladocerans, copepods, smaller dipteran larvae, etc.) and macroinvertebrates (Binckley et al, 2010). Drifting biomass will be calculated per unit volume by estimating the total volume passing through the pipe into the net over the sampling period (4 hrs). When nets are retrieved, samples will be elutriated through a 250-µm sieve and placed into 10 ml Whirlpaks™ for preservation (in 70% ethanol) and transportation to the laboratory for identification. Samples will be sorted by a trained technician in the laboratory using a light microscope and biota will be identified down to the most reliable taxonomic level.

Although Chinook and steelhead are primarily drift feeders, two issues with drift samples arise from the above methodology. First, many fish-bearing habitats in inundated floodplains lack

measurable water velocity because they can consist of backwater areas or disconnected side channels. Secondly, invertebrate drift can be highly variable, resulting in estimates that are unreliable as measures of food availability (Brittain and Eikeland 1988).

To address the above issues, we will examine which resources are actually consumed by fish, and in what amounts, through sampling of fish gut contents. During capture for mark-recapture and growth analysis, and depending on the number of fish present in each habitat, a minimum of 5 and a maximum of 10 fish per habitat type will be captured and gut contents will be removed via gastric lavage. Contents will be placed in 10 ml Whirlpaks™ and preserved in 70% ethanol for later identification in the laboratory. In habitats where no fish are captured, only total drifting biomass will be calculated after laboratory sorting.

We will also obtain data on fish growth and weight changes from mark-recapture data by tagging captured fish with FRyID tags (if funding allows) or marking them with visible implant elastomer (VIE). These are small RFID tags designed for smaller fish characteristic of the timing of sampling of inundated floodplains. Growth estimates will enable the estimation of the conversion of energy from available and consumed food when bioenergetic models are ultimately applied to the data. All captured individuals will be held in aerated buckets filled with river water with monitored water temperature. Before marking or tagging, fish will be anesthetized with 30 mg/l of AQUI-S™ (AquaTactics Fish Health, Inc.). Following marking or tagging and measurement, and gastric lavage on the subset of 5-10 individuals, fish will be allowed to recover for at least 15 min in a bucket of fresh river water.

In the expanded scope of our work (with funding outside of SRFB), we will measure the standing crop of benthic macroinvertebrates in restored and unrestored floodplains by taking three benthic samples per habitat type using a Surber sampler (0.0930 m^2 benthic area) also with a 250-µm mesh. Benthic standing crop can estimate total productivity and may ultimately be a better predictor of fish productivity, even if meiofaunal taxa are underrepresented. Comparison of drift samples and benthic samples should confirm whether benthic and drifting productivity are equivalent and whether benthic samples should be used as a more reliable, less variable indicator of overall productivity. Additionally, we will add monthly sampling events to better understand annual variability.

C. Analytical approach. Describe the statistical tests used to test the hypotheses identified in Part B of the Study Plan. Include a preliminary power analysis.

Initial Analyses

The initial analyses involve testing the hypothesized correlation between food biomass and fish density, biomass, and growth. For this we can partition the variation in fish abundance into the effects of physical habitat features (depth, temperature, flow velocity, substrate type) and food biomass using generalized linear mixed models (GLMMs) with a quasibinomial error structure. Such a configuration can account for a high number of observations of zero fish biomass expected based on data collected in 2023. We will use Bayesian methods to generate the

models (Polivka and Claeson 2020; Griep et al., in preparation), using habitat features and food biomass as model coefficients to predict fish density/biomass. From the models, coefficients with 95% credible intervals that do not overlap zero indicate meaningful effects on the predicted variable. Previous power analyses and data analysis, performed for the ongoing monitoring project, indicate that five samples per habitat type are sufficient to identify variation in fish density. We will use this as a preliminary indication of the replication necessary to identify the correlation between food biomass and fish density/biomass.

We will then identify the relative importance of different meiofaunal and macroinvertebrate taxa in the drifting assemblage by multivariate ordinations. We will use non-metric multidimensional scaling (NMDS) to identify the key taxa whose relative abundances explain most of the variation between samples across different habitat types. Axes in NMDS are calculated based on the key taxa that explain some relative proportion of the variation among samples from individual habitat units. Samples are plotted relative to these axes and the rank order distance between them represents the dissimilarity of the species composition of each. With the quantification of which species determine the differences between habitat types, we will have a preliminary determination of how closely habitat selection by fish tracks food availability. In turn, this will give the strength of food availability as a mechanism driving the survival and productivity of fish on restored and unrestored floodplains.

Habitat Selection Theory

Isodar theory (Morris 1988) describes individual density-dependent habitat selection among habitats that vary in productivity (and ultimately the resulting fitness of inhabitants). Isodars are based on the classical ideal free distribution (IFD; Fretwell and Lucas 1970), which is an equilibrium distribution where individual foragers are distributed proportionally to the quality or productivity, and ultimately the benefits to fitness of each habitat. At equilibrium the relative density across habitats of different quality is such that all individuals in each habitat obtain the same fitness benefit, though the density differs in each habitat. The reasoning is that higher quality habitat can provide for more individuals than lower quality habitat. Application of isodars in this study system has proven useful for detecting restoration effects in the mainstem river (Polivka 2022).

With information on the productivity of food resources for fish, the previous isodar analyses, which were calculated from fish density alone, can be improved because the estimates of productivity can serve as a correlate of fitness. Using the meiofaunal/macroinvertebrate biomass as the measure of productivity in each habitat type, along with the relative density of fish (Fig. 1A), isodars can be generated from the density in Habitat 1 and density in Habitat 2 at a constant level of productivity (Fig. 1B). Isodars therefore describe habitat quality in terms of the density-dependent behavior of the foragers. We will use isodars to make the following comparisons: 1) Habitat types within restored floodplains, and 2) The same habitat type (e.g., ELJs, NLJs) between restored and unrestored floodplains.

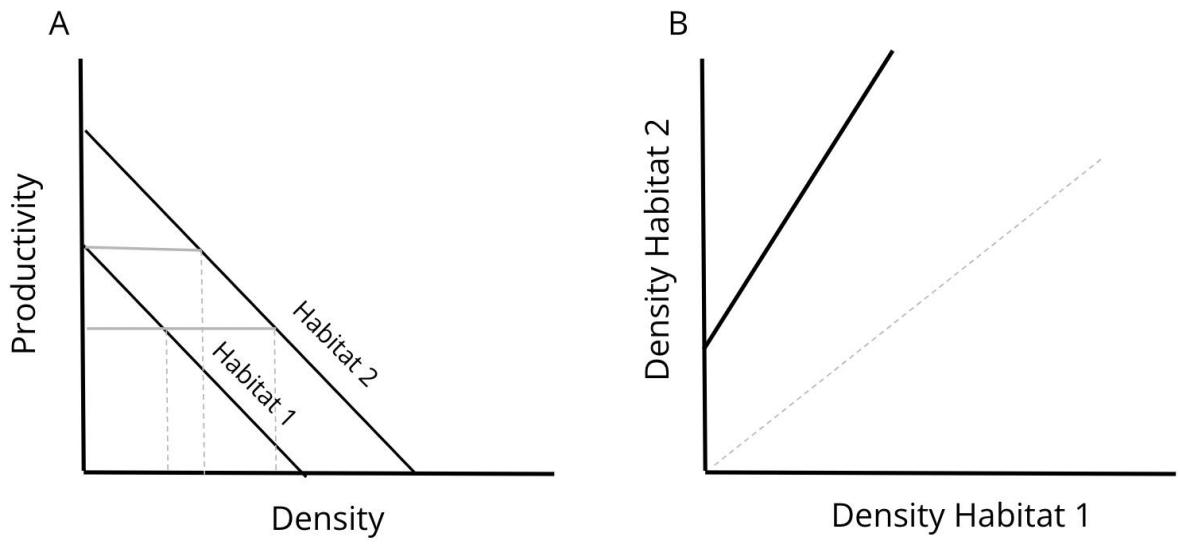


Figure 1. Isodar theory. Isodars are generated from putative fitness effects on density (A). Across two habitats, productivity declines with increasing density of consumers (solid lines). In this representation, Habitat 2 is more productive than Habitat 1 at any given density. Lines of equal productivity (gray horizontal lines) give the relative density in each habitat where they cross the productivity-density lines (gray dashed lines). Plotting those densities gives the isodar (B, solid line). Isodars with slope > 1 indicate, from the slope, the magnitude to which Habitat 2 is more productive than Habitat 1. Isodars with slope = 1 (dashed gray line) indicate equal productivity for both habitat types.

Bioenergetics Modeling

Bioenergetics models synthesize information about the food web and important physical characteristics of the habitat to describe how energy flows to consumers such as fish (Kiffney et al. 2014). The usefulness of the various models is dependent upon the nature of the various inputs and how realistically they represent effects on energy flow (Railsback 2022). The Aquatic Trophic Productivity (ATP) model (Bellmore et al. 2017) was developed in the Upper Columbia and is a dynamic food web model constructed specifically to explore how restoration affects river food webs and fish populations. We will use the ATP to begin analyzing the main pathways of energy flow from the invertebrate community to fish and its dependencies on measured physical habitat characteristics (e.g., temperature, current velocity). In this proposed pilot study, we will focus on the data analysis methods described above with additional (pending) funding and additional potential sources, we expect to be able to derive a more robust, realistic model.

Foraging Theory: *Exploratory Analysis*

Because we will be comparing the availability of specific food resources with actual consumption by fish, the opportunity exists to apply foraging theory to analyze habitat-scale behavior. Foraging theory predicts that a forager should stop foraging in a given habitat when the resources obtained no longer exceed the costs of foraging in that habitat. This leads to a food harvest rate that reaches a low point and the animal abandons foraging for other behaviors such as vigilance against predation risk or an activity that is energetically more favorable than continued foraging at that habitat or patch (Charnov 1974). The remaining food in the habitat is referred to as the giving-up density (GUD; Brown 1988, reviewed in Malone and Polivka 2022). GUDs can be used to quantify the costs of habitat selection, estimate carrying capacity, predict ecological phase shifts, and describe other ecological mechanisms (Malone and Polivka 2022). Higher GUDs imply costly foraging or low quality resources. From the data we will collect, we will explore whether/how we can estimate valid GUDs for the measurement of foraging behavior as a metric of habitat- and, subsequently, reach-scale productivity. There are multiple possible configurations of the data that can all lead to inferences using GUDs, depending on the density of fish and biomass of food. If we can determine a method to measure GUDs, we will include specific foraging assays and experiments when we propose additional funding to expand this monitoring study. Ultimately we intend to analyze food consumption and the relationship between GUDs from habitat types within and across restored and unrestored floodplains for effects related to restoration.

D. Data management. Describe the sponsor's approach to data management, storage, and archival to ensure data quality and availability for sharing.

All data will be archived with the Principal Investigator, with project sponsor Chelan County Natural Resource Department, and with the project partner Hinchinbrook, Inc.

E. Dissemination of results. How will the sponsor disseminate collected data and reports?

We will prepare at least one publication and present study results at regional meetings and conferences. We will also prepare an annual report to the SRFB Committee on the study's progress described in this application.

4. Tasks and Schedule.

A. Identify project collaborators and their roles and contributions to the project. Provide a detailed description of the proposed project tasks, the party responsible for each task, a schedule or timeline for accomplishing them, and list the project deliverables. Include an annual report as a deliverable.

Project Sponsor: Chelan County Natural Resources Department, Matt Holland – contact

Principal Investigator: Pacific Northwest Research Station – USDA Forest Service, Carlos M. Polivka, Ph. D .

Partner Agencies: Hinchinbrook, Inc., Keith van den Broek – Senior Fish Biologist; Quantitative Ecologist: Hinchinbrook, Inc., Stine Griep; Field Technicians: Virginia White - Crew Leader, 2 technicians TBD

Timeline - Pilot Study (SRFB funding):

- March-April: preparation and planning
- April-June: field work
- September-November: analysis
- November-February: reporting and preparation of peer-reviewed publication

Task 1: One crew, composed of a crew leader and technicians employed by the project partners, and supervised/supported by the project sponsor, principal investigator and project partners, will sample meiofauna, macroinvertebrates and fish in three inundated floodplains and one control site in the Entiat River.

The crews will sample each floodplain on two consecutive days every other week for at least four weeks. Depending on water levels, sampling will occur between April and June when floodplains are inundated during the 2025 pilot level study, but sampling will continue monthly year-round when additional funding is procured.

Deliverables: Mean meiofaunal and macroinvertebrate biomass by habitat type and restored vs. unrestored floodplains. This will indicate how overall productivity at the reach scale is affected by restoration.

Task 2: Field crews will collect fish habitat use data (density and biomass), growth data, and gut content samples associated with the habitats from which food resources are sampled.

Deliverables: 1) Analysis of correlation between fish density/biomass and food resource biomass, and 2) overall fish productivity estimates by habitat type and/or restoration treatment.

Task 3: The quantitative ecologist and principal investigator will analyze the data on productivity and fish responses as described in the data analysis section.

Deliverable: All quantitative analyses of data from Tasks 1-2.

Task 4: The quantitative ecologist, principal investigator, and project sponsor will prepare at least one publication and present study results at regional meetings and conferences.

Deliverables: Reports, presentations, and peer-reviewed publications

Task 5: The quantitative ecologist, principal investigator, and project sponsor will prepare an annual report to the Salmon Recovery Funding Board on the study's progress described in the application.

Deliverable: Annual report

Item/Milestone	Outcome/deliverable	Target Date (Month/Year)
Task 1	Mean food resource biomass by habitat type and restoration treatment	4 weeks April-June 2025; extended to September with pending funding
Task 2	Association between fish biomass and food resource biomass.	April-June (as above) 2025
Taks 3	Data analysis	September-November 2025
Task 4	Publications and presentations	November-February 2025-2026
Task 5	Annual report	February 2026

5. Assumptions and Contingencies.

A. Identify assumptions and constraints that could affect the sponsor's ability to achieve objectives and how the sponsor will modify the approach if the sponsor does not meet assumptions.

Our work assumes that we will be able to access floodplains during high flows; however, some high flow situations may preclude the ability to access the sites at the scheduled time. In that case, our timeline will be modified to begin sampling when water conditions allow field procedures to be carried out safely.

Collection permits are required for all of the capture, tagging, and gastric lavage methods discussed. We will add gastric lavage to our existing permit or apply for a *de novo* permit to complete that procedure.

The Entiat sub-basin is prone to wildfires that typically occur during the same months as much of our proposed sampling. Such wildfires often lead to debris flows that adversely affect the ability to sample the drift. Sometimes access to the river at all is prevented by the fire itself or by the need to keep access areas clear for emergency responders. If wildfires preclude a year of data, we will move the field activities to the following year.

6. Literature Cited.

A. If available, clearly cite documents referenced within the study plan with electronic links. If supporting documents are not publicly available, they should be loaded onto PRISM. Where appropriate, a brief literature review can be included in the study plan.

Beechie, T. J., Fogel, C., Nicol, C., & Timpane-Padgham, B. (2021). A process-based assessment of landscape change and salmon habitat losses in the Chehalis River basin, USA. *PloS one*, *16*(11), e0258251.

Bellmore, J. R., Benjamin, J. R., Newsom, M., Bountry, J. A., & Dombroski, D. (2017). Incorporating food web dynamics into ecological restoration: a modeling approach for river ecosystems. Ecological Applications, 27(3), 814-832.

Bellmore, J. R., Baxter, C. V., Martens, K., & Connolly, P. J. (2013). The floodplain food web mosaic: a study of its importance to salmon and steelhead with implications for their recovery. Ecological Applications, 23(1), 189-207.

Binckley, C. A., Wipfli, M. S., Medhurst, R. B., Polivka, K., Hessburg, P., Brion Salter, R., & Kill, J. Y. (2010). Ecoregion and land-use influence invertebrate and detritus transport from headwater streams. *Freshwater Biology*, *55*(6), 1205-1218.

Brittain, J. E., & Eikeland, T. J. (1988). Invertebrate drift—a review. *Hydrobiologia*, *166*, 77-93.

Brown, J. S. (1988). Patch use as an indicator of habitat preference, predation risk, and competition. *Behavioral ecology and sociobiology*, *22*, 37-47.

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Fretwell, S. D., & Calver, J. S. (1969). On territorial behavior and other factors influencing habitat distribution in birds: II. Sex ratio variation in the Dickcissel (Spiza americana Gmel). *Acta biotheoretica*, *19*(1), 37-44.

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Kiffney, P. M., Buhle, E. R., Naman, S. M., Pess, G. R., & Klett, R. S. (2014). Linking resource availability and habitat structure to stream organisms: an experimental and observational assessment. Ecosphere, 5(4), 1-27.

Malone, M. A., & Polivka, C. M. (2022). The behavioural ecology toolkit for fish management and conservation. Fish and Fisheries, 23(6), 1485-1506.

Morris, D. W. (1988). Habitat-dependent population regulation and community structure. Evolutionary Ecology, 2, 253-269.

Polivka, C. M. (2022). "If You Build It…": Methodological Approaches to Detect Postrestoration Responses in Stream Fishes. Fisheries, 47(8), 346-355.

Polivka, C. M.; Claeson, S. M. (2020), Beyond redistribution: In stream habitat restoration increases capacity for young of the year Chinook Salmon and steelhead in the Entiat River, Washington. North American Journal of Fisheries Management. 40(2): 446-458, https://doi.org/10.1002/nafm.10421.

Railsback, S. F. (2022). What we don't Know about the Effects of Temperature on Salmonid Growth. *Transactions of the American Fisheries Society*, *151*(1), 3-12.

Comments

Monitoring projects will not usually include a site visit by the Monitoring Panel, but site visits may occur at the panel's discretion. Use this section to respond to any questions that the sponsor received after submitting the final application.

Response to Post-Application Questions

Please describe how the sponsor responded to the SRFB Monitoring Panel's post-application questions. *List each of the monitoring panel's questions here and use this space to respond directly to the questions. Update the proposal to be consistent with comments.*