American Fisheries Society

Western Division Annual Meeting

Alaska, Arizona-New Mexico, California-Nevada, Colorado-Wyoming, Idaho, Montana, Oregon, Pacific Islands, Utah, Washington-British Columbia

May 8-11, 2023
Boise, Idaho

President's Message

Greetings AFS members and guests,

Welcome to Boise! We're glad you decided to join us for the 45th annual meeting of the Western Division American Fisheries Society, hosted by the Idaho Chapter. Boise is the state capital, with a lot of entertainment and great food, but conveniently located where you can be in the wilderness within a short drive. This makes it an ideal location to reconvene in-person for the first post-COVID Western Division meeting. I know that we are all excited to reconnect with colleagues and friends that we haven't seen in a few years, but please take the opportunity to expand your network and take in all that Boise has to offer.

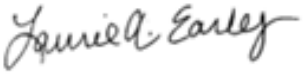
First and foremost, we must acknowledge and share our appreciation for the great team of volunteers that spent endless hours preparing for this meeting. It was no easy feat, as the meeting landscape has changed considerably since the pandemic. Thus, we've encountered more challenges than before, but that didn't slow us down. In the end, the team developed an incredible schedule of events and meeting program that all can enjoy. From Monday workshops to the Alphabet Social and the Welcoming Event at the Idaho State Museum to the Aquatic Film and Photo Festival, the spawning run and student events, there should be something for everyone. Plus, the program is chock full of scientific content that will certainly provide some insight on how we continue with our mission to improve the conservation and sustainability of unique fishery resources and aquatic ecosystems in western North America. All of this could not have been compressed into four short days without the energy and effort of this year's planning team. Please pass along some gratitude to members of the team as you interact with attendees over the next week.

We'd also be remiss if we didn't thank the sponsors for our meeting. Many of them have a booth, so please make sure to swing by and visit with the vendors during the breaks.

Along the line of hosting a meeting that everyone can enjoy, we want to remind folks of AFS's meeting Code of Conduct. For the first time, we will have designated 'Safety Officers', which will be both of us. If at any point in time you want to speak to someone about an incident you experience or witnessed, please feel free to grab one of us. And, we'll take both positive and negative input! We also challenge each and every one of you to meet someone new. For the veteran meeting goers, remember we were all first-timers at one point, so simply saying "hello" to someone you don't know or who may be alone, may be the one thing they need to feel a bit more at "home".

These annual meetings allow us to learn and grow, and hopefully you all will leave feeling a bit more energized and ready to tackle the challenges we face in our profession. Moreover, these meetings provide the opportunity to advance the science around fisheries and aquatic resources and provide a forum to support professionals and students. That at the core, is the AFS mission, and we're glad that you decided to be participate in this year's meeting. We hope you enjoy your time here in Boise and safe travels home!

Sincerely,



Laurie Earley, President
Western Division of the American Fisheries Society

Rob Van Kirk, President
Idaho Chapter of the American Fisheries Society

Meeting Theme

Managing Aquatic Ecosystems and Shifting Baselines: Challenges and Opportunities

Nearly one-quarter into the 21st century, fisheries professionals are challenged as never before by a changing climate. In terms of managing aquatic ecosystems, Dr. Daniel Pauly coined the term "shifting baselines" to refer to the loss of perception of ecological change from one generation to the next, but for the purposes of this meeting, we use the term to refer to unrelenting transformation of the earth's climate that will likely continue for many decades and that will clearly require seismic shifts in how we manage and conserve aquatic ecosystems. A new thought process is emerging to address fisheries and wildlife management and conservation in the face of such dramatic climate change: Resist-Accept-Direct (RAD). Resist represents the traditional practice of implementing actions to counteract changes and restore ecosystems to prior conditions. Accept is when decisions are made to allow ecological conditions to change without implementing restoration actions, perhaps to divert energy away from "lost causes" and focus efforts where positive outcomes are more achievable. Direct is attempting to forecast future conditions and implement actions that attempt to steer ecosystem changes so that some sort of ecological function persists, though the former ecosystem may not. Three plenary speakers and four invited speakers (see page 11 for more details) will provide a forum to explore RAD and other resource management frameworks from various avenues of research, management, and conservation.

Planning Committee Team

General Meeting Organization
Laurie Earley
Kevin Meyer

Program
Jessica Buelow
Tim Copeland
Eric Fetherman
Darcy McCarrick
Mike Peterson
Kristi Stevenson

Workshops
Kat Gillies-Rector
Jenn Vincent

Fundraising/Tradeshow
Luciano Chiaramonte
Conor McClure
Nick Porter

Registration
Rebekah Horn
Jesse McCane
Kristi Stevenson

Posters
Katie McBaine

Website
Kristi Stevenson

Volunteer Coordination
Jim Chandler
Susie Frawley
Jake Hughes
Jack McLaren
Sage Unsworth

Audio/Visual
Corey Dondero
Jenn Vincent

Film Festival
Dan Brauch
Martin Koenig
Eric Stark

Social Events
Corey Dondero
Jenn Vincent

Event Gift
Will Lubenau

Meeting Logo
Jessica Buelow
Stacey Meyer

Diversity/Equity/Inclusion
Kat Gillies-Rector
Rob Van Kirk
Jenn Vincent

Thank You to the Sponsors of the Western Division AFS Meeting 2023

$5000

Salmon Science Network

$2500

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Merck Animal Health/Biomark
Oregon Department of Fish and Wildlife
Washington Department of Fish and Wildlife

$2000

Boise Convention and Visitors Bureau

$1000

Confluence Consulting, Inc.
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HDR
Idaho Department of Fish and Game
Idaho Office of Species Conservation
Idaho Power
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Lotek
The Meacham Foundation
NOAA Fisheries
Oregon RFID
River Design Group
RivHab
SSA Environmental
Syndel

$500

Backcountry Hunters and Anglers
Hickey Brothers Research
Little Pond Nature Prints
Lost River Fish Ecology, Inc.
Oregon Sea Grant
Redd Zone
Smith-Root, Inc.
Tetra Tech
University of Idaho
Upper Snake River Tribes Foundation

$350

Floy Tag & Mfg., Inc.
Leon and Sylvia Panetta
Memphis Net and Twine Company
National Fish Habitat Partnership - Beyond the Pond
Pacific States Marine Fisheries Commission

$200

Frigid Units, Inc.

Vote for your favorite films!

The 8 selected finalist films selected will be shown live during the meeting. There will be 2 showings available on Wednesday May 10 at 8:20-9:50am and 1:50-3:20pm. Please stop by and enjoy these outstanding films!
We will be awarding the top 3 films with the “Audience Choice” awards. Cast your vote for your favorite films by scanning the QR code. Winners will be announced Thursday during the “best paper awards” session at 3PM.

Thanks to all those that submitted films and photos for consideration for this year’s festival!

Click on the following titles to view one of the finalist films or additional submissions.

2023 Finalist Films (Live Showings)

Changing a Landscape to a Lifescape

Restoring Our Rivers: Communities Taking Action

Place-People, Lamprey, and Cultural Ecology

The Odds

The Native Three

The Tide is Coming Home

Natural Infrastructure: Elk River

Life History Project: Betsy Krier

Photo Festival - Live Showing

All photos submitted will be on display as a slideshow during the film festival as part of the live showing. In addition, the 6 finalists chosen by the judges have been printed and will be displayed throughout the meeting. These 6 beautiful aluminum prints will be available for purchase during the fundraising auction!

2023 Additional Film Submissions

Five Years Before the Mast: Sights, Sounds, and Smells from Alaska

Hatchery Research Fieldwork

Holiday Farm Fire Survivors Resolve to Protect McKenzie River, Part 1

Holiday Farm Fire Survivors Resolve to Protect McKenzie River, Part 2

Holiday Farm Fire Survivors Resolve to Protect McKenzie River, Part 3

Improving Fish Habitat in Trestle Creek

The Lost Salmon

Multi-Species Fishery Management in Lake Pend Oreille, Idaho Natural

Infrastructure: Quillayute River

North Fork Tincup Process Based Back Country Restoration

The Path Home

Priest River: A River of Potential

Salmon are Common Ground

Shelter From the Storm

Walleye and Lake Trout Suppression in Lake Pend Oreille

General Conference Information

Oral Presenters were asked to submit their presentation prior to meeting arrival. However, if this has not already been done, speakers are *required to have their presentation uploaded the day before their scheduled talk, with no exceptions*. All talks will be woven together from start to finish for each 4-hour time block, and there will be no opportunity to inject talks on the day of your presentation. Computers will be set up in the lobby for uploading and review; see the schedule below for uploading times each day, and the registration desk for details.

Poster Presenters can attach their poster to their respective poster location (coded by poster number) on Monday afternoon or any time on Tuesday, in Rooms 100C and 130. The designated Poster Session is Wednesday morning (see below). Posters must be dismantled by noon on Thursday.

Code of Conduct: This meeting, like all American Fisheries Society events, is governed by the AFS Code of Conduct (https://fisheries.org/about/governance/afs-meetings-code-of-conduct/). Its purpose is to ensure a safe, productive, and welcoming environment for all meeting participants, including vendors and non-AFS guests. In addition to the Code of Conduct Reporting Form provided as a reporting mechanism for violations (https://fisheries.org/code-of-conduct-reporting-form/), we are providing onsite contacts for Code violations. Laurie Earley (WDAFS President) and Rob Van Kirk (ICAFS President) will accept complaints at any time from meeting attendees. Please take time to familiarize yourself with the Code of Conduct and its importance.

Accommodations for hearing-impaired attendees: Assistive listening devices (ALDs) are available to help amplify sounds you want to hear while minimizing background noise. ALDs can be used with a hearing aid or cochlear implant. Talk to our volunteers at the registration table if this is something that will help you have a better experience at the meeting

Abstracts will be available for every talk and poster on the Idaho AFS website, after the meeting has concluded. Please access these abstracts as needed once they have been posted.

Fundraising for auction and raffle items will be done using the GiveSmart virtual platform accessible with any smartphone. The link is http://e.givesmart.com/events/vGf and it will go live May 5th, the Friday before the meeting begins. Although bidding will be virtual, all items will be present at the meeting so winners can collect their prizes the night of the fundraising banquet. This year, we have rounded up some really great items including an Alpacka pack-raft, several fly rods, a coveted 3-night campground reservation at Redfish Lake, six Idaho fishing trips, and many other prizes. We're hoping to make this one of the biggest years ever for fundraising!

Nursing Moms - There will be a lactation room with a mini fridge available for nursing moms located on the east side of the lobby.

Vote for Best Papers!

You can provide presenter feedback and help contribute to the decision for Best Professional and Student presentations. Scan this QR code and select the day, time, session and speaker and provide your ratings on 5 questions. You can also provide comments to the speaker if you wish. You will remain anonymous unless you identify yourself in the comments. Thank you for participating!

Monday

Alphabet Social: Find your people on the first night of the conference! This social centers on and celebrates LGBTQIA2S+ and BIPOC identities by holding space for affinity group networking. The event will be held at The Idaho State Museum, just prior to the opening social on Monday evening. BIPOC are welcome at 5:30pm, LGBTQIA2S+ identities are welcome to join at 5:50pm, and allies are welcome at 6:10pm.

Welcome Social: Come join us for the Welcome Social to be held Monday evening at the beautiful Idaho State Museum from 6:30-9:30pm. Food and beverages will be provided, and guests are provided free access to wander through the entire museum (no food or drinks allowed in the exhibit area). Come help us kick off the Joint WDAFS/ICAFS Annual Meeting!

Tuesday

Idaho AFS Committee Meetings Lunch from 12:05-1:20pm, with food provided to those who are willing to attend a committee meeting. This is intended for Idaho AFS members only, to discuss annual committee actions. Box lunches can be picked up in the lobby, with meeting locations as follows:

Native Fish Committee in room 120A
Aquaculture Committee in room 120B
Mentoring Committee in room 120C
Anadromous Fish Committee in room 100E
Aquatic Habitat Committee in room 110AB
Public Education Committee in room 110CD

First-Generation College Students Lunch from 12:05-1:20pm in room 100D, with box lunches provided to those who attend. Experiencing college as a first-generation student is a unique experience for both student and family, and can shape your career for years to come. Join us for an informal gathering of students and professionals who were the first in their family to attend college. This event will be held in Room 100D in the Boise Center, starting at 12:05 on Tuesday. Box lunches can be picked up in the lobby.

Early Career Professionals Lunch from 12:05-2:00pm at the Warehouse Food Hall just a few blocks from the Boise Centre (at 370 S 8th St, Boise, ID 83702; 3-minute walk). Join us for an informal lunch geared toward connecting early career professionals within WDAFS! We will meet at 12:05pm in the Boise Centre Lobby near the registration booth and walk over to the Warehouse Food Hall together. Purchase lunch on your own from one of the 14 vendors at the Warehouse Food Hall, and enjoy your meal in a supportive environment while you network with other early career professionals.

WDAFS Executive Committee Meeting Lunch from 12:05-1:20 pm in Room 140. This meeting is for members of the Western Division Executive Committee, and box lunches can be picked up in the lobby.

Spawning Run/Walk on Tuesday from 4-5pm on the Boise Greenbelt. If you are pre-registered, please check in at the registration desk prior to noon on Tuesday to receive your number and t-shirt. You can still register for the event prior to noon on Tuesday (cost is $15.00) but you will not receive a t-shirt if you signed up after April. The start and end of the race will be at Biomark, Inc. Come join in the fun prior to the Student Mixer. Race start time will be 4pm sharp.

Student Mentoring Panel Discussion from 5-6pm in Room 120B. The Idaho Chapter AFS Mentoring Committee is hosting a panel discussion with professionals from several state and federal agencies, NGOs and tribes. Students and young professionals will hear about different career paths that professionals followed to reach their current position. Panelists will also field questions from students and young professionals about career development, graduate school, career planning, and other relevant topics. This event is right before the Student-Mentor mixer and a great way to break the ice or think of interesting topics to discuss later in the evening.

Student/Professional Pizza Mixer from 6-10pm at the Boise Centre in Room 100A. This is an informal mixer aimed at connecting students to professionals in the fisheries field who can help them on their career path. Attendees will get bingo cards to fill out by meeting students or professionals with different traits or career experiences on the bingo card. Completed cards will be entered in a raffle for great prizes, so bring your business cards and your game face! Complimentary food and beverages provided.

Wednesday

Aquatic Film and Photo Festival in Room 100B. There will be two separate showings, at 8:20-9:50am and 1:50-3:20pm, to give attendees additional time to see all of the submitted photos and films.

Vendor Trade Show with morning refreshments from 10:00-11:30am in Rooms 100C & 130. Although each break throughout the meeting is designed to allow for interaction with vendors, this time block has been specifically set aside for vendors to showcase their equipment and services.

Poster Session with morning refreshments from 10:00-11:30am in Rooms 100C & 130. Intertwined with the Vendor Trade Show will be an opportunity to interact with poster presenters for a 90 minute question/answer period.

ICAFS Annual Business Meeting and Luncheon from 11:30am - 1:30pm in Room 100A. This meeting is open to all Idaho Chapter members, although food is limited to individuals who signed up for this event. There will be updates from Chapter EXCOM and Committees, new EXCOM members will be announced, and award recipients will be recognized.

Early Career Professionals Resume/Interview Workshop from 1:40-3:20pm in Room 140. The Western Division AFS Early Career Professionals Committee is excited to host a resume and cover letter review session on Tuesday afternoon! Students and early career professionals can receive constructive feedback on cover letters and resumes, with guidance geared toward both seasonal positions and permanent positions in the fisheries and natural resource fields. Please either bring A) a hard copy or B) a personal computer with a copy of your resume and/or cover letter to participate.

WDAFS/ICAFS Banquet and Fundraiser from 6:00-10:30pm in Room 100A. Come join in the fun and enjoy complimentary food and beverages. This event will include a silent and live auction to raise money for scholarships, classroom programs, travel grants, and other worthy causes.

Thursday

WDAFS Business Meeting and Luncheon from 12:00 - 1:30 pm in Room 100A. This meeting is open to all Western Division members, although food is limited to individuals who signed up for this event. There will be updates from Division leadership, Committees, and awards recipients will be recognized.

Best Student and Professional Poster Award winners will be announced at the conclusion of the meeting, at 3pm in Room 110CD, immediately following the final speaker. Best oral presentations will be announced at a later date, due to time constraints.

Small Stream Restoration Summit

Organizers: Matt Corsi and Cory Mosby, Idaho Department of Fish and Game, and Josh White, US Fish and Wildlife Service

Description: Approximately 97,000 km of wadable streams exist in Idaho with their associated riparian and instream habitat. The majority of these areas are in some stage of degradation, but when healthy, these areas disproportionately contribute to biodiversity, forage production, and water availability. Enhancing these riparian and mesic habitats through low-tech process base restoration techniques, beaver translocation, and beaver mimicry have gained considerable momentum during the past 5 years, but this approach is still in its infancy.

This one-day meeting aims to build a diverse network of experienced stream restoration practitioners. Desired outcomes of this meeting include: 1) growing a network in Idaho to better deliver mesic and riparian restoration across jurisdictional boundaries at meaningful scales, 2) Identify the biggest gaps in science and monitoring related to the applicability and implementation of this approach, and 3) Develop a collective path moving forward and follow-up action items for small stream restoration in Idaho.

Drones and Remote Sensing in Fisheries Science

Instructor: Daniel Auerbach, Washington State University

This workshop will cover a wide array of drone and remote sensing related topics. Attendees will receive an overview of available drone technology, learn what type of data each family of drones collects, learn how to select drones and associated software, be exposed to the management and analysis of remotely sensed data, and learn what is required in designing/implementing a remote vehicle study. The first few hours will be held in the classroom and include hands on activities and demonstrations of software. The second portion of the workshop will be conducted outside and include live flight demonstrations.

Using Program R in Fisheries Science: A Primer

Instructors:Tawni Riepe, Colorado Parks and Wildlife, and Audrey Harris, Idaho Fish and Game

This is half day course is being hosted by the Early Career Professional Committee and is intended for early career professionals and students who want to use R to estimate basic population dynamic rates. Attendees will learn concepts and code from Introductory Fisheries Analyses with R by Dr. Derek Ogle using a hybrid of lecture, code demonstration, and hands on exercises. Students will use R to construct and apply an age-length key to estimate ages of individual fish from their lengths, estimate mortality rates and compare rates among groups, fit a von Bertalanffy growth function (VBGF) and compare function parameters among groups, and fit several stock-recruitment functions.

Primer on the Human Dimensions of Fisheries Management

Instructor: Kenneth E. Wallen, University of Idaho and the Idaho Department of Fish and Game

Description:What is this thing called human dimensions? This primer on the human dimensions of fisheries management will help answer that question with a half-day workshop to introduce the research and engagement facets that comprise HD. Fisheries managers, practitioners, decision makers, and students deal with various people-related challenges but may lack the knowledge or experience to frame management and conservation problems more broadly to include their human dimensions. The purpose of the workshop is to provide a platform for natural resource professionals—in and out of the human dimensions field—to interact in a way that facilitates mutual understanding of what types of questions are asked, the techniques used to answer those questions, and how both are useful to applied, problem-solving focused management. The workshop will consist of: (a) short lectures to introduce the language and foundations of HD, (b) Q&A and participant discussion, (c) case study examples, and (d) a research and/or engagement development clinic.

Identifying and Preventing Harassment in the Field: A Training by FieldFutures

Instructor: Mandy Frazier, Field Futures

Description:This FieldFutures harassment and assault prevention workshop will help participants learn to prevent, intervene in, and report incidents of sexual harassment and assault in scientific or field settings. They will also learn prevention via positive organizational climate-setting activities matters for the movement toward safe, inclusive fieldwork. Grounded in the latest evidence-based research on harassment prevention and organizational psychology, each session is designed to help participants build knowledge, competency, and self-efficacy so they can set and enforce positive norms in fieldwork settings.

Everything you ever wanted to know about monitoring stream temperature but were afraid to ask

Instructors: Francine Meija, US Geological Survey; Christian Torgersen, USGS Forest and Rangeland Ecosystem Science Center; Tyler King, USGS Idaho Water Science Center; Dan Isaak, USFS Rocky Mountain Research Station; Eric Berntsen, Kalispel Tribe Natural Resources Department

Description:Human activities and climate change are warming rivers, affecting water quality and threatening ecologically, economically, and culturally important coldwater species. Recent increases in data and advances in high-frequency sensors, remote sensing and statistical approaches have greatly expanded the breadth of knowledge regarding water temperature. Although this increase in data and approaches creates opportunities, it also presents challenges that need to be understood to effectively answer relevant management and scientific questions. This half-day workshop is designed to give a broad overview of the ever-expanding data and technology associated with monitoring water temperature. We will discuss how to select approaches that

best address the research and management need while considering data availability, scale of application, cost, and logistical and technological limitations. We hope to generate active discussion among participants. Bring your water temperature questions!

Fish Printing Workshop

Instructor: Bruce Koike

Description: Learn the Japanese art of Gyotaku also known as Fish Printing. At the core of this art from is that the actual fish is used in the process. Participants make numerous prints and have access to one-on-one interactions with the instructor. Rice paper, paint, brushes and fish are provided. Come with an adventuresome spirit of learning. To see more created artwork go to http://koikebruce.wix.com/koike-fish-prints.

Dr. Frank Rahel
University of Wyoming

RAD-ical ideas for managing ecosystem change

Managing ecosystems that increasingly deviate from prior conditions is a major challenge for natural resource managers. In many cases, restoring historical states or managing within a natural range of variation may no longer be feasible. The Resist-Accept-Direct (RAD) framework provides a systemic way to consider all management options for such transforming ecosystems. Managers can resist change and attempt to maintain existing ecosystem composition, structure, and function; accept transformation when it is not feasible to resist change or when change is socially acceptable; or direct change to a new ecosystem configuration considered desirable by society. I will discuss how the four major strategies available to fisheries managers (stocking, regulations, habitat improvement, and community manipulations) can be used to resist, accept, or direct changes in fisheries undergoing transformation. While we often focus on management actions to achieve ecological goals, I will also discuss use of the RAD framework for achieving sociological goals for fisheries.

Dr. Frank Rahel holds a Ph.D. from the University of Wisconsin-Madison and is currently a Professor of Zoology & Physiology at the University of Wyoming where he teaches fisheries management and ichthyology. His research involves fish ecology and fisheries management, with particular interests in invasive species, climate change, fish-habitat relationships, and landscape ecology. Recently he has been involved in developing the Resist-Accept-Direct (RAD) framework for managing the biological and social aspects of fisheries in a changing climate.

Dr. Mary Donovan
Arizona State University

Challenges and opportunities for managing coral reef ecosystems for resilience to climate change

Dr. Mary Donovan is a Professor at Arizona State University. She is a quantitative spatial ecologist focused on applied questions that inform conservation and management of coupled human-natural systems. She studies coral reef status and trends by applying quantitative spatial science alongside practitioners and stakeholders who are implementing management and policy. Her research includes studies on complex ecological dynamics, local and global impacts on reefs, marine spatial planning, invasive species, fisheries, and ecological resilience

Dr. Amy Teffer
University of Massachusetts in Amherst

Climate-adaptive stocking

Climate change is shifting the environments into which fish are being stocked. Without accounting for this change, supplemented populations (i.e., strains) are increasingly maladapted to the thermal and hydrological conditions they will experience. Stocking is a critical component of natural resource management with applications in ecological restoration and resource extraction. So, how should we supplement populations when the future doesn't look like the past? We have the benefit of enormous expertise and infrastructure already in place to adapt our current stocking practices. Climate-Adaptive Stocking (CAS) is a novel framework to apply established concepts, including portfolio theory, evolutionary rescue, and assisted migration. CAS seeks to leverage expert knowledge, experimentation, and well-established theories into a practical approach to improve the effectiveness of fish stocking practices in supporting self-sustaining populations under a shifting climate. The CAS process begins by first refining our understanding of the natural variation in climate-associated tolerances and traits within managed species, guiding strain selection based on predicted resilience in shifting environments. We can then match strain-specific tolerances to the environments into which we place fish to maximize the odds that supplemented populations will thrive, now and in the future. By tracking the relative success of strains across conditions, managers can use this information to design strain portfolios suitable to the variability in conditions and uncertainty in climate projections for their region. Managers faced with the monumental task of supplementing wild populations as the climate changes can organically improve the return on investments, both ecologically and economically. CAS harnesses a broadly applied and politically accepted tool to work to our advantage in the long fight against climate change and biodiversity loss by only slightly shifting the mindset and practice of supplementation managers.

CAS is a component of the Climate-Adaptive Population Supplementation (CAPS) framework, which is a cross-taxa, climate-informed approach to population supplementation led by a team of researchers from Cornell University (Peter McIntyre, Thomas Detmer), the DOI Northeast Climate Adaptation Science Center at the University of Massachusetts Amherst (Amy Teffer), the University of Vermont (Anthony D'Amato, Peter Clark), and the US Forest Service (Keith Nislow).

Dr. Amy Teffer is a fisheries biologist and disease ecologist working with the USGS Northeast Climate Adaptation Science Center at the University of Massachusetts Amherst. She studies the cumulative impacts of climate change and human disturbances on fish and ecosystems across environmental gradients and scales. Her most recent work is focused on pathogen impacts on wild salmon and trout, climate-adapted fish production and stocking, and coastal habitat restoration to promote healthy ecosystems and thriving diadromous fisheries. With coproduction at the core of these efforts, she partners with managers and stakeholders to fill knowledge gaps and find solutions to the challenges facing fishes. She is dedicated to improving equity and balance in the process and outcomes of her work by integrating creativity, humor, and compassion.

Invited Talks

Dr. Charlotte Cote, University of Washington

Indigenous food sovereignty, environmental justice, and sustainability

Climate change and environmental injustice affect communities across the globe, but Indigenous peoples face greater impacts because of settler colonialism that continues to undermine our food sovereignty/security and our relationships to the eco systems that sustain our communities. I will discuss how Indigenous food sovereignty is connected to decolonization and moves beyond it being a political and economic right. Enacting food sovereignty is grounded in Indigenous philosophies and principles that emphasize cultural responsibilities Indigenous peoples have with their environment and restores our sacred relationships to the plants, animals, and ecosystems.

Dr. Rob Van Kirk, Henry's Fork Foundation

New approaches to providing streamflow for fisheries in the American West

Most rivers in the American West are highly managed for irrigation and other uses, but they also support popular trout fisheries and other ecologically valuable resources. Streamflow to support these resources has been conceptually based on minimum streamflow and natural hydrologic regimes, and the prior appropriation doctrine that governs water allocation in the West is generally considered an impediment to providing these flows. Potentially applicable federal laws and policies often do not apply to popular nonnative trout fisheries or to non-listed native species, both of which often occur in agricultural landscapes where hydrologic regimes have been altered by a century of reservoir management, irrigation diversion, seepage, and groundwater return flow. In these cases, traditional approaches such as improving irrigation efficiency can fail to provide instream flows and may even be detrimental to fish and wildlife resources. We propose a new paradigm based on the viewpoints that fisheries and related resources can be maintained in regulated hydrologic regimes and in watersheds dominated by private-land agriculture, and that prior appropriation can be a pragmatic tool for providing instream flow at times and places where it addresses ecologically limiting factors. In particular, conjunctive management of surface and groundwater resources, including aquifer recharge as a management tool, provides opportunities to buffer watersheds against the effects of climate change within existing water allocation systems. However, application of this paradigm requires collaboration among water users, agricultural producers, tribes, government agencies, and conservation organizations.

Mike Belchik,

Landscape-scale fisheries restoration and climate change resiliancy: The Yurok Tribe’s approach to Klamath River Restoration

Paul Powers,

Restoration of resilient river - wetland corridor

Monday, May 8th

Time	Event	Location
7:30 - 5:00	Registration	Lobby
8:00 - 12:00	Monitoring Stream Temperature	Room 110B
8:00 - 12:00	Primer on the Human Dimensions of Fisheries Management	Room 100E
8:00 - 5:00	Small Stream Restoration Summit	Room 100D
9:00 - 12:00	Fish Printing Workshop	Room 110A
1:00 - 5:00	Using Program R in Fisheries Science	Room 100E
1:00 - 5:00	Drones and Remote Sensing in Fisheries Science	Room 110B
1:00 - 3:00	Identifying and Preventing Harrasment in the Field: A Training by FieldFutures	Room 120A
11:30 - 5:00	Vendor Set-up	Rooms 100C & 130
1:00 - 5:00	Poster Set-up	Rooms 100C & 130
2:00 - 5:00	Speaker Presentation Uploads	Lobby
4:00 - 5:00	ICAFS EXCOM Pre-Meeting	120C
5:00 - 5:30	Volunteer and Moderator Meeting	120A
5:30 - 6:30	Alphabet Social	Idaho State Museum
6:30 - 9:30	Welcome Social	Idaho State Museum

Tuesday, May 9th

Time	Event	Location
7:00 - 5:00	Registration	Lobby
7:00 - 5:00	Speaker Presentation Uploading	Lobby
8:00 - 5:00	Vendor Booths	Rooms 100C & 130
8:00 - 5:00	Poster and Fundraising Displays	Rooms 100C & 130
8:00 - 10:00	Meeting Opening and Plenary Session	Room 100A
10:00 - 10:20	Refreshments with Vendors/Posters/ Fundraising	Rooms 100C & 130
10:20 - 12:05	Invited Speaker Session	Room 100A
12:05 - 1:20	ICAFS Committee Meetings Lunches	See above
12:05 - 1:20	First-Generation College Students Lunch	Room 100D
12:05 - 2:00	WDAFS EXCOM Lunch	Room 140
12:05 - 1:20	Early Career Professionals Lunch	Warehouse Food Hall
1:20 - 3:40	Contributed Presentations (concurrent)	See below
3:40 - 5:00	Refeshments with Vendors/Posters/ Fundraising	Rooms 110C & 130
4:00 - 5:00	Spawning Run/Walk	Biomark
5:00 - 6:00	Student/Mentor Panel Discussion	120B
6:00 - 10:00	Student/Professional Mixer	Room 100AB

Wednesday, May 10th

Time	Event	Location
7:00 - 5:00	Registration	Lobby
7:00 - 5:00	Speaker Presentation Uploading	Lobby
8:00 - 5:00	Vendor Booths	Rooms 100C & 130
8:00 - 5:00	Poster and Fundraising Displays	Rooms 100C & 130
8:00 - 10:00	Contributed Presentations (concurrent)	See below
8:20 - 9:50	Film and Photo Festival - morning showing	Room 100AB
10:00 - 11:30	Poster Session with morning refreshemnts	Rooms 100C & 130
10:00 - 11:30	Vendor Trade Show wirh morning refreshemnts	Rooms 100C & 130
11:30 -1:30	ICAFS Annual Business Meeting & Lucheon	Room 100AB
1:40 - 3:20	Contributed Presentations (concurrent)	See below
1:50 - 3:20	Film and Photo Festival - afternoon showing	100AB
1:40 - 3:30	Early Career Professionals Resume/Interview Workshop	Room 140
3:20 - 3:40	Refeshments with Vendors/Posters/ Fundraising	Rooms 100C & 130
3:40 - 5:00	Contributed Presentations (concurrent)	See below
6:00 - 10:30	Banquet and Fundraiser	Room 100AB

Thursday, May 11th

Time	Event	Location
8:00 - 12:00	Vendor Booths	Rooms 100C & 130
8:00 - 12:00	Poster take-down	Rooms 100C & 130
8:00 - 10:00	Contributed Presentations (concurrent)	See below
10:00 - 10:20	Refreshements with Vendors	Rooms 100C & 130
10:20 - 12:00	Contributed Presentations (concurrent)	See below
12:00 - 1:20	WDAFS Business Luncheon and Awards	Room 100A
1:30 - 3:10	Contributed Presentations (concurrent)	See below
12:00 - 3:10	Vendor take-down	Rooms 100C & 130
3:10	Meeting Closing and Best Paper Awards	110CD
3:15- 4:45	ICAFS EXCOM Post-Meeting	Room 120C

Tuesday Morning

Plenary Session

Room 100A

8:00 - 8:15	Introduction to the Meeting	**Laurie Earley**, President of the Western Division of the American Fisheries Society, **Rob Van Kirk**, President of the Idaho Chapter of the American Fisheries Society **Leanne Roulson**, Past President of the American Fisheries Society
8:15 - 8:20	Introduction to the Plenary Session	**Kevin Meyer**, President-Elect of the Idaho Chapter of the American Fisheries Society
8:20 - 8:45	**Dr. Frank Rahel**	RAD-ical ideas for managing ecosystem change
8:45 - 9:10	**Dr. Mary Donovan**	Challenges and opportunities for managing coral reef ecosystems for resilience to climate change
9:10 - 9:35	**Dr. Amy Teffer**	Climate-adaptive stocking
9:35 - 10:00	**Panel Discussion**	
10:00 - 10:20	***Refreshments with Vendors/Posters/Fundraiser - Rooms 100C and 130***	

Invited Speakers

10:20 - 10:50	**Dr. Charlotte Cote**	Indigenous food sovereignty, environmental justice, and sustainability
10:50 - 11:15	**Dr. Rob Van Kirk**	New approaches to providing streamflow for fisheries in the American West
11:15 - 11:40	**Mike Belchik**	Landscape-scale fisheries restoration and climate change resiliancy: The Yurok Tribe's approach to Klamath River Restoration
11:40 - 12:05	**Paul Powers**	Restoration of resilient river - wetland corridor

12:05 - 1:20	**ICAFS Committee Meeting Lunch**	*See Daily Events*
12:05 - 1:20	**First-Generation College Students Lunch**	Room 100D
12:05 - 1:20	**Early Career Professionals Lunch**	Warehouse Food Hall
12:05 - 2:00	**WDAFS EXCOM Lunch**	Room 140

* Student	Tuesday Afternoon					
Room	120A	120B	110AB	110CD	100D	100E
Session Name	Instream Flow and Water Level Protection	Contributed Talks	Contributed Talks	Contributed Talks	Contributed Talks	Contributed Talks
1:30	UAV Floodplain and River Design **RivHab** **Tech Talk**	Open Protocol Acoustical Telemetry System **Lotek** **Tech Talk**	Habitat modeling approaches in the Lower Boise River **HDR** **Tech Talk**	The advantages of HDX technology **Oregon RFID** **Tech Talk**	Improving Aquatic Organism Passage (AOP) through culverts with Flexi-Baffle **SSA Environmental** **Tech Talk**	Syndel Biosecurity Solutions **Syndel** **Tech Talk**
1:40	The emergence of instream flow and water level conservation as an integrative discipline **Thomas Hardy**	Visualizing the core of Idaho Fish & Game's anadromous snorkel program **Alexa Ballinger**	Habitat suitability assessment of Loggers Creek **Dorene MacCoy**	Trout management in the Big Wood River: Past and present **Tucker Brauer**	Investigating angler use and harvest using creel surveys and fish tagging **John Heckel**	The role of a university-operated conservation hatchery on a multiple agencies involved experimental supplementation project **Tien-Chieh Hung**
2:00	Developing water level claims for Upper Klamath Lake, Oregon based on physical habitat needs of Lost River *Deltistes luxatus* and shortnose *Chasmistes brevirostris* sucker, two endangered fish species **Dudley Reiser**	Diversity in life history movement and survival of juvenile steelhead in Idaho **Marika Dobos**	Side channel restoration at the Diane Moore Nature Center, Boise, Idaho **Gregory Kaltnecker**	Distribution and abundance of Redband Trout and nonnative trout in the Wood River basin of central Idaho **Jennifer Vincent**	Using state-space models to estimate recreational angling effort and infer processes that regulate angler dynamics **Joshua McCormick**	Evaluating an egg supplementation program in the lower Boise River **Zoe Brandt**
2:20	Wild trout abundance in relation to winter streamflow in the Henry's Fork Snake River **John Heckel**	Assessment of current smolt production and smolt-to-adult return rates for RAD management of Snake River spring/summer Chinook **Timothy Copeland**	Fish in the city: Urban runoff alters the gut microbiome and physiology of Western Mosquitofish *Gambusia affinis* **Matea Djokic***	Seasonal post release survival and movement of Brown Trout in a southern hydropeaking tailwater **Hayden Wall***	Angler typologies revealed using license purchasing histories **Michael Lant***	A current review of epigenetic effects associated with salmonid supplementation and domestication **Ilana Koch**

* Student	Tuesday Afternoon (continued)					
Room	120A	120B	110AB	110CD	100D	100E
2:40	The future of instream flow and water level conservation; Science, law, policy, and the public **Tom Annear**	Estimation of adult steelhead in a coastal river using SONAR **Kevin See**	Interactions between runoff volume, timing, and annual temperatures shape adfluvial sucker spawning migration schedule **Timothy Walsworth**	Toward empirical assessment of adaptive capacity in aquatic populations across scales: From genomes to landscapes in native Rainbow Trout populations in Idaho **Chris Caudill**	How to tell fish stories and reach a broader audience **Sara Cassinelli**	Effects of hatchery supplementation on natural production of a Pacific salmon population **Shubha Pandit**
3:00	Instream flow and water level protection Q/A **Tom Bassista**	Addressing the complexities of steelhead behavior when estimating adult abundance **Carli Baum**		Conservation of the Paiute Cutthroat Trout: Discovering genetic markers to monitor multiple refuge populations and translocations **Yingxin Su***		Effects of using natural-origin Chinook Salmon in hatchery broodstocks **Darcy McCarrick**
3:20		The quest for fisheries-specific salmon and steelhead hooking mortality estimates **Ian Courter**		Using de novo transcriptomes to decipher the relationships in Cutthroat Trout subspecies *Oncorhynchus clarkii* **Andrea Kokkonen***		Strategic evaluation of goals for spring/ summer Chinook Salmon hatcheries in the Snake River Basin **Jonathan Ebel**
3:40 - 4:00	***Refreshments with Vendors/Posters/Fundraiser - Rooms 100C and 130***					
4:00 - 5:00	***Spawning Run/Walk***					
5:00 - 6:00	***Student Mentoring Panel Discussion - Room 120B***					
6:00 -10:00	***Student/Professional Mixer - Room 100AB***					

* Student	Wednesday Morning					
Room	120A	120B	110AB	110CD	100D	100E
Session Name	Contributed Talks	Forward-looking Science and Stewardship of Large River Systems	Free Round of PBR (Process-Based Restoration)	The Future of the Western Division of AFS	Contributed Talks	Contributed Talks
8:00	PIThy: A web-based application for processing and analysis of PIT-tag data		Introduction to Process-based Restoration Symposium	Modeling stream temperature and flow from gridded climate datasets in Alaska's Yukon and Kuskokwim basins		The demise of salmon and steelhead in the Upper Snake River Basin: A chronological history of dam blockage
8:10	**Brian Maschhoff**	Boise River floodplain restoration - It's for the birds! **River Design Group Tech Talk**	What should streams look like? How does the concept of reference condition relate to the practice of stream restoration?	**Rebecca Shaftel***	Always watching so you don't have to: Vision technology to monitor fishes **Merck Animal Health Tech Talk**	**Dennis Daw**
8:20	PIT tag data tools on the Columbia River DART website	The diversity of northwestern U.S. rivers, threats, and future prospectuses		Evaluating the success of eradicating non-native Brook Trout using Trojan-Y chromosome fish in southern Rocky Mountain streams	Interactions among Yellow Perch, Northern Pikeminnow, and Smallmouth Bass in Lake Cascade, Idaho	Evaluation of fish assemblage in the Grande Ronde Valley, OR, underscores potential threats to local Chinook Salmon and steelhead populations
	Jennifer Gosselin	**Dan Isaak**	**Steve Wondzell**	**Michael Miller***	**Bryce Marciniak***	**Sean Gibbs**
8:40	PIT-tag analysis tools from Columbia Basin Research	Historical Baselines I: Trajectories of fisheries management and Chinook Salmon abundance in Idaho's Salmon River Basin	Process-based riverscape restoration - now or never	Why so salty? How a rare and endemic animal lives in harsh environments	Growth and food habits of Walleyes in the Lake Pend Oreille system, Idaho	Evaluating Chinook Salmon and steelhead response to tributary reconnection
	Rebecca Buchanan	**Timothy Copeland**	**Chris Jordan**	**Audrey Lindsteadt***	**Susie Frawley***	**Stacey Meyer**
8:20 - 9:50	***Film and Photo Festival - morning showing - Room 100AB***					

* Student	Wednesday Morning (continued)					
Room	120A	120B	110AB	110CD	100D	100E
9:00	**IGNITE Talks**: Surfing the tidal wave: Use of transiently aquatic habitat by juvenile Pacific salmon and other fishes in estuaries **Dan Scurfield**; An evaluation of Lake Trout natural reproduction potential in Bear Lake **Cindy Nau**; A portable riverbank photo studio: How to take better fish photographs despite muddy water **Jan Boyer**; Towards a better understanding of invasive crayfish impacts on salmonids **Claire Vaage***; Logging for Largemouth **Joe Thiessen**; Fall Chinook stocking in Coeur d'Alene Lake: Enough is enough **Carlos Camacho**; Effects of introduced Northern Pike on a managed Rainbow Trout fishery in a southwestern reservoir **Jane Trujillo**	Historical Baselines II: Revisiting historical Chinook Salmon abundance estimates to inform recovery potential - What have we learned? **Russ Thurow**	New models of evaluation and communication for processing uncertainty in process-based restoration **Caroline Nash**	There and Back Again: Community traits and interactions mediate aquatic-terrestrial linkages across a mosaic of headwater stream-riparian ecosystems in Northern Yellowstone National Park **Jeremy Brooks***	Evaluating Wallowa Lake's food web and potential limiting factors for Sockeye Salmon reintroduction **Brian Simmons**	Steelhead populations show modest response to 2012-2016 California drought **Haley Ohms**
9:20		How can large rivers support cold-water fish in a warmer future? **Jonathan Armstrong**	Can you have your water and use it, too? The persistent, pernicious issue of downstream water availability **Christine Brissette**	Reach-scale associations between Brook Trout and Bull Trout in Idaho: Patterns across space and time **Nicholas Voss***	Trophic niche dynamics of Brown Trout and Mottled Sculpin in a regulated Rocky Mountain river **Nitsa Platis***	Two-year cycles in Snake River steelhead growth suggest competition with Pink Salmon in the Pacific Ocean **Ryan Vosbigian***
9:40		Proactive science and stewardship of salmon watersheds **Jonathan Moore**	Wood you believe it? Experimental nonnative wood addition enhances in-stream habitat for native desert fishes **Benjamin Miller***	Student invovlement in the Western Division of AFS and how the WDAFS Early Career Professionals Committee can help as students finish their degree programs **Jack McClaren, Audrey Harris, Tawni Riepe**	Investigating the role of network complexity in sustaining biodiversity in meta-food webs of a wilderness river **Laurel Faurot**	A re-interpretation of radio tag data for passage of adult salmonids past dams in the Columbia and Snake rivers **Brian Maschhoff**
10:00 - 11:30	**Trade Show and Poster Session with refreshments - Rooms 100C and 130**					
11:30 - 1:30	**ICAFS Business Lucheon - Room 100AB**					

* Student	WednesdayAfternoon					
1:50 - 3:20	**Film and Photo Festival - afternoon showing - Room 100AB**					
Room	120A	120B	110AB	110CD	100D	100E
Session Name	NOAA's Habitat Restoration through the Bipartisan Infrastructure Law	Forward-looking Science and Stewardship of Large River Systems	Free Round of PBR (Process-Based Restoration)	The Future of the Western Division of AFS	The Integration of Fish Habitat Design and Monitoring Response	Bull Trout: Considerations for Management and Conservation
1:40	NOAA's Habitat Restoration through the Bipartisan Infrastructure Law - Introduction	The need for constructing endangered fish habitats that conform to climate-driven flow changes in a western U.S. river	Food-web dynamics in a river-floodplain mosaic overshadow effects of engineered logjams: Consequences for salmon and process-based restoration	Utilizing the spotting patterns of S. confluentus to identify individuals in photo identification software	Update on the latest in fish tracking from Innovasea **Innovasea Tech Talk**	
1:50	**Larissa Lee**	**Richard Valdez**	**Colden Baxter**	**Svyettlana Parry***	Introduction to The Integration of Fish Habitat Design and Monitoring Response Symposium	Introduction to the Bull Trout: Considerations for Management and Conservation Symposium
2:00	Leveraging funding from the Bipartisan Infrastructure Law and Inflation Reduction Act **Jessica Helsley**	Reconnecting the Kootenai River floodplain to restore ecosystem productivity and native fish recruitment **Shawn Young**	Measuring channel response to Process-Based Restoration **Eric Winford***	Electrofishing and angling data reduce error in abundance estimates for trout in the Lamar River **Keith Wellstone***	Improved habitat design through integration of advanced technology and response monitoring **Jeanne McFall**	Expanding our understanding of Bull Trout viability **Dan Nolfi**
2:20	Strategic Action Planning to support coast Coho recovery – Overview and lessons learned **Tim Elder**	Huu-ay-aht Watershed Renewal Program: Looking forward after the first 5 years **Kaitlyn Manishin**	Quantifying and mapping the thermal and hydrologic retention capacity of beaver habitat and beaver restoration analogs with UAS **Matthew Steinwurtzel***	The story of one invertebrate, two fish parasites, and the largest dam removal project in the world **Elliott Cameron***	Drone Assisted Stream Habitat (DASH) Surveys: Quantifying habitat to inform and assess rehabilitation efforts **Tulley Mackay***	Bull Trout: An IDFG perspective **Brett Bowersox**

* Student	Wednesday Afternoon (continued)					
Room	120A	120B	110AB	110CD	100D	100E
2:40	A collaborative approach to ecosystem restoration in the McKenzie River Sub-basin (OR) **Jared Weybright**	Challenges and innovations for stewarding transboundary river systems **Erin Sexton**	Resist-accept-direct for restoration: Landscape-scale prioritization of floodplain reconnection in Lahontan Cutthroat Trout habitat using remote sensing and GIS **Hayley Glassic**	Potential benefits of implementing lake-level informed removal efforts to control Common Carp **Ellie Wallace***	Hydrologic analysis for river restoration projects: How to integrate ecologically relevant flows into restoration design **Tyler Rockhill**	A synthesis of Bull Trout population genetics **John Hargrove**
3:00	Steelhead passage through an agricultural floodplain - Funding needs and sources **Tom Elliott**	The social-ecological system of the Kenai River fishery (Alaska, USA) **Chase Lamborn**	A Watershed Pyramid Scheme– RAD-ical perspectives from Central Oregon streams **Jonathan Kochersberger**	Estimating the relative production of migratory Westslope Cutthroat Trout in tributaries to the lower Priest River, Idaho **Collin Hendricks***	Integrated monitoring and adaptive management to support the reconnection of historic floodplains to the Lemhi River **Jeffrey Diluccia**	The genomic of isolated lake Bull Trout **Alexandra Fraik**
3:20	***Refreshments with Vendors/Posters/Fundraiser - Rooms 100C and 130***					
Session Name	NOAA's Habitat Restoration through the Bipartisan Infrastructure Law	Forward-looking Science and Stewardship of Large River Systems	Free Round of PBR (Process-Based Restoration)	Contributed Talks	The Integration of Fish Habitat Design and Monitoring Response	Bull Trout: Considerations for Management and Conservation
3:40	Removing barriers on the Olympic Peninsula **Nicole Rasmussen**	Estimated effects of a Stage 0 treatment on juvenile Chinook length and abundance **Aleah Hahn***	Integrating data from multiple tools for monitoring riverscapes and prioritizing restoration actions **Robert Al-Chokhachy**	Characterizing the fish assemblage in the Lake Powell forebay and identifying the potential for nonnative fish escapement into the Lower Colorado River **Barrett Friesen***	Using mobile PIT array technology to monitor juvenile salmonid use of restored side channel and off-channel habitats **Bryce Oldemeyer**	Informing conservation and management of adfluvial Bull Trout in Lake Pend Oreille, Idaho using genetic tools **Jeff Strait**
4:00	A collaborative approach to removing barriers on ESA listed streams in Idaho **Abbie Gongloff**	Spatio-temporal variation in estuarine summer water temperature and implications for nursery function for juvenile Pacific salmon with climate warming **Phoebe Gross***	Using a landscape-scale approach to prioritizing LTPBR sites through partnerships and collaboration **Shelby Weigand**	An experimental test for coexistence with the freshwater invader, Western Mosquitofish **Samuel Lewis***	Increasing future effectiveness by assessing past actions: Fish habitat capacity change at habitat improvement sites in a heavily impacted river **Jim Gregory**	Population demographics and dynamics of juvenile Bull Trout in a montane ecosystem **Sage Unsworth***

* Student	Wednesday Afternoon (continued)					
Room	120A	120B	110AB	110CD	100D	100E
4:20	A community-based coalition strategy for NOAA Transformational Habitat Funding **Jay Krienitz**	Patterns in predation: Understanding climate mediated predation impacts of a subarctic predator **Benjamin Rich***	How to keep the PBR flowing: Perspectives from Tribal, NGO, and land management practitioners **Scott Miller, Wes Keller, Warren Colyer**	How non-native Wakasagi may threaten the persistence of endemic Delta Smelt in the San Francisco Estuary **Yi-Jiun Jean Tsa**	Hand pulls, herbicide, and channel relocations: Winning the battle with Eurasian Watermilfoil in Jefferson Slough **Mike Sanctuary**	Evaluating Bull Trout fish/redd metrics in the Puyallup Basin, Washington **Jeffery Johnson**
4:40	NOAA's Habitat Restoration through the Bipartisan Infrastructure Law - Discussion and future opportunities **Larissa Lee**	Material flow and meta-food webs of a floodplain mosaic: Effects of river regulation and introduced species on the Snake River, ID **James Paris**		A species on the edge: Can intraguild predation explain Burbot decline **Robert Eckelbecker***		
5:00			Beyond Process-Based Restoration - Following the science **Michael Pollock**	Optimizing invasive species eradication in time and space: A case study of Green Sunfish removal in intermittent streams **Jessica Diallo***		
5:20			Free Round of PBR Closing Remarks **Brian Hodge, Matt Corsi**			
6:00 - 10:30	**Fundraising Banquet - Room 100AB**					

* Student	Thursday Morning					
Room	120A	120B	110AB	110CD	100D	100E
Session Name	Addressing Aquatic Organism Passage	Non-permanent Rivers and Streams	Filling the Void: Expanding Anadromous Fish into Historical Habitat	Applying Research in Hatcheries	Western Native Fishes	Contributed Talks
8:00			Lessons from the recovery of Columbia Basin Sockeye Salmon and implications for restoration into other subbasins **Jeff Fryer**	Research in aquaculture: Strategic innovation **George Schisler**		
8:10	Introduction to the Addressing Aquatic Organism Passage Symposium				Introduction to the Western Native Fishes Symposium	
8:20	Incorporating non-summer growth potential elevates the importance of downstream habitats in aquatic connectivity decision making		Okanagan Nation Alliance's Okanagan Basin Sockeye Salmon Reintroduction and Restoration Program (1995-2023)		Assessing the genetic variation of Lahontan Cutthroat Trout in the Walker River Tributaries	Community based regional cooperation for effective monitoring, control and surveillance of Arabian Sea fisheries of Pakistan: A case study of international cooperation for capacity building, training and sustainability **Muhammad Naeem Khan**
8:30	**Helen Neville**		**David Duvall**	Bridging the gap between public and private aquaculture, collaborative research opportunities, and why we're better together	**Paul Lee***	
8:40	Outcomes from a Forest Road and Fish Passage Assessment on the Coeur d'Alene Reservation: A 15 year retrospective **Stephanie Hallock**	What are non-perennial waters and why should we care? An introduction to the session **Leanne Roulson**	A case for sprawl: Encouraging salmon to move to the suburbs using targeted hatchery releases **David Venditti**	**Jesse Trushenski**		Assessing the utility of coral reef indicators for evaluating ecosystem-based management thresholds **Shannon Hennessey**

* Student	Thursday Morning (continued)					
Room	120A	120B	110AB	110CD	100D	100E
9:00	Use of flexible baffles to improve Aquatic Organism Passage (AOP) through culverts in North America **Shane Scott**	Identifying potential climate-change refugia for fishes in the face of warming, drying, barriers, and invasive species **Niall Clancy***	Is trap and haul a viable, long-term management solution to passage issues at Big Bear Falls in the Potlatch River Basin, Idaho? **Brian Knoth**	Collaboration of research and hatchery production staff to benefit management of hatchery trout fisheries **Will Lubenau**	Upper Columbia River Redband Trout in the midst of climate change **Aspen Nelson**	Challenges of implementing marine ecosystem based management **Moses Koroma**
9:20	Tools for tracking road stream crossings and streamflow permanence - feature mapping with mobile data collection **Emily Heaston**	Analyzing modeled representations of no- and low-flow in the Pacific Northwest **Adam Price**	Clearwater Basin anadromous fishes - Past, present, and future **Jason Vogel**	Balancing feed costs and growth, health, and angler preference for catchable Rainbow Trout reared on the standard feeds from four commercial feed manufacturers **Eric Fetherman**	Harnessing genomic techniques to inform conservation management of the Lahontan Cutthroat Trout *Oncorhynchus clarkii henshawi* **Alana Luzzio***	Research across an international border: Partnering to assess a shared at-risk species **Dayv Lowry**
9:40	Lessons learned from a decade of monitoring adult Chinook movement in the Lostine River, Oregon **Shane Vatland**	Using lidar and spectral imagery to identify and model streamflow in small streams **Konrad Hafen**	This history of spring and summer Chinook Salmon fishing in Idaho **Joe Dupont**	Case studies of implementing research outcome into the operation of a conservation hatchery **Tien-Chieh Hung**	Conservation challenges for endemic crayfishes of western North America **Eric Larson**	Exploring rockfish (Sebastes) diversification using a phylogenetic comparative approach: Depth, color, and pattern **Peter Searle***
10:00 - 10:20	***Refreshments with Vendors - Rooms 100C and 130***					
10:20	Fish passage as a key step in the process to restore native fish assemblages by means of non-native trout removal **James DeRito**	Evaluating the effects of intermittent flow on the resilience and vulnerability of fish assemblage structure **Cienna Hanson***	The case for effective hatchery management: Restoration of fall Chinook Salmon in the highly altered, secondary habitats of the Snake River **William Young**	Triploid Burbot *Lota lota* production: Optimization of thermal and hydrostatic parameters, tetraploid induction, and confirmation of triploid sterility **Luke Oliver**	Effects of catch-and-release ice fishing on trout mortality in a highly pressured fishery **Nathan Tillotson**	Positive selection and adaptive radiation in Rockfish **Tanner Van Orden***

* Student	Thursday Morning (continued)					
Room	120A	120B	110AB	110CD	100D	100E
Session Name	Addressing Aquatic Organism Passage	Non-permanent Rivers and Streams	Filling the Void: Expanding Anadromous Fish into Historical Habitat	Applying Research in Hatcheries	Western Native Fishes	Contributed Talks
10:40	Restoring fish passage in the Tillamook Bay and Nestucca Watershed **Cory Sipher**	Non-permanent streams in the Colorado River Basin insulate against hybridization in catostomid species **Zachary Hooley-Underwood**	Heesu, the other anadromous fish: Restoring Snake Basin Pacific Lamprey **Jay Hesse**	Spontaneous autopolyploidy testing protocol for three-month-old Kootenai River White Sturgeon **Mark Elliston**	Exploring impacts of lake level decline on a critical native forage species in a large terminal desert lake **Sarah Barnes***	When digestive physiology doesn't match "diet": *Lumpenus sagitta* (Stichaeidae) is an "omnivore" with a carnivorous gut **Daniel Rankins***
11:00	Transformational aquatic connectivity restoration through the Bipartisan Infrastructure Law and beyond **Amy Horstman**	Characterizing the availability of native salmonid spawning habitats in intermittent tributaries **Skylar Rousseau***	Lessons learned from a decade of salmon and steelhead reintroduction on the Deschutes **Megan Hill**	Investigating Kootenia River White Sturgeon natural substrate during egg incubation **Brian Michaels**	Age-structured survival rates of Burbot in the Kootenai River's hatchery-augmented fishery **Joshua Heishman***	Utility of parentage-based tagging for monitoring Coho Salmon *Oncorhynchus kisutch* in the interior Columbia River basin **Rebekah Horn**
11:20	Fish passage monitoring and remediation in a highly modified New Zealand ecosystem **Ryan Easton***	The effect of flow regime on the feeding ecology of Redband Trout *Oncorhynchus mykiss* in an intermittent stream **Christopher Walser**	Recolonization by steelhead and salmon in the White Salmon Subbasin following dam removal **Joe Zendt**	Aquatic Gas Optimization: A novel oxygenation solution for fish hatcheries **Sarah Hoffmann**	Plasticity and genetic basis of thermal tolerance and performance traits in Redband Trout **Zhongqi Chen**	Using quantitative PCR to estimate Chum Salmon *Oncorhynchus keta* abundance with environmental DNA on the Chena River **Maggie Harings***
11:40	AOPs - Connecting agencies, disciplines, and habitat **Kevin Davis**		Assisted migration of Coho Salmon: Stakeholder engagement in adaptive management **Joseph Benjamin**	Starting at the source: How the College of Southern Idaho views teaching students to conduct research as an essential requirement of the aquaculture program curriculum **Melissa Wagner**	History of Burbot monitoring in the Kootenai River - The power of PBT **Aaron Black**	Adaptive haplotypes associated with age-at-maturity in Dworshak National Fish Hatchery steelhead **Audrey Harris**
12:00 - 1:20	**Western Division Business Meeting and Lucheon - Room 100A**					

* Student	Thursday Afternoon					
Room	120A	120B	110AB	110CD	100D	100E
Session Name				Applying Research in Hatcheries	Contributed Talks	
1:30				Hatchery propagation did not reduce natural steelhead productivity relative to habitat conditions and predation in a mid-Columbia River subbasin **Mark Roes**	Population structure of White Sturgeon *Acipenser transmontanus* in the Columbia River inferred from single nucleotide polymorphisms **Stuart Willis**	
1:50				Fecundity trends of Chinook Salmon in the Pacific Northwest **Michael Malick**	Evidence of reduced growth in Kootenai River White Sturgeon and implications for recovery **Troy Smith**	
2:10				The influence of fall body length and rearing conditions on smolt migration survival in relation to Columbia River migration conditions for spring Chinook Salmon reared at Leavenworth National Fish Hatchery from 2010-2020 **Ben Kennedy**	Using microchemistry to inform growth dynamics of Kootenai River White Sturgeon **Courtnie Ghere***	

* Student	Thursday Afternoon (continued)					
Room	120A	120B	110AB	110CD	100D	100E
Session Name				Applying Research in Hatcheries	Contributed Talks	
2:30				An evaluation of rearing strategies for steelhead production at Hagerman National Fish Hatchery, Idaho - Can a Partial Recirculating Aquaculture System (PRAS) address the challenges of a large-scale steelhead mitigation program? **Rod Engle**	White Sturgeon population dynamics and demographics of a hatchery-established population **Donavan Maude***	
2:50				Smoltification strategies: understanding a unique feature of salmonid biology and how to manage the process in aquaculture **Jesse Trushenski**		
3:10				**Best Paper Awards**		

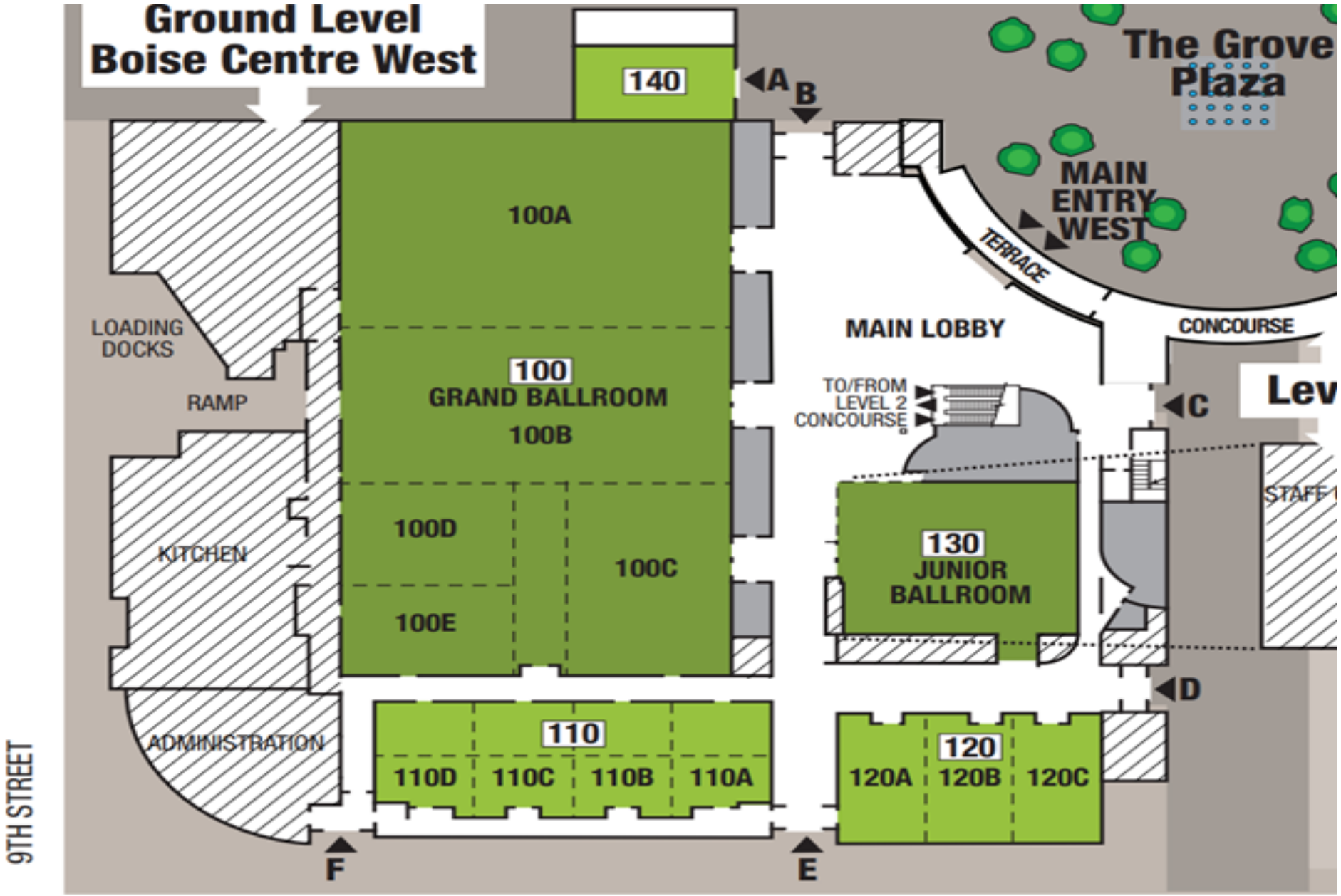
#	Poster Title	Author
1	Opening rivers for the movement and migration of native fishes in the Bear River Basin	**James DeRito**
2	Influence of increasing water temperature on the thermal tolerance of *Gonidea angulata* and its host fish, *Cottus spp*.	**Rachael Valeria***
3	Revisiting the mitochondrial DNA phylogeography of Mountain Whitefish *Prosopium williamsoni* in Idaho	**Erika Alvarado**
4	A novel method to map channel units using non-spatial field data to develop scalable summaries and inform restoration design	**Michael Briggs**
5	Effect of temperature in growth, survival, and chronic stress responses of juveniles of Arctic Grayling *Thymallus arcticus*	**Alonso Longoria***
6	Comparison of pectoral fin rays and lapilli for estimating age of Northern Pikeminnow in a montane reservoir	**Bryce Marciniak***
7	The heart of the issue: What drives interpopulation differences in physiological and behavioral plasticity?	**Jon Masingale***
8	Effect of climatic variation on spawning migrations of Utah Sucker and Green Sucker	**McKay Curriden***
9	The drying of Dry Creek: Influence of springs on headwater stream intermittency	**Elizabeth Crowther***
10	Does stream connectivity and species assemblage affect fish diet composition in headwater streams?	**Brandy Smith**
11	Drivers and consequences of Chinook Salmon *Oncorhynchus tshawytscha* juvenile migratory diversity in a wilderness river	**Samuel Owens***
12	Shocking news: A deep dive into the electrofishing literature	**Jim Reynolds**

*** Student**

#	Poster Title	Author
13	Lower Boise River mussel surveys	**Dorene MacCoy**
14	Phylogeography of *Prosopium* species in Idaho	**Katharine Coykendall**
15	Effects of domestication practices on genetic variation associated with reproductive traits of Rainbow Trout	**Sara Schwarz**
16	Using environmental DNA to assess spatiotemporal variation in Arctic Grayling and Chinook Salmon throughout the Chena River	**Kristen Reece***
17	Evaluating the need for regulation change in a popular fishery	**Phil Saporito**
18	Precision of age determination using pectoral fin rays removed with or without the articulating process	**Jessica Moon***
19	Annual flows and spatial distribution of Bull Trout	**Thomas Doolittle***
20	Evaluation of non-lethal genetics sampling techniques for fry	**Darcy McCarrick**
21	Biological carryover effects from juvenile migration on age at maturity in wild spring/summer Chinook Salmon in the Snake River, USA	**Caitlin O'Brien**
22	What can divergent long-term monitoring efforts tell us about small scale salmonid habitat restoration in the Pahsimeroi River, Idaho?	**Luke Anderson***
23	Conservation of imperiled native *Catostomus* suckers using a barrier intervention	**Jillian Campbell***

*** Student**

The Boise Center Floor Plan



Symposia:
Instream Flow and Water Level Protection: A Look In the Past, Current Programs and the Future

Organizers: Tom Bassista-Idaho Department of Fish and Game, Instream Flow Council Regional Director (Region 1)

The protection of instream flow and water levels in lakes and reservoirs is a critical component for healthy fisheries. Post World War II construction and development of reservoirs, highways, bridges, subdivisions, agriculture and forestry all contributed to a need for better streamflow and water level recommendations and management. However, it was not until 1995 when the National Instream Flow Program Assessment project was formed which culminated in the formation of the Instream Flow Council (IFC) in 1998. The IFC's mission is to improve the effectiveness of instream flow and water level programs for conserving aquatic resources. Throughout the Nation and Canadian Provinces there are varied instream flow and water level programs. To this day it is still critical to engage stakeholders at all levels to recommend instream flow and water levels commensurate with healthy fish populations. This session will focus on the history of instream flow and water level protection, showcase a few programs from around the western US and conclude with an update on both the ambitious efforts of the IFC and AFS to Establish a new Instream Flow and Water Level Conservation Center. It is critical to understand our past, examine what is working and help carve a path forward for future biologist and managers to protect and enhance our fishery resources through ecologically driven instream flow and water level recommendations.

Tom Annear

The future of instream flow and water level conservation; Science, law, policy, and the public

The Cooperative Instream Flow Service Group (CIFSG) in Fort Collins played a vital role in developing and promoting the discipline of instream flow and water level conservation (IFWLC) from 1977 thru 2000. Their training focused on the application of credible, science-based techniques and helped standardize approaches to instream flow studies used by thousands of practitioners around the world. Despite these important advances, there was still considerable variation in selection and application of methods and the interpretation of results by practitioners. To address these uncertainties; build on CIFSG accomplishments; and integrate the continued advances in science, law, policy, and public demands associated with managing aquatic resources, state and provincial fish and wildlife agencies formed the Instream Flow Council (IFC) in 1998. Over the first 9 years of their existence, the IFC published a total of 4 books to clarify the utility of various methods and offer guidance on how to interpret their findings. However, the lack of centralized training, development, and support for over 20 years has led the discipline to fragment and lose some of the credibility that was provided by the CIFSG. To address this trend, the IFC and American Fisheries Society agreed to pursue development of a new Training Center in 2019. They subsequently assembled a 10-person steering committee, secured a MSCG grant, and wrote a feasibility assessment that has been internationally reviewed. The proposed Center will emphasize integrating five ecological components with appropriate laws, policies, and public involvement in addition to networking with other entities, helping guide future research, and providing support to practitioners. To date, the committee has found overwhelming support. They are now in the process of securing a training location, funding, and trainers. View their recently completed feasibility report at www.instreamflowcouncil.org.

Tom Bassista

Instream flow and water level protection Q/A

Please join this talk for an interactive Q/A session with the 4 presenters and moderator that will conclude this symposium. The Q/A session will allow for in-depth conversation about instream flow and water level conservation and how it is important for fisheries scientist and managers in helping to protect and preserve fisheries. The Q/A session will explore the use the habitat models and/or fish population data to help drive instream flow and water level recommendations that benefit aquatic

ecosystems and fisheries.

Thomas Hardy

The emergence of instream flow and water level conservation as an integrative discipline

The ethos of instream flow and water level conservation (IFWLC) can be traced back to ancient civilizations such as Greece and Rome that recognized that flowing waters provide important benefits and are the property of all the people. Fast forward to the turn of the 20th century through 1960's in western societies, IFWLC primarily focused on water quality and wastewater assimilation. By the 1970's numerous approaches began to emerge that incorporated habitat assessments and aquatic resource needs. Beginning in the early 1980's, the rapid expansion of analytical approaches covering a wider array of disciplines such as hydrology, hydraulics, sediment transport, water quality and habitat modeling paralleled the development and access to desktop computers and their nascent operating systems. By the 1990's, desktop computer systems facilitated access to more interdisciplinary analysis systems, exemplified by the efforts of the Cooperative Instream Flow Service Group (CIFSG) and their development of the Instream Flow Incremental Methodology (IFIM) which supported integrated analysis modules for hydrology, hydraulics, water quality and aquatic habitat modeling. The increasing power of computers, advanced operating systems, and sampling technologies over the past two decades has resulted in ever more sophisticated analysis frameworks that integrate not only the physical, chemical and biological sciences but have incorporated additional disciplines such as economics and policy. By the early 2000's, IFWLC as an integrative discipline was well established and recognized across most developed countries. The advancement of ever more sophisticated analysis systems that integrate geospatial data targeting ecological systems at watershed scales continues at an accelerated pace. However, what has failed to keep pace with these advancements is access to credible training programs. In fact, the last broadly accessible IFWLC training pragmatically stopped in 2000 with the dissolution of the CISFG. This deficiency is being addressed by the IFC/AFS efforts to establish an IFWLC Center.

John Heckel

Wild trout abundance in relation to winter streamflow in the Henry's Fork Snake River

Winter is a difficult time for wild trout. During winter, physiological changes occur that result in declining body condition, depletion of lipid reserves, and low streamflows cause a reduction of instream habitat. Therefore, winter is the bottleneck for wild trout survival and when the majority of mortality occurs in a wild trout population. To offset the challenges of survival during winter, juvenile trout seek refuge in habitat that provides forage, thermal refugia, and cover from predators. In the Box Canyon of the Henrys Fork Snake River, juvenile trout rely on such habitat in interstitial spaces within the benthos and stream margins. However, the Box Canyon is immediately downstream of an agricultural water storage reservoir that annually draws down to a low pool by the end of irrigation season, which during lean water years can limit the amount of winter streamflow. Fisheries biologists from the Idaho Department of Fish and Game began investigating the relationship of winter streamflow to wild Rainbow Trout Oncorhynchus mykiss abundance in the Box Canyon in the early 2000s. Of 25 different streamflow variables investigated with regression models, mean winter streamflow (i.e., December-February) was the most significant variable ($r^2 = 0.45$) affecting trout abundance. We found that stronger year classes were related to higher winter streamflows. Despite the evidence of the importance of higher winter streamflows, a minimum flow in Box Canyon does not exist to protect aquatic resources. Therefore, the Idaho Department of Fish and Game and its collaborators use the flow model as tangible evidence to recommend winter streamflow in Box Canyon, to forecast trout abundance, and to describe the health of the fishery.

Dudley Reiser

Developing water level claims for Upper Klamath Lake, Oregon based on physical habitat needs of Lost River *Deltistes luxatus* and shortnose *Chasmistes brevirostris* sucker, two endangered fish species

Upper Klamath Lake (UKL), Oregon is a shallow (average depth 7.1 ft), hyper-eutrophic lake that undergoes seasonal fluctuations in surface elevation as regulated by the U.S. Bureau of Reclamation's Link River Dam. The lake supports populations of two endemic sucker species, Lost River Sucker (Deltistes luxatus) (LRS), and Shortnose Sucker (Chasmistes brevirostris) (SNS) both of which are listed as "endangered" under the Federal Endangered Species Act (ESA). Both species are primarily adfluvial, but the LRS and to a much lesser degree SNS also support distinct populations of lacustrine spawning fish, making use of a series of spring influenced shoreline areas

for spawning. Because UKL is subject to algae blooms (Aphanizomenon Flos-Aquae) and periodic die-offs, water quality conditions can vacillate dramatically and have resulted in periodic fish kills. The seasonal fluctuations in lake level have the potential to influence both the quality and quantities of in-lake habitat for both species. In 1990, the United States Bureau of Indian Affairs (BIA) acting on behalf of the Klamath Tribes began investigating the relationships between the lake levels in Upper Klamath Lake and key habitats necessary for the sustainability of these two fish species. From a physical habitat perspective, this included in-lake spawning, larval nursery, and adult habitats, as well as lake levels affording access to water quality refuge habitats in adjoining Pelican Bay. Water quality analysis was also included in the investigation. This paper presents the results of the physical habitat analysis that in tandem with the water quality analysis resulted in water right claims for monthly lake levels based upon the habitat needs of these two sucker species. These claims were submitted, reviewed and ultimately determined to be valid in 2013 by the Oregon Water Resources Department as part of the Klamath Basin Adjudication.

Symposia:
Forward-looking Science and Stewardship of Large River Systems

Organizers: Jonathan Moore, jwmoore@sfu.ca; Jonny Armstrong,Jonathan.armstrong@oregonstate.edu

Large river systems and their fishes are rapidly shifting due to climate change and other anthropogenic drivers. From retreating glaciers to warming river temperatures to rising sea-levels in estuaries to removing large dams, we are in an era of major transformation of large and connected river systems. There is in an urgent need for science to be forward-looking in order to inform proactive stewardship of these systems. In this symposium, we invite talks that illuminate how fishes and large river systems are coping with change, predict how these systems may change in the future, consider potential policy levers for action, and implement proactive conservation options. Presentations are particularly encouraged that link science to policy and action, and that consider diverse ways of thinking on forward-looking watershed stewardship. Collectively, we hope that this symposium would showcase different approaches and ideas that connect to on-the-ground efforts to foster resilience in this era of rapid change.

Jonathan Armstrong

How can large rivers support cold-water fish in a warmer future?

Mainstem rivers are typically the warmest portion of the riverscape during summer. In a warmer future, these seasonally warm habitats appear to be increasingly risky places for cold-water fish, such as salmonids. However, many species, populations, or life-histories of salmonids require mainstem habitat. Even if these habitats are stressful, or even lethal during summer, they may be optimal during the rest of year. Here I will explore case studies showing how salmonids exploit seasonally warm rivers and how accounting for seasonality and animal movement can change how we look at conservation opportunities across landscapes.

Timothy Copeland

Historical Baselines I: Trajectories of fisheries management and Chinook Salmon abundance in Idaho's Salmon River Basin

An understanding of past conditions, population baselines, and spatial distributions is crucial to inform effective management of fish populations. Surveys of Chinook Salmon redds in Idaho began >70 years ago to monitor populations potentially affected by dam construction on the Columbia and Snake rivers. Redd counts were also used to manage fisheries which, at that time, covered most of the accessible spawning habitat in Idaho. Trend redd counts in the Salmon River declined several orders of magnitude from >13,000 redds in the late 1950s to 334 redds in 1980. In the 1950s and early 1960s, harvest from downriver and terminal fisheries often exceeded 60%; those fisheries were increasingly curtailed through the 1970s. Hence, declines in abundance were greater than indicated by the decline in redd counts. Hatchery programs were founded to mitigate for fishery losses and declining fish counts at dams soon consisted of increasing proportions of hatchery-origin fish. The Salmon River populations were listed under the Endangered Species Act in 1992, yet numbers of redds in the Salmon River basin declined to 192 redds in 1995. A very limited fishery on hatchery fish was supported until the hatchery system matured in the 2000s, after which the fishery was expanded to most reaches used by hatchery fish. Recreational fisheries now focus exclusively on marked hatchery fish and are intensively monitored and regulated to protect wild populations. Redd counts remain well below population viability thresholds and spatial distribution has declined since the 1960s. Importantly, historical redd counts and past fisheries are being used as benchmarks in the development of goals to restore Chinook Salmon in the Snake River basin to healthy and harvestable levels. This case study illustrates the importance of long-term trend data to establish realistic baselines and inform future management and conservation at large scales.

*Phoebe Gross**

Spatio-temporal variation in estuarine summer water temperature and implications for nursery function for juvenile Pacific salmon with climate warming

Estuaries support many important species including anadromous fishes like Pacific salmon (Oncorhynchus spp.), but this key function may be dramatically altered by forthcoming climate change. Juvenile salmon may rear and grow in estuaries during seaward migration, and rapid estuarine growth can improve marine survival. Fish growth is temperature-dependent; thus, spatio-temporal temperature dynamics could play a key role in shaping growth potential across estuaries. Studies in freshwater systems have increasingly revealed how fish rely on both broad- and fine-scaled spatio-temporal temperature variability, yet few studies have investigated these dynamics in estuaries. In addition, research is needed to understand how these dynamics may shift given oncoming climate warming. We addressed these knowledge gaps by (1) assessing summer temperature patterns across different habitats within two contrasting estuaries on Vancouver Island, BC, (2) using this data to explore juvenile Chinook salmon (Oncorhynchus tshawytscha) growth potential across each system using bioenergetics modeling, and (3) investigating changes in growth potential under a scenario of increased temperature. We found that water temperature varied over multiple spatio-temporal scales—including daily tidally-driven cyclic patterns, between-habitat differences in mean daily temperature, and a seasonal trend of maximum summer temperatures in late-July. This led to variable growth potential across both systems—while all sites showed increases through early-summer, some dropped to negative values in late-summer while others remained positive. Under the climate change scenario, excessively hot temperatures led to further decreases in growth potential relative to present conditions in one estuary. In contrast, growth potential largely increased across the other. Together, this work illustrates how climate-change induced temperature increases may have diverging impacts on Pacific salmon populations dependent on estuary habitats and locations. Building an understanding of these responses can help inform management actions to protect diverse estuarine habitat mosaics that support diverse growth opportunities for salmon and other fishes.

*Aleah Hahn**

Estimated effects of a Stage 0 treatment on juvenile Chinook length and abundance

Low-tech habitat restoration techniques, including Stage 0 treatments, are increasingly applied but often lack robust evaluation of their effects. In 2018, one kilometer of the South Fork McKenzie (SFM) River, OR was modified to the Stage 0 condition for the benefit of ESA-listed Chinook by raising the incised channel to the geomorphic grade line, reconnecting historic side channels, increasing floodplain connectivity, and distributing large wood throughout the reach. This study combined field observations with the individual-based bioenergetics model inSALMO to examine how the treatment may impact juvenile Chinook length, abundance and migration timing across water years and changes in reservoir operations. Hydraulics representative of pre- and post-treatment conditions, variable food availability, and altered water temperatures were applied to represent pre- and post-treatment conditions for the SFM. Lower depths and velocities were observed at the treated site than at the untreated site. Model results

indicate the hydraulics in the treated reach significantly increase the size of rearing. Additionally, the treated reach produces a significantly larger population of rearing juveniles that leave the system later in the summer. Sensitivity analysis indicates that outmigration abundance is most sensitive to changes in temperature while mean outmigrant length is most sensitive to changes in hydraulics. Additional model outputs indicate the treated reach produces a larger population, but that population increase is mitigated by an increase in predation deaths in the treated site, likely tied to their increased residence time. Collectively, the model results demonstrate an increase in juvenile length without significant changes in total population abundance; further studies should examine if these patterns are consistent across the diverse conditions found at various Stage 0 sites.

Dan Isaak

The diversity of northwestern U.S. rivers, threats, and future prospectuses

Rivers constitute small portions of drainage network extents but are disproportionately important in terms of overall habitat volume and their functionality as migratory corridors for mobile species and life histories, support of fisheries, other recreational pursuits, and economic activity. Because of the landscape position of rivers at relatively low elevations in large valleys, these systems tend to be warmer, frequently flow through private lands, and may often be heavily altered in terms of habitat conditions and aquatic communities. Nonetheless, across large regions a diversity of rivers and riverine conditions exist that must be understood to properly assess risks and strategically allocate conservation resources. Using an example from the northwestern U.S., we describe the extent of the region's rivers, degrees of impairment, and hydroclimatic trends in recent decades. Unsurprisingly, a minority of rivers still possesses a high degree of biophysical integrity whereas the majority are subject to multiple degrading factors which increase the complexity of the decision space with regards to conservation. We extend the example with case histories highlighting the scope of conservation issues and how interactions with local conditions and management objectives often necessitate site-specific decision making rather than the application of general approaches. At the heart of the challenges associated with river conservation and restoration is the multitude of services, many of which are contravening, that society asks of rivers and which are sometimes impossible to rectify with a finite resource. A key challenge in river management, therefore, is identifying where desired conservation outcomes are possible and where these outcomes may no longer be possible as trends in hydroclimatic conditions and human population growth continue in the northwestern U.S.

Chase Lamborn

The social-ecological system of the Kenai River fishery (Alaska, USA)

Fisheries are complex and dynamic systems made-up of both social and ecological components. Tools such as social-ecological frameworks can facilitate the holistic explorations of complex systems like fisheries, while also providing the opportunity to identify information gaps. However, these general frameworks lack the specificity to be applicable to specific social-ecological systems. Therefore, we provide a method for developing inductively generated social-ecological models, and present a collaboratively developed social-ecological model of the Kenai River Fishery. We developed the model through iterative interviews with stakeholders throughout the Kenai Peninsula using a novel participatory Fuzzy Cognitive Mapping process grounded in Ostrom's social-ecological systems framework. Individual social-ecological models, developed one-on-one with stakeholders, were combined into a single aggregated model representing the Kenai Fishery's structure and function. We validated this aggregated model through subsequent interviews with stakeholders and focused literature reviews. The result is a model that can: 1) illustrate the breadth and interconnectedness of the Kenai River Fishery's social-ecological system; 2) be used to facilitate discussions around management of the fishery; and 3) be used to explore the components and interactions that move the system toward or away from sustainability. Using the model, we identify how the nature of salmon (migratory) and their habitat (large and unpredictable) leads to uncertainty about effective management strategies. This uncertainty, in addition to a large and diverse set of resource users, creates conflicting management goals that ultimately limit the governance system in making decisions that might increase the sustainability of the fishery.

Kaitlyn Manishin

Huu-ay-aht Watershed Renewal Program: Looking forward after the first 5 years

The Huu-ay-aht First Nations (HFN) Watershed Renewal Program aims to protect and restore high-value cultural and habitat areas that were degraded by anthropogenic impacts, primarily forestry. Long-term objectives focus on the restoration of ecosystem processes and short-term objectives focus on the management and conservation of high-value species and habitats. Since its inception in 2017, the program has employed over 25 HFN citizens and provided both on-the-job and classroom training. The program currently operates with about five seasonal technicians as guided by aquatic biologists with LGL Limited and HFN Lands and Resources. The program covers the entire Hahuuƚi (HFN traditional territory) and includes the inland waters and forests of several major watersheds: Sarita, Pachena, Sugsaw, Carnation, and Klanawa. In the first five years aquatic activities included: floodplain mapping and restoration, culvert and stream crossing assessment, multiple watershed assessments, and instream and side channel restoration. Salmon are one high-value group and Sarita River Chinook Salmon is a primary stock of interest. On the Sarita River, spawner escapement is monitored via snorkel surveys and juvenile outmigration is assessed using a rotary screw trap and mark-recapture methods. Studies of juvenile estuary use are also underway. The combination of watershed assessments and the monitoring of multiple life history stages provides an opportunity to examine the relationship between environmental changes and population dynamics. A suite of proposed projects aims to make Sarita Chinook an indicator for the COSEWIC-listed West Vancouver Island, Ocean, Fall (South) population and contribute to the knowledge of Chinook Salmon ecology in rain-dominated coastal rivers.

Jonathan Moore

Proactive science and stewardship of salmon watersheds

In watersheds of western North America, migratory salmon support ecosystems, economies, and cultures. However, these fish and their fisheries are threatened by climate change and multiple stressors. How do we steward salmon systems in this era of rapid change? Here I will share some stories of science and its application for salmon stewardship and climate resilience. First, glacier retreat is uncovering new rivers and lakes for salmon in some locations. Research is identifying where and when these new habitats will be created. These nascent ecosystems are also hotspots for mining exploration that could harm these future salmon habitats. Second, climate change is altering river temperature and flow regimes and these stressors could be magnified by land-use activities such as forestry or by water withdrawals. For example, forestry substantially warms water temperatures. Thus, watershed activities could exacerbate climate impacts or, if practices are improved, increase climate resilience. While there is urgent need for global action on climate change, these examples illustrate the importance of local habitat conservation and protection to foster the resilience of salmon watersheds.

Jame
s Paris

Material flow and meta-food webs of a floodplain mosaic: Effects of river regulation and introduced species on the Snake River, ID

Human interactions with rivers often lead to biotic homogenization and suppression of indigenous biodiversity. Two pervasive human influences on large rivers are flow regulation through dams and introductions of non-native species. Although combined effects of these stressors have been examined in rivers downstream of large dams, understanding of how disrupted flow regime and novel communities influence food web structure and function within spatially heterogeneous floodplains more distant from dams is lacking. We studied food-webs of a floodplain habitat mosaic in the Snake River, Idaho, characterized by diminished flooding and prevalent non-native species. At five sites encompassing longitudinal and lateral dimensions of the floodplain, we estimated secondary production of invertebrates and fishes, trophic basis of production of fishes, and organic matter flow through food webs. Fish communities consumed ~70% more benthic prey production in habitats scoured by groundwater upwelling and flood-water connectivity with the main river compared to un-scoured sites dominated by fine sediments. However, in bed-scoured springbrooks, ~20% of total fish consumption was of relatively indigestible plants and algae by introduced trout, and invasive New Zealand mud snails (Potamopyrgus antipodarum), despite representing ~20% of benthic production, contributed only 2% of total consumption by fishes. Based on a “meta-food web” analysis, which sequentially aggregated and compared food webs at increasing levels of landscape complexity, introduced fishes contributed 2X more spatially repeated food-web links than indigenous species. These findings suggest that river regulation and introduced species constrained material flow through floodplain-mosaic food webs, and introduced fishes dominated and homogenized the floodplain-scale food web. Despite evidence of large-scale, anthropogenic alteration of food webs, we also observed a natural capacity for dynamism in feeding interactions, which is key for future resilience. Looking ahead, designing ecological flows and reducing non-native species are needed to promote native, riverine biodiversity in light of rapid and relentless environmental change.

*Benjamin Rich**

Patterns in predation: Understanding climate mediated predation impacts of a subarctic predator

Global climate change and invasive species have been implicated as primary drivers of loss of freshwater diversity and productivity. The effects of climate change are especially pronounced in subarctic streams which are experiencing altered temperature and flow regimes. Recent declines in returns of Chinook Salmon (Oncorhynchus tshawytscha) and Coho Salmon (Oncorhynchus kisutch) in Southcentral Alaska have raised concerns that freshwater mortality of juveniles could be a driver of these trends. Invasive Northern Pike (Esox lucius) are a major source of freshwater mortality of juvenile salmon and may have increasing impacts mitigated by climate change. We examined stomach contents of Northern Pike in Southcentral Alaska's Deshka River across 11 years with an emphasis on juvenile salmon to understand patterns in predation. We found that individual Northern Pike consumption of juvenile Chinook Salmon and total Oncorhynchus species decreased across years, juvenile Coho Salmon increased, and total fish consumption remained constant. These finding suggest that Northern Pike may be switching to alternative fish prey as salmon become less available. We also found a positive relationship between streamflow and the number of juvenile Chinook salmon and total Oncorhynchus in diets. The strength and direction of this relationship varied by season, with positive water level correlations outside of the expected parr/smolt out migration time, suggesting that juvenile Chinook may use off-channel habitats during seasonal high flows increasing predation risk. Pike consumption of juvenile Chinook Salmon was positively correlated with water temperature across seasons suggesting that future warming could further increase predation rates. These findings collectively suggest that the impacts of Northern Pike on salmon have increased over time in response to climate and other factors in this system. They also suggest that changing stream flow and temperature regimes will have very real implications for impacts of Northern Pike and other introduced predators in the subarctic.

Erin Sexton

Challenges and innovations for stewarding transboundary river systems

This talk focuses on transboundary rivers spanning the Province of British Columbia and the western states of Washington, Idaho, Montana and Alaska. Transboundary waters present unique challenges for holistic watershed management, given that rivers can cross multiple jurisdictions from their headwaters to their ocean outlets. In Northwestern North America, a suite of transboundary watersheds shared by the U.S. and Canada are home to globally significant wildlife, connected waters and native fish. They are hotspots of cultural and ecological significance, and importantly, belong to Indigenous nations that are artificially divided by the US/CA colonial boundary. Holistic science and policy approaches in these large rivers are confounded by fragmented jurisdictions, resulting in piecemeal governance of otherwise connected waters. This talk explores a series of case studies from a suite of transboundary rivers to highlight important challenges and emerging innovations for supporting proactive science and stewardship. Key challenges stemming from fragmented governance include conflicting environmental thresholds across connected waters, piecemeal assessment of environmental impacts and benefits, siloed decision-making that excludes impacted governments, and failure to incorporate a forward-looking approach to climate change. In response to these challenges, innovative solutions are emerging, many of them led by Indigenous nations at the forefront of adaptive governance. Some of these innovations include adopting watershed-scale frameworks for both science and policy, creating data platforms that reconcile multi-sourced data across large rivers systems, conferring legal personhood and other unique protections to rivers and glaciers, and adopting land use planning that anticipates that species and habitats will shift as climate changes in these important watersheds.

Russ Thurow

Historical Baselines II: Revisiting historical Chinook Salmon abundance estimates to inform recovery potential - What have we learned?

Most North American native fish stocks have declined since Euro-American settlement, and the "shifting baseline syndrome" (SBS) is the paradigm that causes each generation of biologists to accept, as a baseline, the stock size and species composition that occurred during their careers. The SBS is a fundamental challenge in resource management, potentially resulting in an unconscious acceptance of declining resources; lack of awareness of historical abundances and production potential; establishment of inappropriately low rehabilitation targets; and use of contemporary populations to incorrectly measure recovery. The latter may lead to misinterpreting

even modest salmon population increases as “record returns”. Without accurate estimates of historical production potential, the utility of even the highest quality and longest-term databases is compromised. Inherent risks of the SBS challenge biologists to maximize use of historical information and accurately reconstruct past baselines. Central Idaho biologists employ redd counts to monitor Chinook salmon population trends and counts have been consistently completed since the 1950s. Such long-term datasets represent an invaluable baseline against which current population status may be examined. However, because salmon overexploitation and habitat alterations occurred decades before initial quantitative assessments, contemporary managers may still misjudge population potentials. In response to the need for historical accuracy, we integrated long-term archival (1952-1964) redd counts with contemporary, continuous redd count and spawn timing databases to estimate historical (1950s-1960s) spring/summer Chinook salmon production potential in the Middle Fork Salmon River basin. Here we describe our assumptions and analytical approaches for merging the temporal and spatial characteristics of redds with maximum, archival redd counts to estimate historical potential. We also applied historical harvest information to estimate pre-harvest potential in the 1950s-1960s and 1880s. We examine whether the SBS has influenced contemporary management, assess changes during the past decade, and discuss options to improve management in the future.

Richard Valdez

The need for constructing endangered fish habitats that conform to climate-driven flow changes in a western U.S. river

Warmwater fish habitat in the San Juan River of the southwestern U.S. has been reduced by over 30% as a result of water depletion, reservoir inundation, and cold-water dam releases combined with drought-related changes in hydrology. This reduction and a suite of other factors has contributed to declines in native fish populations including the federally endangered Colorado Pikeminnow (Ptychocheilus lucius) and Razorback Sucker (Xyrauchen texanus). Conservation efforts for these species include determining flow needs; protecting, managing, and augmenting habitats; and stocking hatchery fish. But the young of stocked fish have low survival due largely to a paucity of nursery habitat not being reformed and maintained under current conditions. Flow recommendations for Navajo Dam releases designed to mimic the river’s natural hydrograph have not been met due to water shortages, and the desired outcomes of increased channel complexity and enhanced fish habitat have not been observed. Forecasted hydrology that includes ongoing drought, shows that achieving the flow targets through further dam reoperations is unlikely. Mechanical construction of early life-stage habitats is a highly recommended complement to flow management for offsetting the effects of flow reduction and habitat loss. Habitats with features that are effective and resilient under a range of flows are important in counterbalancing the effects of climate change.

Shawn Young

Reconnecting the Kootenai River floodplain to restore ecosystem productivity and native fish recruitment

Kootenai Tribe of Idaho (KTOI) has and will continue implementing a portfolio of aquatic habitat improvement actions across the Kootenai River Ecosystem. The Kootenai River Habitat Restoration Program (KRHRP) is reconnecting and reestablishing water balance, nutrient exchange, planktons (including ichthyoplankton) transport, and passage for advanced early life stages of fish to and from off-channel aquatic habitats. KTOI and collaborative partners aim to restore water and associated nutrient transport to and from off-channel habitats to boost overall ecosystem productivity. By reconnecting and improving off-channel habitats that promote increased plankton abundance and historically normative temperature regimes, these reconnected nursery and rearing habitats once again support fish early life stage development and growth. Thus, habitat actions are paramount to reversing the current situation of persistent recruitment failure of several native fish due to the combined negative effects of extensive levees and Libby Dam altering the hydro- and thermo-regimes. White Sturgeon, Burbot and Kokanee have experienced extreme declines. Kootenai Sturgeon are federally endangered, and Kootenai Burbot and Kokanee were once functionally extirpated from portions of their former range across the Kootenai/y River and Lake in Montana, Idaho, and British Columbia. By combining conservation aquaculture with extensive Parental Based Tagging capabilities (Idaho Fish and Game for Burbot, and University of California-Davis for White Sturgeon), KTOI has released Burbot and White Sturgeon early life stages, fertilized eggs to fingerling juveniles, across habitat types, including re-connected floodplain wetlands, tracked survival, and correlated survival to environmental conditions at release sites. As a prime example of strategic early life releases in restored habitats effectiveness, KTOI has successfully rebuilt Burbot population abundance while simultaneously evaluating habitat dynamics. Kootenai River fish restoration strategies now take full advantage of recent floodplain reconnections, and illustrate importance of large-river floodplain and off-channel habitats.

Symposia:
Free Round of PBR: The Future for Research, Monitoring, and Implementation of Process-Based Restoration

Organizers: Brian Hodge, brian.hodge@tu.org, Daniel Dauwalter, Helen Neville, Caroline Nash, Scott Miller, and Matthew Steinwurtzel

Process-based restoration (PBR) has garnered a great deal of interest across the West and PBR tactics (e.g., beaver mimicry) are being implemented with increasing frequency in hopes of reinstating processes considered central to riverscape health. The rapid expansion of PBR is generating new insights and opportunities but also revealing new challenges for those charged with managing and conserving aquatic ecosystems. For instance, how does restoring beaver-related processes influence sediment storage, streamflow, and stream temperature, and what are the implications for fish? Could beaver dams or their analogs have the unintended consequence of restricting fish movement or of favoring invasive fishes and pathogens? Answers to such questions are still few in number, and underlying these questions is a potential divergence between managing for ecosystem services and managing for individual species. Deliberate monitoring, data collection, and reporting will improve our abilities to manage adaptively and predict the effects of PBR on riverscapes and the fishes therein. This symposium will bring together managers, scientists, and practitioners to make sense of a shifting landscape and discuss how best to navigate emergent and potentially competing priorities. Presenters will reveal recent insights and recommend avenues for future research on the efficacy and complexity of process-based restoration.

Robert Al-Chokhachy

Integrating data from multiple tools for monitoring riverscapes and prioritizing restoration actions

Habitat serves as the template for biological processes. However, anthropogenic-related activities have degraded riparian and stream habitat, contributing to the declines of native fishes. Given that habitat restoration remains one of the plausible mechanisms for increasing the capacity and resilience of fish populations, particularly in the context of climate change, improving our approaches for habitat assessments is becoming increasingly important. Here, we demonstrate how using multiple monitoring approaches can enhance our ability for assessing habitat status, characterizing the capacity of these ecosystems (i.e., restoration targets), and prioritizing restoration for imperiled fishes. We merge data from remote sensing approaches, drones, and field sampling to overcome spatial heterogeneity common in habitat along stream networks and assist in the recovery of Lahontan cutthroat trout (Oncornhychus clarkii henshawi), a subspecies of cutthroat trout listed as Threatened across the current distribution in the Great Basin (NV, OR, CA). Our results indicate considerable portions of stream networks are disconnected from floodplains—a pattern further supported by metrics indicating excessive levels of fine sediments and low channel diversity. Our data further suggest a paucity of available structure (i.e., large woody debris) for reconnection to floodplains—likely driven by historic land management practices and the aridity of the Great Basin. Our results also highlight the need for active, process-based restoration methods to reconnect habitats to floodplains, allowing for greater resilience of habitats to increasing frequency and severity of droughts. However, through these efforts we acknowledge uncertainty in the capacity of different landscape types and the long-term effectiveness of restoration methods in the Great Basin.

Colden Baxter

Food-web dynamics in a river-floodplain mosaic overshadow effects of engineered logjams: Consequences for salmon and process-based restoration

Process-based restoration (PBR) of river-floodplains is aimed at re-expression of shifting habitat mosaics, in contrast to more engineered habitat treatments involving installation of features such as large wood or pools. Yet, empirical studies are generally lacking that assess how the structure and productivity of patch-scale food webs

that sustain fishes like salmon change through time in natural river-floodplains, such that relationships underpinning the assumptions of PBR remain untested. Moreover, such natural process dynamics have not been compared to effects of restoration efforts like engineered wood jams or pools. We quantified changes in secondary production, organic matter flow, and food-webs across a mosaic of main-channel and side-channel habitats of the Methow River, WA, USA over two periods (2009-2010 and 2015-2016), and we compared the natural process dynamics (that would, in many cases, be a goal of PBR) to change in a side-channel treated with engineered logjams and pools. Organic matter flows through food webs varied among untreated habitats, ranging from minimal change over time in the main-channel, to ~4-fold shifts in side-channel webs. In the side-channel whose habitat was manipulated, production of benthic invertebrates and juvenile salmonids increased by 2X and 4X, respectively, but these magnitudes of change did not surpass temporal variation observed among untreated habitats of the mosaic. For instance, juvenile salmonid production rose 17-fold in one untreated side-channel habitat, and natural aggregation of large wood in another untreated side channel coincided with community and food-web dominance by juvenile salmonids. Our findings suggest natural dynamism across floodplain habitat mosaics is linked to patchiness in food-web characteristics that may exceed ecological responses to localized habitat manipulation, complexity that may buffer salmon and biodiversity in the long term. As such, the results also support efforts to preserve or restore (via PBR) the processes that create and maintain this dynamic food-web mosaic.

Christine Brissette

Can you have your water and use it, too? The persistent, pernicious issue of downstream water availability

Natural distributed storage has been posited as key strategy to improve resilience in the face of drought and climate change. As such, process-based restoration projects aiming to slow streamflow and increase floodplain aquifer recharge are increasing in popularity on public and private lands. Natural distributed storage projects are designed to increase the area and duration of floodplain inundation through both low-tech (e.g., beaver dam analogs, low-head dams) and heavy equipment (e.g., Stage 0 restoration) approaches. While this work has many potential ecological benefits, changes to annual streamflow patterns, including flood attenuation and increased baseflows, are often an explicit project goal. Meanwhile, given the potential water rights implications of these changes, a growing group of practitioners also claim that flow impacts of aquifer recharge projects are negligible. All of this begs the question, can you have your water and use it too?

As process-based restoration has become more common, research of its effects on factors like riparian productivity and depth to groundwater have followed. However, its effects on streamflow are still poorly described. The issue of how these projects influence stream flows for aquatic resources and downstream water rights is complicated, in part because of persistent uncertainty in our hydrologic understanding of these systems. Namely, these changes can vary considerably across site conditions and can be difficult to capture with standard monitoring equipment, raising the question of which impacts are statistically vs. practically significant and whether case studies can be extrapolated to other landscapes.

This presentation will provide an overview of process-based restoration tactics commonly used to generate natural distributed storage and describe common changes documented in peer-reviewed research and practice. We will also present select case studies from Western States where these issues are coming to a head.

Hayley Glassic

Resist-accept-direct for restoration: Landscape-scale prioritization of floodplain reconnection in Lahontan Cutthroat Trout habitat using remote sensing and GIS

Applying tools to prioritize restoration, such as using process-based restoration (PBR) efforts, effectively at a landscape scale is increasingly important in fisheries conservation. Riverscapes, which include the floodplain (i.e., valley bottom), riparian corridor, and instream habitat, provide crucial ecological and socioeconomic function. However, riverscapes have been extensively altered by anthropogenic activities, which resulted in reductions in valley bottom connectivity, riparian condition, and instream habitat condition. Assessing riverscape health requires an understanding of connectivity between the active channel and the valley bottom. Prioritizing actions may be best achieved by understanding capacity for recovery, which could be contextualized relative to valley bottom area; larger valley bottoms are likely to have greater capacity for riparian production or water storage. While remote sensing methods can effectively characterize riparian vegetation, documenting inundation extent can provide a more

complete depiction of floodplain connectivity. Here, we provide examples of how remote sensing and geospatial products can help prioritize restoration for riverscapes within the resist-accept-direct (RAD) framework, with specific focus on Lahontan Cutthroat Trout (LCT) habitat. We used Sentinel-2 normalized difference vegetation index (NDVI), a field-informed likelihood raster of the proportion of active valley bottom (AVB; frequently flooded surfaces), and a composite NDVI-AVB status ranking to prioritize where restoration in relation to floodplain connection could occur at a landscape scale. We show that the status inference when using the NDVI-AVB composite differs from inferring status using NDVI alone. Within the RAD framework, we show that considering the effort and capacity of restoration simultaneously can further prioritize where actions to increase or maintain floodplain connection could exist on the landscape. Riverscape restoration using PBR presents a key opportunity to bolster aquatic ecosystems given changing climatic conditions. Our approach shows that using multiple data sources will provide more context in directing efforts to enhance LCT habitat and riverscapes.

Chris Jordan

Process-based riverscape restoration - now or never

The overwhelming majority of riverscapes across the continental US are dramatically impaired due to current or legacy land and water use. The mode of impairment is predominantly structural starvation, resulting in, or resulting from, overly efficient conveyance channels that are vertically and laterally separated from their adjacent floodplain volumes. The scope and scale of the impairment is so pervasive as to have long been accepted as the normative condition of North American streams, rivers, and floodplains. But, because this shifted baseline sees channels where riverine wetland corridors once ran and continuous forests where successional patches once thrived, our management models maintain, perpetuate, and even restore to this degraded, reduced function state. Therefore, it is time to act. It is time to reawaken the biofluvialgeomorphic mess that functional riverscapes were, and can be, again. It is time to undrain the drained land, unforest the plantation hillslopes, unsimplify the straightened and cleaned channels, unchannelize the ghost of anastomosing floodplain connected streams and rivers. Process-based riverscape restoration is the simple conceptualization of functional riverscapes being valley bottoms with space, structural complexity, and flow inefficiency, all forced by connections to dynamic hillslopes, that together yield a resilient natural system made more productive and robust by perturbation and movement of energy and materials. A century of biological, hydrological, geological science, and the science adjacent practice of stream restoration have reinforced the pastoral ideals of static stream, river, and floodplain conditions and enabled an environmental compliance industry based on the premise of no net loss. As such, introducing the natural state of riverscapes as dynamic, laterally and vertically connected systems dependent on landscape scale “disturbance” runs contrary to a deeply seated premise that the natural world is static and pristine. However, if we expect to achieve the fire resilient, climate change adapted, drought and flood resistant, and protected species recovering riverscapes our management programs claim, we must first accept, allow, and foster the messy, dynamic nature of nature.

Jonathan Kochersberger

A Watershed Pyramid Scheme– RAD-ical perspectives from Central Oregon streams

Many historically perennial streams in Central Oregon have become more intermittent in recent years, requiring managers to reconsider prioritizing fish-habitat focused projects against those intending to improve overall geomorphic and ecological function. In many streams, the loss of persistent water presence and/or increasing water temperatures creates greater limitations on fish presence that form-based physical habitat components alone cannot address. Climate change and shifting precipitation patterns in this region may have fundamentally changed what the restoration potential is in some of these systems. Even the best-designed restoration project may not feasibly return any of these systems back to a “historic” condition.

This presentation will share an applied use of the Resist-Accept-Direct (RAD) concept for setting objectives for process-based restoration on the Ochoco National Forest. Here, managers have prioritized resetting the site conditions so that physical and ecological “process” can move forward to provide the desired riparian conditions and sustainable habitat. Specifically, managers are shifting primary objectives to floodplain reconnection that increases recharge and retention capacity in valley floors, with objectives around habitat-specific features for fish and amphibians becoming secondary. The overarching goal of this approach is to create riparian conditions that increase the ability of these systems to withstand extreme climatic events with the expectation that this approach will create a diversity of both aquatic and terrestrial habitat in most settings. Emphasizing focus on the foundational components of a watershed “pyramid” (hydrology and geomorphology) that can set the stage for processes that inform the physicochemical and biological conditions for proper ecological function.

*Benjamin Miller**

Wood you believe it? Experimental nonnative wood addition enhances in-stream habitat for native desert fishes

Habitat simplification is contributing to the decline of native fishes in the Colorado River basin, including the San Juan River (SJR), where flow regulation, water overallocation, and nonnative riparian vegetation (primarily Russian olive Elaeagnus angustifolias) are major contributing factors. We conducted an experiment to investigate the potential effectiveness of enhancing native fish habitat by using an abundant resource, namely, Russian olive branches. In this experiment, we constructed a total of 155 woody structures over the course of two years at 19 paired treatment and reference (no wood added) reaches within the main channel of the SJR. To evaluate responses of wood addition, we sampled fishes and macroinvertebrates, measured habitat characteristics (depth, velocity, dominant substrate type, and geomorphic units), and deployed portable PIT tag antennas. To date, we have captured a total of 1,264 fishes in treatment reaches (17% native species) and 1,153 fishes in reference reaches (10% native). Densities of native fishes and macroinvertebrates were 72% and 160% higher, respectively, on average in treatment reaches than in reference reaches. Habitat characteristic variability (CV) was higher on average in treatment than in reference reaches (depth: 21%, velocity: 50%, dominant substrate size: 28%). After the addition of wood, the number of geomorphic features in treatment reaches increased by 7.3x on average, whereas in reference reaches, the number of geomorphic features remained unchanged. Our preliminary results suggest that addition of nonnative woody structures is an effective management action for enhancing native fish habitat by facilitating hydraulic and geomorphic diversity. While flow management has been the primary tool used by managers to improve habitat conditions for native desert fishes, this approach is increasingly less effective with water overallocation, increased aridity, and riparian vegetation encroachment. Managers might consider pairing flow management with non-flow, process-based, alternatives, such as wood addition, to enhance habitat for native fishes.

Scott Miller, Wes Keller, Warren Colyer

How to keep the PBR flowing: Perspectives from Tribal, NGO, and land management practitioners

Federal legislation investing in ecosystem restoration combined with increased social awareness present generational opportunities to invest in riverscape health. The dynamic in part has shifted from questions of how to plan and fund small-scale projects to how to implement a series of coordinated actions among partners to make transformational, watershed-scale impacts. In this session we bring together diverse practitioners, including representation from the Nez Perce Tribe, Trout Unlimited, and the Bureau of Land Management, to discuss bottlenecks and opportunities to increase the geographic scope and pace of process-based restoration. Through a series of case studies, we outline opportunities to improve restoration prioritization, design, implementation, assessment, and adaptive management. We highlight unprecedented funding opportunities and the challenges to seizing them, including competing perspectives regarding healthy rivers, agency mandates, and state and federal regulations. Lastly, we highlight the importance of partnerships to restoring riverscapes at meaningful spatial scales, and the need for increased research and monitoring of process-based restoration outcomes to inform and improve future projects.

Caroline Nash

New models of evaluation and communication for processing uncertainty in process-based restoration

Since its inception, process-based restoration has attracted attention as a more “nature based” approach to stream and wetland restoration. By aiming to either directly harness, induce or mimic natural processes, the expectation is that these projects will restore degraded ecosystems at a fraction of the cost of traditional, form-based approaches. Common expectations include that projects will increase water availability, improve water quality, enhance biodiversity, and increase forage quality of surrounding floodplains with minimum long-term maintenance. These lofty expectations have fueled considerable interest and increasing amounts of funding towards its use by both private landowners and public land managers. However, as is often the case in restoration, the practice has greatly outpaced science, due in part to the fundamental nature of process-based restoration. How do we balance flexibility and objectivity as we evaluate projects that are, by definition, built on inducing process rather than generating specific measurable outcomes? How can we, as land managers and practitioners, rigorously learn from these projects to improve long-term outcomes?

These uncertainties are driving challenges not only for practitioners seeking to acquire funding and support for projects, but also for regulators at every level of government

seeking to uphold their statutory requirements while facilitating what are often experimental approaches. This presentation will introduce the concept of process-based evaluation, which combines contingency-based process-pathway charts and trend-based monitoring. This evaluation model seeks offer a flexible approach to monitoring and adaptively managing projects across a range of landscapes, project types and budgets. In demonstrating this model of evaluation, we will explore persistent uncertainties in the science documenting commonly expected outcomes of process-based stream restoration.

Michael Pollock

Beyond Process-Based Restoration - Following the science

In the USA stream restoration as currently practiced is largely an engineering exercise focused on immediate and tangible benefits within a fairly constrained spatial extent with limited consideration of the larger processes that affect and are affected by the restorative action. Process-based restoration as originally conceived was a logical framework for engaging in stream restoration within the context of thinking about natural processes. Beechie et al. (2010) outlined four process-based principles: (1) restoration actions should address the root causes of degradation, (2) actions must be consistent with the physical and biological potential of the site, (3) actions should be at a scale commensurate with environmental problems, and (4) actions should have clearly articulated expected outcomes. However no criteria for assessing whether a restoration project was “process-based” were provided, leading to more than a decade of ambiguity as to what process-based meant operationally and the widespread use of the term to describe a wide range of restoration projects. In 2021 Ciotti et al. proposed four design evaluation criteria for process-based restoration: (1) expansion of fluvial process space and connectivity (2) utilization of intrinsic natural energy (3) utilization of native materials that do not over-stabilize and (4) explicit incorporation of time and adaptive management into project design. These evaluation criteria should help provide some much needed rigor to the definition and application of process-based restoration projects.

*Matthew Steinwurtzel**

Quantifying and mapping the thermal and hydrologic retention capacity of beaver habitat and beaver restoration analogs with UAS

Historically, beaver-mediated habitat would have been a ubiquitous and multifunctional aspect of Idaho’s river and riparian ecosystems. Beaver impacts on river systems include the maintenance of surface-water storage during drought or low flows and the creation of cool-water refugia through increasing groundwater exchange. Throughout the Columbia River Basin, the loss of these ecosystem services has resulted in widespread, but difficult to quantify, impacts on salmonid populations. As forecasts for climate change impacts in our region include less predictable flow and warmer surface waters, the implementation and monitoring of restoration activities that mimic historical beaver impacts and facilitate cold-water refugia for imperiled salmonids is critical. In this study, we combine state-of-the-art unmanned aerial systems (UAS, or ‘drone’) imagery to produce red-green-blue band (RGB) and thermal infrared (TIR) models in both a pristine river with abundant beaver impacts and a comparative restoration context. TIR models are verified through the deployment of in situ temperature loggers. Photogrammetry modeling techniques are used to illustrate and quantify the effects that both a network of beaver ponds has on ~0.75km2 of a Wilderness stream and the impacts of implemented Beaver Dam Analogs (BDAs) on a stretch of river that provides habitat for ESA-listed salmonid stocks. We hypothesize that the spatial proximity of beaver ponds to main-channel habitats dampens main-channel diurnal temperature ranges through measured thermal maxima. Additionally, to test the prediction that beaver-mediated stream sites increase riparian water-surface elevations, we use Digital Elevation Models (DEM) to quantify temporal changes of beaver dam reservoirs and the post restoration effects on surface water elevations. We discuss the scale at which these habitat effects may have implications for the bioenergetics and growth of juvenile salmonids. We also discuss the broader application of this instrumentation to address the research limitations encountered in other watersheds.

Shelby Weigand

Using a landscape-scale approach to prioritizing LTPBR sites through partnerships and collaboration

To achieve landscape-scale low-tech mesic and wet meadow restoration across the Northern Great Plains, practitioners need a consistent standard of practice for the inventory of resources, planning, and design of restoration actions associated with the resulting priority reaches/complexes for restoration, and alignment of monitoring with

restoration objectives. This includes spatiotemporal scales at which we mimic, promote, and sustain desired processes. With the development of a Watershed Analysis Framework, the opportunity to replicate and expand this practice at truly a landscape scale is ripe. Approximately 45,400 miles of intermittent/ephemeral stream and 1,100 miles of perennial stream on BLM administered lands in Montana, North Dakota and South Dakota could be improved by low-tech process-based restoration activities. Additionally, with increased interest from local watershed groups in Montana and partnerships with additional land managers such as The Nature Conservancy this project addresses the need for producing a replicable, watershed-scale assessment and prioritization for low-tech restoration on both public and private lands across the West.

*Eric Winford**

Measuring channel response to Process-Based Restoration

There are few tools available for resource managers to evaluate short-term geomorphic changes related to low-tech, process-based restoration (LTPBR). This lack of information reduces our ability to determine whether a project is on the desired trajectory, which can impede development of adaptive management plans to correct actions gone awry or maintain and improve processes working as intended. To investigate this problem we outline a cost-effective, highly accurate, and easily repeatable monitoring approach using unmanned aerial vehicle (UAV) technology coupled with structure-from-motion (SfM) photogrammetry to evaluate two LTPBR projects in central Idaho.

Our approach builds off previous work using SfM photogrammetry and digital-elevation models (DEMs) to detect channel response to LTPBR. Instead of DEMs, we used a point cloud analysis tool, developed specifically for detecting change of rough, complex surfaces in three dimensions. Change detection using point cloud analysis provides greater accuracy because small surface complexities, such as point bar aggradation, can be lost through interpolation when generating DEMs. This improved accuracy allows managers to track geomorphic change over shorter temporal scales, providing a monitoring solution to inform adaptive management within a relevant time frame. Working with point clouds also eliminates the need to generate DEMs, simplifying the analysis process.

Our results demonstrate the ability to detect small, short-term changes in stream geomorphology, specifically deposition upstream and downstream of LTPBR structures and areas of erosion adjacent to structures where streamflow is directed. We also outline best practices for UAV data collection to optimize point cloud change detection and offer a data processing workflow that provides flexibility to overcome data collection shortfalls and discrepancies. Finally, because our two project sites vary across physical and temporal scales and restoration objectives, we demonstrate the utility of our approach across a spectrum of LTPBR projects.

Steve Wondzell

What should streams look like? How does the concept of reference condition relate to the practice of stream restoration?

The practice of river restoration requires that practitioners set goals – and those goals are a statement of “What Streams Should Look Like”. The concept of reference condition attempts to provide an objective basis for setting those restoration goals. However, as Dufour and Piégay (2009) argue, the concept of reference condition is too often based on the “Myth of Paradise Lost”. My talk explores the limitations of this concept and is primarily based on my own experience trying to develop models to project historical conditions and potential future conditions for riparian zones in the upper Middle Fork John Day River, OR. I take a historical retrospective of major events influencing land-use in the Pacific Northwest, starting today and traveling backwards through time to Lewis and Clark who spent the winter of 1805-06 at the mouth of the Columbia River. I argue that history is too easily forgotten, and despite widespread general knowledge of the last two-hundred years of Euro-American settlement, historical legacy is not sufficiently considered when attempting to define a reference condition. This retrospective suggests that it is impossible to pick a time period that represents a reasonable reference condition.

Symposia:
The Future of the Western Division of AFS: Research from Throughout the West

Organizers: Eric Fetherman, Western Division of AFS, eric.fetherman@state.co.us

The Western Division of the American Fisheries Society contains ten chapters (Arizona/New Mexico, Alaska, California/Nevada, Colorado/Wyoming, Idaho, Montana, Oregon, Pacific Islands, Utah, and Washington/British Columbia), each having a diverse range of students and professionals conducting a wide variety of research. This symposium will highlight the research being conducted within each of the Chapters throughout the Western Division as we start shifting baselines and moving towards the future of the fisheries profession. The Western Division invites you to come support your fellow students and professionals, and learn something new about the unique fisheries work being conducted throughout the west.

*Jeremy Brooks**

There and Back Again: Community traits and interactions mediate aquatic-terrestrial linkages across a mosaic of headwater stream-riparian ecosystems in Northern Yellowstone National Park

In Northern Yellowstone National Park, restoration of terrestrial apex predators had cascading consequences for riparian plant communities, transitioning them from grassland to willow-dominated. However, the extent of these changes was partially mediated by changing prey vulnerability and geomorphic context, resulting in a mosaic. The restored willow communities have been used to suggest that wolves 'saved' Yellowstone's rivers and native fishes, however little is known about how these linkages may very across a mosaic. Using a riverscape approach, we investigated how diverse aquatic and terrestrial communities interact to mediate reciprocal (land-water-land) linkages across a mosaic of stream-riparian ecosystems.

From 2018-2021, we intensively sampled eight headwater streams to characterize riparian plant communities, terrestrial organic matter and invertebrate inputs, the diversity and productivity of aquatic primary producers, invertebrates, and fishes, aquatic food web linkages and trophic transfer efficiencies, aquatic insect emergence, and riparian insectivore composition and abundance.

Riparian vegetation state determined dominant basal organic matter, which influenced benthic invertebrate community composition and productivity. The resulting phenology and vulnerability of benthic invertebrates, paired with the fish assemblages' consumption of benthic invertebrate production and terrestrial invertebrate input, mediated the timing and magnitude of aquatic insect emergence. In turn, the timing and magnitude of emergence, coupled with riparian vegetation, mediated responses by riparian insectivores. At each link of these reciprocal processes, traits of organisms and their interactions mediated subsequent linkages.

Traits and interactions of organisms were critical to understanding localized stream-riparian ecosystems which, rather than occurring as homogenous or categorical states, contribute to heterogeneity in the larger-scale riverscape. Such heterogeneity may diversify a portfolio of ecological patterns and processes that, as models show, can promote foodweb and ecosystem stability. Therefore, the restoration of apex predators did not single-handedly 'save' the ecosystem, but contributed important complexity and heterogeneity to reciprocally-linked aquatic and terrestrial communities of Yellowstone.

*Elliott Cameron**

The story of one invertebrate, two fish parasites, and the largest dam removal project in the world

Current plans to decommission and remove four hydroelectric dams on the Klamath River will allow anadromous salmon to access historic spawning grounds and alter their pathogen distribution. Two of these pathogens, Ceratonova shasta (Cs) and Parvicapsula minibicornis (Pm), are obligate parasites that can cause disease in salmon

throughout the Pacific Northwest. Both parasites alternate between waterborne spore stages and infecting both salmon and annelid hosts. While the river below the dams has been monitored for these parasites, more data are needed on distribution and abundance above the dams in preparation for anadromous fish passage. We sampled both water and annelids to describe the distribution of these parasites spatially and temporally between the dams that will be removed. In 2021, Cs spore levels were highest in August at the majority of sample sites, measuring up to 28 spores/L. The highest density of Pm measured was 78 spores/L. Annelid densities were highest downstream of the J.C. Boyle and Copco 2 dams, and these locations also had the highest densities of annelids infected with Cs. Interestingly, although densities of Pm were higher than Cs in water samples, the prevalence of Cs in annelids was higher than Pm. These data suggest there may be hotspots of myxozoan infection risk and provide a better understanding of disease dynamics in the Klamath River's hydroelectric reach.

*Collin Hendricks**

Estimating the relative production of migratory Westslope Cutthroat Trout in tributaries to the lower Priest River, Idaho

Iteroparous salmonids that exhibit a migratory life history are essential to functioning metapopulations. They are demographically important as migratory females produce more eggs than non-migratory individuals. Additionally, they provide genetic support through gene flow, resulting in more robust, genetically diverse populations. The lower Priest River flows into the Pend Oreille River in the panhandle of northern Idaho and is a significant contributor of migratory Westslope Cutthroat Trout Oncorhynchus clarkii lewisi (WCT) in the Clark- Fork Pend Oreille Basin. The goal of our study is to determine which tributaries to the lower Priest River are producing the most migratory WCT. To answer this question, we expanded an existing genetic baseline within the Priest River basin from 4 to 13 representative populations. We collected non-lethal tissue samples from WCT in tributary streams by backpack electrofishing. We collected tissue samples from migrant WCT captured in the mainstem Priest River by angling. These migratory fish of unknown populations will be genetically assigned back to their most likely stream of origin using the program RUBIAS 0.3.3 in R version 4.1.3. All WCT (□100mm) were also implanted with a PIT tag. Four Priest River tributaries known to produce migratory WCT have PIT tag arrays near their mouths. These arrays in combination with fish that have been tagged form the past three years will provide a physical estimate of movement into and out of tributaries. In addition, these tagged fish will allow us to validate the accuracy of our genetic assignments. Subsequent studies will attempt to describe the biotic and abiotic factors that influence the expression of the migratory life history of Westslope Cutthroat Trout.

*Audrey Lindsteadt**

Why so salty? How a rare and endemic animal lives in harsh environments

*R*are animals are difficult to study, but understanding habitat selection behavior and comparative physiology is essential for managing populations. We challenge the paradigm that rare species living in extreme habitats are physiologically adapted to these environments and love it there. The Narrow-foot Hygrotus Diving beetle (Hygrotus diversipes) is a rare aquatic beetle that lives in central Wyoming. This species was discovered in 1964 and became a Category II Candidate Species under the US Endangered Species Act (ESA) from 1984 to 1996. It is currently being petitioned for Category 1 listing under the ESA. The beetle occupies intermittent streams in shortgrass prairies and experiences many harsh environmental pressures like desiccation, flash flooding, and high conductivity (salinity). Annual surveys of the beetle's used and available habitat have been performed since 2010. We hypothesize H. diversipes is physiologically stressed in the extreme environments it inhabits, but is forced to select for these habitats due to biotic interactions. Our field surveys measure and analyze what stream and pool characteristics this species selects for. For example, preliminary results suggest the detection of this beetle is negatively correlated with the presence of fish. We also analyzed the water conductivity this beetle selects for in the wild and compared these results to the range of conductivity that has the best survival rates in a controlled lab setting. So far, our results from the lab experiment suggest H. diversipes survival rates decrease as conductivity rises above 15,000µS/cm despite this being a common conductivity measured in the field. The predicted effects of climate change may test the upper conductivity limit of H. diversipes if this species is indeed already physiologically stressed in its habitat. This could be devastating for this rare and endemic species.

*Michael Miller**

Evaluating the success of eradicating non-native Brook Trout using Trojan-Y chromosome fish in southern Rocky Mountain streams

Brook Trout Salvelinus fontinalis often outcompete and displace native trout in western North America. Due to the limitations of traditional suppression techniques, managers are interested in implementing the Trojan Y-Chromosome approach to skew sex ratios and extirpate non-native Brook Trout populations. However, there is limited information about the comparative performance of YY-male (MYY) and wild Brook Trout in regards to reproductive success. Additionally, questions remain pertaining to the utility of stocking MYY fish verses YY-female (FYY) fish. To address these knowledge gaps, we collected population data from three Brook Trout populations subjected to ongoing MYY treatments in northern New Mexico. Population parameters were then used to evaluate the time to extirpation of wild Brook Trout using age-structured models. Our simulations assumed varying stocking (25 to 100%) and removals (0 to 75%). In addition, we evaluated model sensitivity to changes in reproductive success and survival of MYY fish. In general, stocking FYY fish reduced the time to extirpation at lower stocking and suppression rates compared to MYY fish. For instance, extirpation occurred in 22 years with FYY fish compared to more than 50 years with MYY fish, assuming 0% suppression and 25% stocking. Sensitivity analyses indicated that models were relatively insensitive to changes in the reproductive success and survival of MYY fish. Collectively, our results suggest that either MYY of FYY fish can be used to eradicate wild Brook Trout populations but FYY fish are likely the most efficient means of eradicating non-native Brook Trout in streams typical of western North America.

*Svyettlana Parry**

Utilizing the spotting patterns of S. confluentus to identify individuals in photo identification software

PIT tagging is commonly used to learn more about population dynamics and habits of species like Bull Trout, but comes with challenges that could be avoided with another identification method. In this study we tested the potential of photo-identification as an alternative identification method for bull trout using the Interactive Individual Identification System (I3S) that utilizes natural markings on fish to identify individuals. To test the ability to identify individual Bull trout from spotting patterns, we used photographs of bull trout captured in 2017-2019 by the IDFG at Fourth of July Creek, Idaho. During weir operations, 166 Bull Trout were sampled of which 34 fish were recaptured. Using the I3S software, we identified spotting patterns found on each fish picture, we created “spotting fingerprints” in the I3S system for each fish, and compared “fingerprints” to identify recaptures. In a blind test, two readers were given the pictures and tasked with creating fingerprints and determining which fish were recaptures and which were not. The first reader was able to identify 26/34 recaptures as top hits in their database, and the second reader was able to identify 25/34 recaptures as top hits in their database, giving the readers a 76% and 73% accuracy, respectively. The first reader had an average 4.64 deviation score for their top matches and the second reader had a deviation score of 7.02 for their top matches. We discovered that photograph quality and spot selection affected the accuracy of identifying recaptures in the I3S system. If standardization of photograph quality and spot selection can be established, photoidentification has a future of being a viable alternative to traditional tagging and to be utilized in fisheries management efforts.

*Rebecca Shaftel**

Modeling stream temperature and flow from gridded climate datasets in Alaska’s Yukon and Kuskokwim basins

Stream temperature and streamflow are critical controls on freshwater habitat dynamics and are important for understanding climate impacts on freshwater resources. In Alaska, using empirical stream temperature and streamflow datasets for research poses several challenges: data are often unavailable for an area of interest, datasets are typically of short durations, and sites are managed independently across agencies and organizations. Fortunately, advances in gridded climate products and downscaled climate projections provide alternatives for quantifying freshwater habitat conditions in remote regions like Alaska. For this project, we reviewed products and validated models against in situ data to develop more complete historical time series of stream temperature and streamflow. Specifically, our objectives included: 1) developing a list of gridded or modeled products available for Alaska, 2) comparing products with a focus on streamflow and temperature, and 3) comparing three different stream temperature models. We validated alternative products representing streamflow and temperature using empirical datasets associated with a case study of Chinook Salmon habitat in the Yukon and Kuskokwim basins. Our results indicated that a global modeled steamflow product had a strong positive correlation to observed streamflow (mean r = 0.79 for 11 sites). Boosted regression tree models that included daily gridded air temperatures along with other covariates had the highest positive correlation to observed stream temperatures (r = 0.97 for 31 sites) over other commonly used models and good prediction accuracy (mean RMSE = 0.7□). Overall, we found several products that could be used to develop accurate time series of freshwater habitat conditions in Alaska and utilized in fisheries research. Potential applications include predicting aquatic species distributions, spread of invasive species, food availability, fish growth potential, and generally informing fish responses to climate change for

research and management.

*Nicholas Voss**

Reach-scale associations between Brook Trout and Bull Trout in Idaho: Patterns across space and time

Bull Trout Salvelinus confluentus is an iconic coldwater salmonid native to the Pacific Northwest with high conservation and recreational value. Bull Trout face a wide array of biotic and abiotic threats, which can make identifying the primary stressor in a given locality difficult. Introduced Brook Trout S. fontinalis is a particularly widespread threat to Bull Trout persistence, but the relative threat of different Brook Trout densities is unclear. We sought to identify reach-scale threshold or "tipping-point" densities of Brook Trout beyond which Brook Trout may become a leading threat to juvenile or stream-resident Bull Trout. Identification of such values could aid in future threat assessments, inform Bull Trout recovery, or set goals for Brook Trout suppression. First, we examined patterns across space by using a large dataset to (1) identify Brook Trout densities associated with consistent declines in the abundance of Bull Trout <250 mm and (2) use multiple lines of evidence to investigate the role of habitat in structuring their interactions. Bull Trout and Brook Trout were rarely sympatric at the reach scale across a wide range of abiotic conditions (n = 385 reaches), and significant thresholds occurred at very low Brook Trout densities. Next, we examined patterns across time by re-sampling a series of historical electrofishing locations in the Little Lost River basin (Idaho) where both species co-occurred in the late 1990s. Over the past two decades, Bull Trout abandoned all sampled reaches where Brook Trout historically occurred or recently invaded. Taken together, our results collectively support an existing hypothesis that the long-term co-occurrence of these two species is inherently unstable and suggest that Brook Trout are a leading threat to Bull Trout in reaches where Brook Trout become locally established. We discuss our results in the context of Bull Trout conservation strategies and directions for future research.

*Ellie Wallace**

Potential benefits of implementing lake-level informed removal efforts to control Common Carp

Invasive species control can be challenged by dynamic environmental conditions that periodically reduce control efficiency or increase invader productivity. In Utah Lake, UT, common carp (Cyprinus carpio) control efforts have been challenged by periodically elevated lake surface elevations that reduce gear efficiency and increase recruitment. As such, tailoring removal efforts to take advantage of favorable control conditions or actively manipulating lake surface elevation may benefit control efforts. Here, we use a simulation model fit to empirical data to examine potential benefits of control strategies either actively managing lake-levels or implementing mechanical removal conditional on low lake-levels for achieving carp control in Utah Lake. We examined strategies in which lake-level oscillates naturally, is held constant, is maintained either above or below specific thresholds, and where removal efforts are only implemented when lake surface elevation is below specific thresholds. Only strategies where the lake is maintained at reduced surface elevation meaningfully increased the probability of achieving carp biomass targets relative to current control efforts. However, lake-level manipulation may be infeasible as it presents serious socio-economic trade-offs and could have negative impacts on the threatened, native June sucker (Chasmistes liorus) population. Our results suggest that removal efforts conditional on low lake levels yield similar reduction success rates as current efforts. However, given efforts would not occur annually in such a conditional strategy, efforts could be intensified during favorable conditions without increasing the associated long-term costs. Our results suggest applying the same total effort as the current strategy, but concentrating it during favorable conditions improved control program performance. For management and conservation, efficiently allocating limited resources is critical for management and conservation, and quantitative explorations of alternative strategies, such as the analysis presented herein, can identify those strategies most likely to achieve conservation and management goals.

*Keith Wellstone**

Electrofishing and angling data reduce error in abundance estimates for trout in the Lamar River

Reliable estimates of population size are a key aspect of fisheries management, particularly when evaluating the success of invasive species suppression. We used empirical electrofishing and volunteer-angler data to simulate and evaluate mark-recapture sampling designs for estimating the abundance of Yellowstone Cutthroat, Rainbow, and hybrid trout in a reference reach of the Lamar River. We used RMark to conduct simulations that allowed capture probabilities to vary by occasion to evaluate changes in the precision and accuracy of trout abundance estimates across a variety of mark-recapture sampling designs. Estimated abundance was 758 trout (95%

CI 497-1,190) with capture probabilities of 0.13 for angling. We incorporated uncertainty in capture probabilities into each simulation by randomly drawing from a beta distribution. The largest reduction in error occurred when angling was included in a capture event, and this reduction in error was greater when two angling events were included. An all-angling approach yielded the lowest coefficient of variation estimates, varying from 0.07 to 0.14. This approach also yielded the most accurate results, with relative bias varying from -0.27 to 0.59. Leveraging volunteer-angler efforts using a standardized mark-recapture sampling design could be an alternative to traditional abundance estimation by electrofishing. Angling and electrofishing could also be combined in a multi-gear approach; however, the order and frequency in which sampling gears are used should be considered, as they could influence results.

Symposia:
The Integration of Fish Habitat Design and Monitoring Response

Organizers: Jeanne McFall, jeanne@rivhab.net, 208-401-6129

Design methodology to improve quantity and quality of fish habitat has evolved significantly in the past 15 years. This evolution is largely due to technological advances in monitoring both biological and physical aspects. Empirical data provides feedback into design methods allowing adaptive engineering and improved biological and physical response. Accuracy of achieving targeted conditions is improved using advancements in monitoring, which becomes more critical with threats of climate change. We invite presentations exploring fish habitat design incorporating monitoring feedback. Examples of using empirical data to steer design, technological advances of physical monitoring including drone technology, and the use of monitoring data to improve habitat designs are all welcome.

Jeffrey Diluccia

Integrated monitoring and adaptive management to support the reconnection of historic floodplains to the Lemhi River

Adaptive management, as it applies to river restoration, is an iterative process involving biological and physical effectiveness monitoring designed to continually assess fish response while improving management actions and project outcomes over time. In the Lemhi River sub-basin, Idaho, large scale floodplain rehabilitation efforts benefit from ongoing research, monitoring, and evaluation studies. The Henry reach project, located in the middle of the Lemhi River watershed, was implemented in 2021 to restore floodplain function and increase juvenile parr and winter pre-smolt capacity for ESA-listed fish. Rigorous monitoring studies that utilize a network of advanced Passive Integrated Transponder (PIT) tag detection arrays has allowed for effective monitoring of fish use in constructed lateral channel complexes and inundated riparian zones. Monitoring outcomes demonstrated that the project was very effective in expanding capacity for multiple life stages of juvenile Chinook salmon, particularly in modified floodplain areas. A combination of optimal channel geometry at inlets and sufficient flow resulted in thousands of juveniles accessing and utilizing the diverse floodplain condition that exists in these areas. Furthermore, multiple life stages were represented. As a result, project biologists worked with engineers and the landowner to develop additional treatment under a second project phase to increase fish use in other project areas. Proposed actions include further inundating other floodplain benches by constructing channels that mimic existing inlets, raising surface height of the river, and increasing lateral complexity by constructing relic beaver dam complexes. Following implementation of these treatments, continued monitoring will help determine if these adaptations achieve the expanded project objectives. Results will also help shape future habitat project designs through this ongoing adaptive management, monitoring, and feedback process.

Jim Gregory

Increasing future effectiveness by assessing past actions: Fish habitat capacity change at habitat improvement sites in a heavily impacted river

Over the past ten years, numerous organizations have cooperated to implement habitat improvement projects to benefit juvenile Chinook Salmon and steelhead in the Yankee Fork, a tributary to the Salmon River basin severely impacted by historical mining. Habitat improvement projects have varied in extent, risk, and cost. Therefore, as future improvement projects are planned, it is important to understand past project types' relative contribution to fish populations. However, the fish population response to improvements can be masked by variable adult returns affected by out-of-basin factors. Therefore, an assessment of change in fish habitat quantity and quality is necessary for this assessment. From 2013 to 2022, fish habitat measurements were collected in the Yankee Fork drainage, including in habitat improvement areas, using the Columbia Habitat Monitoring Protocol (CHaMP). This protocol produces over 100 metrics that quantify various aspects of fish habitat. However, how these habitat metrics relate to fish populations is unclear. Recently, a quantile random forest model was developed to estimate Chinook Salmon parr carrying capacity using a subset of CHaMP metrics. We used this model to assess habitat capacity in various reaches of the Yankee Fork drainage and to assess habitat capacity uplift of habitat improvement types. Habitat capacity comparisons before and after habitat improvement were also made. These comparisons and the relative risk and cost of habitat improvement projects will help guide future habitat improvement strategies for the Yankee Fork.

*Tulley Mackay**

Drone Assisted Stream Habitat (DASH) Surveys: Quantifying habitat to inform and assess rehabilitation efforts

Adapted from the Columbia Habitat Monitoring Program, the Drone Assisted Stream Habitat (DASH) survey was developed to measure habitat characteristics deemed important for Chinook salmon and steelhead in an efficient, cost-effective manner that can be implemented across multiple spatial scales. DASH consists of rapid, on-the-ground habitat assessments at the channel unit scale paired with remote sensing technology (e.g., unmanned aerial vehicles, bathymetric light detection and ranging) and semi-automated data post-processing to improve survey efficiency and repeatability, and reduce potential human error. DASH metrics can be input to quantile random forest (QRF) models to estimate carrying capacity for Chinook salmon and steelhead at multiple life stages, or used to support habitat suitability criteria (HSC) models for species with associated suitability curves. QRF and HSC model results elucidate habitat characteristics limiting fish productivity, providing information to help prioritize areas for rehabilitation, inform rehabilitation design, and quantify habitat and carrying capacity improvements from rehabilitation efforts. DASH has been used in the upper Salmon River subbasin to determine population bottlenecks precluding Chinook salmon and steelhead recovery at the watershed scale, and to evaluate relatively high-quality habitat across central Idaho to establish target conditions for habitat rehabilitation. Currently, Mount Hood Environmental is in the preliminary stages of using DASH to estimate habitat capacity improvements from specific rehabilitation actions in the Lemhi River, Idaho.

Jeanne McFall

Improved habitat design through integration of advanced technology and response monitoring

Adapted from the Columbia Habitat Monitoring Program, the Drone Assisted Stream Habitat (DASH) survey was developed to measure habitat characteristics deemed important for Chinook salmon and steelhead in an efficient, cost-effective manner that can be implemented across multiple spatial scales. DASH consists of rapid, on-the-ground habitat assessments at the channel unit scale paired with remote sensing technology (e.g., unmanned aerial vehicles, bathymetric light detection and ranging) and semi-automated data post-processing to improve survey efficiency and repeatability, and reduce potential human error. DASH metrics can be input to quantile random forest (QRF) models to estimate carrying capacity for Chinook salmon and steelhead at multiple life stages, or used to support habitat suitability criteria (HSC) models for species with associated suitability curves. QRF and HSC model results elucidate habitat characteristics limiting fish productivity, providing information to help prioritize areas for rehabilitation, inform rehabilitation design, and quantify habitat and carrying capacity improvements from rehabilitation efforts. DASH has been used in the upper Salmon River subbasin to determine population bottlenecks precluding Chinook salmon and steelhead recovery at the watershed scale, and to evaluate relatively high-quality habitat across central Idaho to establish target conditions for habitat rehabilitation. Currently, Mount Hood Environmental is in the preliminary stages of using DASH to estimate habitat capacity improvements from specific rehabilitation actions in the Lemhi River, Idaho.

Bryce Oldemeyer

Using mobile PIT array technology to monitor juvenile salmonid use of restored side channel and off-channel habitats

Quantifying salmon and steelhead population-level responses to restoration projects is often difficult due to low spawner abundances, the relative size of projects, and influences from out-of-basin conditions (e.g., ocean conditions, hydrosystem survival, etc.). Monitoring site-scale responses of habitat use of restored or reconnected reaches by juvenile salmonids can be logistically difficult and expensive. Recent advancements in mobile passive integrated transponder (PIT) tag detection technology (i.e. litz cords) present a cost effective and non-permanent alternative to traditional in-stream PIT tag arrays. These mobile setups allow for rapid deployment and monitoring of restored and reconnected habitat; particularly side channel and off-channel habitats. Due to the temporary nature of mobile tag detection setups, observation data is rarely integrated into Columbia River Basin data repositories making it difficult to summarize and interpret data through traditional tools and methods. In response, we developed an open-source R Package that integrates local tag detection data from mobile tag detection sites with publicly available detection/capture data within the Columbia River Basin to summarize fish movements within localized areas (restoration sites) as well as the greater Columbia River Basin. We show an example of how this tool can be used to summarize capture histories for juvenile salmonids migrating through restored reaches in the Lemhi River, ID, how output data can be incorporated into open-source web applications for data visualization, and provide a brief overview of how the data can be used to quantify the impact juvenile Chinook salmon use of restoration sites has on migration timing, growth, and survival.

Tyler Rockhill

Hydrologic analysis for river restoration projects: How to integrate ecologically relevant flows into restoration design

River restoration projects typically assess common flood recurrence intervals (2-, 5-, 10-, 25-, 50-, and 100-year) to develop design elements such as Engineered Log Jams (ELJs), constructed side channels, floodplain restoration, and more. These flows are significant for watershed and river processes in terms of sediment, wood, and nutrient fluxes as well as geomorphically to form and modify the streambed and floodplain. However, this focus on larger flows overlooks the importance of more frequent flow events as well as the influence of climate change on streamflow. This presentation synthesizes and explains hydrologic metrics that are significant for restoration design and the benefits of integrating ecologically relevant flows.

Mike Sanctuary

Hand pulls, herbicide, and channel relocations: Winning the battle with Eurasian Watermilfoil in Jefferson Slough

Eurasian watermilfoil (Myriophyllum spicatum, EWM) is an aquatic invasive species known to form thick mats capable of blocking sunlight and killing native plants that fish and other underwater species rely on for food and shelter. EWM is most commonly found in shallow areas of ponds, lakes, and reservoirs, but can also be found in slow-moving sloughs. In 2013, a 20-acre infestation of Eurasian watermilfoil was identified in Jefferson Slough, a former braid of the Jefferson River near Whitehall, Montana. This nursery is known as the source of an expanding population of milfoil in the upper Missouri River above Canyon Ferry Reservoir. Beginning in 2014, efforts to control milfoil from Jefferson Slough began with multiple hand pulls followed by two years of triclopyr herbicide applications with little success. In 2016, a 3,500-foot segment of the channel was relocated through milfoil-free substrate and resized to improve fine sediment transport while burying the remaining milfoil biomass in the deactivated channel segment. Five years of annual monitoring indicates complete eradication of milfoil from the target reach and a reduction of milfoil-infested area in Jefferson Slough by 20%. The channel relocation and resizing technique has proven an effective means of managing an aquatic invasive species in a perennial waterway used by irrigators and trout anglers. This successful strategy is currently being considered for lower infested reaches of Jefferson Slough and in other similar hydrologic settings to control or eliminate the establishment of milfoil in the Upper Missouri watershed.

Symposia:
Bull Trout Genetic Considerations for Management and Conservation

Organizers: Brett Bowersox, Idaho Department of Fish and Game, brett.bowersox@idfg.idaho.gov; John Hargrove, Idaho Department of Fish and Game / Pacific State Marine Fisheries Commission,john.hargrove@idfg.idaho.gov

Bull Trout are widely distributed across the Pacific Northwest and Canada with the species utilizing a variety of aquatic ecosystems and multiple life history strategies across the range. Genetic representation of this diversity is also complex with two central lineages (coastal and interior) expressed by the species, but significant genetic differentiation present on finer spatial scales compared to other Pacific salmonid species. While the genetic structure of Bull Trout across the listed portion of the species range in the United States has been previously described, advances in genetic techniques provide opportunity to ask more refined management and conservation questions for the species. Genetic monitoring can address key questions such as abundance monitoring, small population genetic resilience, interactions with non-natives fishes, and genetic implications of life history diversity. Presentations in this symposium will highlight ongoing genetic evaluations and the management application of these evaluations to address data gaps with the species.

Brett Bowersox

Bull Trout: An IDFG perspective

Bull Trout (Salvelinus confluentus) are a native char to the Pacific Northwest of the United States and western Canada. The species was federally listed as threatened in the United States under the Endangered Species Act in 1999. The listing was based on declines in population abundance and distribution compared to historic levels, existence of threats to future persistence, and a general lack of data on status. Since that time, resources have been expended to increase understanding of the species, identify threats posed to the species, and to implement conservation measures to address threats. Bull Trout range within Idaho is the most extensive and highest quality of any state in the listed portion of the species range. While some Bull Trout populations in the state are subject to threats which are a conservation concern for long-term persistence, the majority are found within large and connected drainages without significant threats identified, resulting in reduced conservation concern. Efforts to describe status of the species in Idaho have documented high overall abundance, relatively stable populations trends, and wide spatial distribution across much of the species historic range. Similar to Idaho's other native salmonids, listed and non-listed, conservation actions have been implemented to maintain or improve Bull Trout status. Given these documented conditions, Bull Trout listing status has been debated in Idaho since listing occurred. Recently, the Idaho Department of Fish and Game has partnered with the U.S. Fish and Wildlife Service and other state, tribal, and federal entities to draft a Species Status Assessment for Bull Trout. This document contains a biological baseline for reassessing status and inform listing decisions. This presentation highlights current information on status and ongoing and upcoming conservation efforts for the species in Idaho related to the Species Status Assessment and integration of that document into prioritization of management action in the future.

Alexandra Fraik

The genomic of isolated lake Bull Trout

Four life history forms of bull trout (charr; Salvelinus confluentus) are known across their native range; anadromous, two potamodromous forms (fluvial and adfluvial) and non-migratory stream-residents. Although a few bull trout populations located in small, sub-alpine lakes are known, the biology of this life history form is incomplete. We undertook a genomic and morphometric characterization of a subalpine lake population of bull trout in the Clearwater mountains of northern Idaho to determine whether a fifth, non-migratory, lake resident life history form is possible. Bull trout were sampled from Fish Lake (elevation = 1,812 m), its outflow, Lake Creek, in the North Fork Clearwater River watershed, as well as Lake Pend Oreille to serve as an outgroup. Using > 30,000 single nucleotide polymorphisms (SNPs), we estimated patterns of diversity and divergence between the lake and creek populations. There was significant genetic divergence between Fish Lake and Lake Creek bull trout populations providing strong support for reproductive isolation. Additionally, we found evidence suggesting Fish Lake and Lake Pend Oreille bull trout share more recent common

genetic ancestry than Lake Creek bull trout have with either population. Morphometric analysis of bull trout from Fish Lake and Lake Creek identified a singular difference that explained 94.5% of the variance in a principal components analysis between the two populations. Although questions remain, the evidence to date implies that Fish Lake bull trout are non-migratory, since there is no gene flow between Lake Creek. The morphometric analysis provides evidence for a unique bull trout phenotype in Fish Lake. The bull trout of Fish Lake may represent a non-migratory, lake resident life history form of this species. These findings are important because of conservation concerns for US bull trout, as life history diversity and small population persistence are key features of recovery plans for this species.

John Hargrove

A synthesis of Bull Trout population genetics

Genetic data play an important role in the management of imperiled species, providing fundamental information on the distribution of genetic diversity across the landscape and the biotic and abiotic forces that shape it. Bull Trout (Salvelinus confluentus) is a coldwater species listed as threatened in the United States and portions of Canada that has been characterized genetically at various spatial scales. These studies have identified several consistent patterns, namely the presence of distinct lineages (interior and coastal), strong genetic structuring at the population-scale, and small effective population sizes. Despite numerous genetic studies conducted over the last 25 years, little effort has been made to evaluate the extent to which similar processes are responsible for shaping genetic diversity across space and through time. This talk provides a synthesis of population genetic studies on Bull Trout to understand the role of biological and environmental factors in shaping genetic diversity and identifies several research needs moving forward.

Jeffery Johnson

Evaluating Bull Trout fish/redd metrics in the Puyallup Basin, Washington

Bull Trout were ESA listed in the coterminous U.S. in 1996 and have remained in threatened status. Currently, the USFWS conducts 5 year reviews of the status of listed species, including Bull Trout. Five year reviews consist of an evaluation and update of threats to the listed species. Population demographics are among the threats reviewed, including abundance of spawning adults. In the Puyallup Basin, annual spawner surveys are conducted to index the number of spawning adults. Redd counts are multiplied by 2.5 to estimate the total number of spawning Bull Trout. Although 2.5 is near the mean Bull Trout fish/redd metric in the literature (2.68), there is a large amount of variation (1.6 – 4.5). Fish per redd metrics are influenced by a number of factors, including redd survey efficacy. Therefore, we aim to estimate fish/redd for Bull Trout in the White River Basin to aid the five year review. For over 15 years Bull Trout captured in the lower White River Basin at a trap and haul facility have been implanted with PIT tags and moved upstream. Additionally, USFWS, MNRP, and PTI have opportunistically tagged Bull Trout throughout the watershed 2017 to present. To estimate the number of fish/redd, we operate PIT arrays near the mouth of White River tributaries with consistent Bull Trout spawning activity. With the assumption that fish >250mm entering spawning tributaries during spawning timing (August through October) are spawning, we are able to produce a fish/redd estimate. Additionally, we plan to operate PIT arrays in different tributary habitats to understand factors influencing redd survey efficacy, and promote more precision estimates of spawner abundance with habitat specific fish/redd metrics where prudent.

Dan Nolfi

Expanding our understanding of Bull Trout viability

Ongoing management and policy decisions for threatened and endangered species can be challenging in the face of limited data. Bull trout across all coterminous U.S populations (DPS) were listed in 1998 as threatened under the Endangered Species Act (Act). Since listing, the Service has conducted two 5-year status reviews pursuant to section 4 of the Act, resulting in decisions to continue with protections afforded by the Act. In our current/upcoming 5-year review, we are/will utilize the recent species status assessment (SSA) for the bull trout to inform our recommendation of whether to maintain or change the status of the species. The SSA provides Service decisionmakers with a characterization of species viability. For bull trout, we characterize viability based on an analysis of 118 bull trout core areas comprised of over 600 local populations. Although considerable information and data exists on bull trout, datasets sufficient to describe viability across the range are limited. The Service relied on core area working groups, which included external partners, to provide expert level support in core areas with limited data. As a result, the Service was able to evaluate demographic and habitat factors to assess the resiliency of core areas for bull trout across their range. The process we used may provide insight that can be useful in

implementation of the Act for other species with limited data.

Jeff Strait

Informing conservation and management of adfluvial Bull Trout in Lake Pend Oreille, Idaho using genetic tools

The Lake Pend Oreille (LPO) and Clark Fork River (CFR) system supports one of the largest and most robust adfluvial meta-populations of Bull Trout (Salvenlinus confluentus) in the United States. Fish from >30 distinct spawning populations use LPO throughout their life histories. A microsatellite loci panel provides high assignment probabilities for most populations in the LPO/CFR system. Since 2001, this information was used to inform the passage of adult Bull Trout attempting migration to spawning tributaries upstream of Cabinet Gorge Dam. More recently, however, genetic tools have also provided the opportunity to evaluate incidental gillnet bycatch and mortality of Bull Trout as part of a Lake Trout (S. namaycush) suppression program on LPO. We genotyped > 4,000 Bull Trout captured as mortalities in gillnets in LPO from 2006 to 2022 using 12 microsatellite loci and performed population assignment tests. Using these population assignments, we evaluated the spatial distribution and proportional harvest of Bull Trout populations in LPO. Overall, the populations appear to distribute spatially throughout the lake, with fish from each drainage being captured outside of the zone where their natal tributary or migratory pathway meets the lake. Additionally, despite intense gillnet pressure near major spawning tributaries, incidental mortality of these populations was not disproportionately higher than their relative redd counts. Since 2020, all bull trout captured via gillnet in LPO are being sampled for (future) genetic analysis. These data will be used to further evaluate overall stock proportions and to evaluate basin wide demographics through time. Genetic tools are an important part of conservation in the LPO and CFR system and the program will continue to expand their uses in the future.

*Sage Unsworth**

Population demographics and dynamics of juvenile Bull Trout in a montane ecosystem

Bull Trout (BLT) Salvelinus confluentus was listed as threatened in the conterminous United States in 1998 under the Endangered Species Act. Although some BLT populations in Idaho are stable or increasing, BLT in the U.S. Fish and Wildlife Service's designated Coeur d'Alene Core Area (CDACA) have experienced substantial declines in abundance. This population has been monitored annually since 1992 using spawning ground surveys, but little is known about the early life stages of BLT in the system. An understanding of juvenile BLT population demographics and dynamics is a crucial first step towards identifying factors limiting BLT abundance in the CDACA. In 2022, we sampled 95 stream reaches on the mainstem St. Joe River and four tributaries (Heller, Medicine, Sherlock, and Wisdom Creeks). Sampling reaches consisted of 27 multi-pass depletion and 68 single-pass surveys. In total, 579 BLT were sampled varying in length from 32 mm to 257 mm (mean ± SD; 123 ± 39 mm). Of the sampled BLT, 241 were from the mainstem St. Joe River (121 ± 40 mm), 169 were from Medicine Creek (120 ± 35 mm), 105 were from Wisdom Creek (136 ± 42 mm), and 63 were sampled in Heller Creek (117 ± 32 mm). A single BLT (84 mm) was sampled in Sherlock Creek. For all BLT greater than 70 mm, scales were removed for ageing, a small portion of the anal fin was removed for genetic analysis, and a passive integrated transponder (PIT) tag was injected into the body cavity. Fish movement is currently being tracked throughout the basin using five PIT tag arrays. Additionally, habitat surveys were conducted at a subset of study sites to evaluate dominant habitat associations. This study will provide insight on the ecology of BLT that can be used to guide conservation and management decisions in the basin.

Symposia:
NOAA's Habitat Restoration Through the Bipartisan Infrastructure Law: Lessons Learned From Funded Projects and Upcoming Opportunities

Organizers: Larissa Lee (NOAA Fisheries, Restoration Center), larissa.lee@noaa.gov, 206-503-0668; Laurel Jennings (NOAA Fisheries, Restoration Center)

The Bipartisan Infrastructure Law (BIL) presents a once-in-a-generation opportunity for NOAA and partners to continue making an impact for fisheries, threatened and endangered species, and coastal communities. The BIL provides roughly $3 billion over 5 years for NOAA, with significant funding available for habitat restoration, conservation, and resilience efforts. This symposium will begin by highlighting the funding being made available through competitive grant opportunities managed by NOAA and the projects that were funded in the first year of those competitions. This includes funding opportunities and projects for fish passage restoration and hydrologic reconnection. We then invite partners who have received BIL funds to share what they will be able to accomplish with these first round of funds, lessons learned so far, and provide further detail or insight about their projects and what this BIL funding means for their work. We will conclude with a discussion of NOAA's upcoming opportunities for funding and support.
https://www.noaa.gov/infrastructure-law

Tim Elder

Strategic Action Planning to support coast Coho recovery – Overview and lessons learned

Freshwater habitat restoration is the best approach to rebuild abundant and resilient Coast Coho (Oncorhynchus kisutch) populations along the Northern California and Oregon coasts. Efforts to restore freshwater habitats face a variety of challenges, however, including identifying population specific limiting factors, coordinating restoration efforts between multiple state, federal and local agencies/organizations and leveraging restoration funds over large geographic areas.
Wild Salmon Center, in partnership with state and federal agencies, has developed a successful long-term planning process that is accelerating the pace and efficacy of habitat restoration along the Oregon coast. Through this unique partnership, WSC facilitates the development of Strategic Action Plans (SAP) that utilize local, population-scale data, to determine how and where watershed processes should be restored over the long-term (20 – 30 years) to address watershed specific limiting factors. This process then generates a list of high priority projects that begin to address the limiting factors in the short-term (4 – 6 years). The Coast Coho Partnership bundles the high priority projects into funding proposals that supply local partners with the funds needed to implement projects.
To date, four Strategic Action Plans have been completed and four more are in development. WSC has leveraged over $10 million to support high priority restoration projects within the SAP areas. This presentation will give a brief overview of the SAP process and discuss some of the ongoing challenges and lessons learned from 8 years of coordinated habitat restoration efforts.

Tom Elliott

Steelhead passage through an agricultural floodplain - Funding needs and sources

Restoring ESA listed middle-Columbia steelhead in the Yakima Basin is a Yakama Tribal priority, and low juvenile passage survival through lower Toppenish Creek is a critical limiting factor for this fish population. However, implementing full restoration of Yakama resources in this agriculturally developed and topographically altered floodplain system requires adequate funding from multiple sources that support different aspects of a long-term, landscape scale restoration program. In this presentation I will present the unique setting, fish population issues, restoration strategies, and funding framework for passage and habitat work in a landscape rich in Tribal culture

and resources, yet also supporting a multi-billion dollar agricultural industry. Specifically, recent funding awards from the BIL should accelerate restoration progress after years of laying the necessary groundwork with stable, but limited, funding from other sources and technical support from Federal partners. I will also provide some early lessons learned from the project work to date. Ongoing funding level increases are necessary to complete the initial rehabilitation of lower Toppenish Creek, which has been degraded by over 150 years of agricultural development. This work is driven by the need for Yakama Tribal members to fully exercise their treaty rights within the Yakama Reservation, Ceded Territories, and Usual and Accustomed places.

Abbie Gongloff

A collaborative approach to removing barriers on ESA listed streams in Idaho

In 2023, the Idaho Governor's Office of Species Conservation (OSC) worked with three project sponsors (Idaho Department of Fish and Game, and Idaho and Nez Perce Soil and Water Conservation Districts) to garner an award of $4.2 million in Infrastructure funds to remove four fish passage barriers in the Salmon and Clearwater Basins. The OSC is in a unique position to collaborate with project sponsors across geographic boundaries to increase fish recovery efforts using federal funds. The four projects will permanently restore the migration corridors to a cumulative 24.7 miles of high-quality habitat for ESA-listed fish, reduce flooding hazards, and provide safe transport routes in rural areas. These projects are distinctive in their challenge to provide match for other federal funding sources, a high price point, and their location in geographic locations not prioritized by other funding sources. In the Clearwater Basin, Big Cedar Creek, tributary to Clear Creek, and George Creek, tributary to Cottonwood Creek, have fish passage barriers for Snake River Steelhead (Oncorhynchus mykiss). When removed, access will be provided to 1.7 mile and 8 miles, respectively, to all life stages of steelhead. In the Salmon Basin, two complete fish passage barriers will be removed in Poison Creek and Kinnikinic Creek, both tributaries to the main Salmon River. When removed, access will be provided to 6.7 mile and 8.3 miles, respectively, to all life stages of Snake River Spring/Summer Chinook Salmon (Oncorhynchus tshawytscha) and Snake River Steelhead (O. mykiss). These sites experience flooding on a mix of private, county, and state property, requiring time and funding resources from all entities in these underserved rural areas.

Jessica Helsley

Leveraging funding from the Bipartisan Infrastructure Law and Inflation Reduction Act

The Bipartisan Infrastructure Law (BIL) and Inflation Reduction Act (IRA) present significant funding opportunities to address habitat protection and restoration, water quality and quantity issues, fish passage – roads, dams, and tide gates – and most importantly, to improve the resiliency of watersheds in the face of climate change. Since the enactment of these laws, project practitioners throughout the Pacific Northwest have put on their hard hats and waders getting to work to rebuild our iconic ecosystems. The funding provided in these historic pieces of legislation creates a remarkable opportunity to change the current trajectory of many of our iconic fish and wildlife, like salmon and orcas, while directly benefitting Tribes, economies, ecosystems, and local communities throughout the United States.

Wild Salmon Center has created a summary of relevant funding included in the BIL and IRA that could benefit habitat restoration efforts so that Tribes, non-profit organizations, state and federal agencies, and local communities can more easily access the breadth of funding opportunities that we can collectively bring to bear to make significant habitat improvements.

Join us as we review these key funding opportunities. It is critical that we coordinate our efforts – determine what is needed on the ground in the watersheds that we know best – and begin implementation so that we utilize this generational investment for transformational change across habitats for the myriad of species depending upon us.

Jay Krienitz

A community-based coalition strategy for NOAA Transformational Habitat Funding

Washington Department of Fish and Wildlife's Habitat Program, together with a strong coalition of local partners, has built a robust strategy to advance habitat recovery and successfully compete for NOAA's Transformational Habitat Restoration and Coastal Resilience funding. This strategy utilizes a strong regional state funding administrator (WDFW) to help build local coalitions that advance project development, implementation, and coordinate on application development. This process strengthens local collaboration, facilitates adaptive management of these community-based funds within the scope of work (a single regional lead can manage a local coalition budget), and

moves a large portfolio of projects forward together including community engagement, design, construction, and monitoring. As a state funder leading the application, WDFW passes all funding through to sponsors without requiring indirect costs, passing at least 30% more funds down to the local project sponsors, putting millions of additional dollars directly into local projects. With these cost savings, WDFW also funds a small portion to new and existing WDFW staff to directly support local teams meant to serve the entire local restoration coalition. WDFW is also a local restoration lead on state lands. These NOAA funds provide meaningful and measurable outcomes while funding local staff capacity to continue the work. This is especially important now that we need to accelerate our outcomes in the face of climate change and take advantage of the current federal funding environment. This coalition includes multiple sovereign tribes, county and local governments, state agencies, American Rivers, Adopt-A-Stream, and The Nature Conservancy. This project combines two successful applications to NOAA and is titled "Transformational Collaborative Chinook Recovery in Whidbey Basin North and South" and will receive nearly $24 million for this initial 3-year award in 2023.

Larissa Lee

NOAA's Habitat Restoration through the Bipartisan Infrastructure Law - Introduction

The Bipartisan Infrastructure Law (BIL) presents a once-in-a-generation opportunity for NOAA and partners to continue making an impact for fisheries, threatened and endangered species, and coastal communities. The BIL provides roughly $3 billion over 5 years for NOAA, with significant funding available for habitat restoration, conservation, and resilience efforts. This presentation will kick-off the symposium by sharing information about how habitat restoration is being implemented through NOAA's Office of Habitat Conservation (OHC) BIL funding. We'll share information about the four notices of funding opportunity (NOFOs) that OHC put out in 2022, which focused on fish passage and transformational coastal habitat restoration and resilience. We'll highlight some new and notable eligibility and evaluation criteria for those opportunities, such as the elimination of any match requirement and an emphasis on meaningful engagement with Tribes and underserved communities. Lastly, we'll present information on what projects were awarded funding in our first year implementing BIL funds, in order to inform applicants and restoration practitioners about the types of projects and applications that may be most competitive in future funding opportunities. We will examine various factors in these applications, such as the range of fund amounts that were allocated per award, the location of projects, whether funded applications were presented as a suite of projects or a single restoration site, the project type (e.g. planning, design, construction; culvert replacement, dam removal etc.), and the type of organization that received funding, among other factors. We will also examine how these locations overlap with critical habitat layers for NOAA's ESA-listed salmon. This funding is expected to be available for five years, and this information is presented to spark conversations about how to implement projects through NOAA's funding opportunities that are most impactful to species recovery.

Larissa Lee

NOAA's Habitat Restoration through the Bipartisan Infrastructure Law - Discussion and future opportunities

The Bipartisan Infrastructure Law continues to present new opportunities for NOAA and partners to continue making an impact for fisheries, threatened and endangered species, and coastal communities over the next few years. We'll use this session to close out the symposium on NOAA's Habitat Restoration through the Bipartisan Infrastructure Law. We'll discuss and summarize overall lessons learned that we heard from projects and proposals received during our FY22 funding opportunities. We'll invite presenters from throughout the symposium to a short panel discussion, so that audience members can ask more questions and gain insights from their work. We'll end by reviewing upcoming funding opportunities, NOAA priorities, and how to craft competitive restoration project applications for these funding opportunities.

Nicole Rasmussen

Removing barriers on the Olympic Peninsula

Where lush rainforest meets the sea on the Olympic Peninsula, Washington's coastal rivers produce the most abundant and diverse remaining wild Pacific salmon populations in the contiguous United States. Unfortunately, salmon and steelhead have limited access to these habitats due to a legacy of human alteration that has fragmented the watersheds and disconnected streams from mainstem river corridors. At the same time fish were being cut off from access to their home waters, tribal members and tribal natural resources managers were prevented access to decision making tables.

In 2017, the Coast Salmon Partnership, Wild Salmon Center, and Trout Unlimited launched the Coldwater Connection Campaign a cooperative approach that brought Olympic Peninsula Tribes and nonprofits together to reconnect salmon and steelhead habitat on the western Olympic Peninsula. We are using a science-based, field-informed, and collaborative process to identify projects that will have the most benefit for the fish. The work has leveraged private and public funding sources to support multiple phases of work beginning with GIS modeling and increasing Tribal capacity, followed by field assessments, project design, and construction. A Decision Support Tool used the best available geospatial datasets to model the ecological benefits of fish barrier correction. Modeling was followed by on-the-ground verification, and nonprofit organizations and tribal natural resource departments have worked together to select sites for further project development. Our goal is to use philanthropic dollars to leverage state and federal funding to correct 50 fish barriers over the next 10 years. This goal adds to the correction of state-owned fish passage barriers in these same watersheds that will be addressed by Washington State Department of Transportation in response to the federal court injunction. Together this work will improve salmon and steelhead access to approximately 125 miles of habitat on the western Olympic Peninsula.

Jared Weybright

A collaborative approach to ecosystem restoration in the McKenzie River Sub-basin (OR)

Working across land ownership is a challenge to implementing watershed conservation projects intended to restore natural processes. While developing cooperative partnerships among diverse stakeholders is a common approach to meet this challenge, maintaining collaboration over time or during periods of crisis is extremely difficult. Since 2014, a coalition of partners representing non-profit organizations, a land trust, a utility, and local, state, and federal agencies has worked together to implement watershed restoration across private and public lands in the McKenzie River sub-basin (Oregon). The Pure Water Partners program works with private landowners through long-term agreements to protect and restore riparian and floodplain forests, vital to maintaining high water quality and providing critical aquatic habitats. Complimentary to private lands work are collaborative efforts to design and implement valley-scale projects to restore natural processes on federal and conservation lands. This cooperative framework allowed for an immediate respond to watershed restoration needs on lands impacted by the 2020 Holiday Farm Fire, which burned over 173,000 acres of private and public lands in the McKenzie River sub-basin. The coordinated response to the wildfire included riparian restoration on nearly 300 acres across 250 private properties and the development of floodplain enhancement projects covering almost 500 acres. Partners completed one instream project in 2022, a second is on track for 2023 implementation, and two large-scale projects (~ 200 acres each) will be completed in 2024 and 2025. The collaborative partnership relies on a combination of formalized agreements, relationship development, and an intentional approach to centering the work's success over the recognition of individual organizations. Partners include the Bureau of Land Management, Eugene Water & Electric Board, McKenzie River Trust, McKenzie Watershed Alliance, Upper Willamette Soil and Water Conservation District, and the U.S. Forest Service Willamette National Forest.

Symposia:
Addressing Aquatic Organism Passage - Challenges, Responsibilities, Opportunities and Examples

Organizers: Justin Jimenez, USFS Northern Region Aquatic Ecologist, justin.jimenez@usda.gov, Sharmila Premdas Jepsen, BLM Lead Fisheries Biologist and Aquatic Invasive Species Coordinator, spremdas@blm.gov, and Shane Scott, SSA Environmental LLC, 4719 NE Salmon Creek St., Vancouver, WA 98686, Phone: (360) 601-2391, shane@sscottandassociates.com,
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Ensuring adequate aquatic organism passage (AOP) is a ubiquitous challenge in fisheries management. Fisheries professionals and organizations responsible for fisheries management need to work collectively to ensure it is addressed holistically and ecologically. Socially, we also need to address the challenge to prove that the cost/benefit ratio is worth investing in for fish, people, and communities. This symposium will share examples of projects and programs focusing on AOP restoration or improvement. In addition to aquatic organism passage, symposium presentations will address culvert replacement, repair and/or rehabilitation, stream simulation, barrier inventories and prioritization tools, climate resiliency, costs, funding as well as partnerships.

Kevin Davis

AOPs - Connecting agencies, disciplines, and habitat

Since 2008, the North Zone of the Idaho Panhandle National Forest (IPNF) has implemented a number of culvert replacement projects aimed at restoring or improving fish passage to upstream habitat. These projects are called Aquatic Organism Passage, or AOP's, since fish and other forms of aquatic life benefit from the improved access provided under roadways. Often time's old culverts are at the end of their serviceable lifespan, about 25 years, and need to be replaced. This is an opportunity to replace the culvert as well as improve aquatic organism passage. In other cases, a culvert is functioning properly with respect to passing streamflow but it is a barrier due to a vertical drop at the outlet, or it is excessively long and in both cases fish cannot navigate through the pipe. Installing a bottomless arch culvert or a bridge to replace the culvert will provide access to previously inaccessible habitat to native fish species. Aquatics and Engineering on the North Zone of the IPNF have completed seventeen AOP projects since 2008. Intra-agency support and cooperation between Hydrology, Fisheries, and Engineering is critical to project development and implementation. These projects have garnered a great deal of external support in funding and design. Partners have included Avista, Kalispel Tribe, US Fish and Wildlife Service, Bonner County, and Collaborative Forest Landscape Restoration Program (CFLRP). Without these partners many of the projects would not have been possible.

James DeRito

Fish passage as a key step in the process to restore native fish assemblages by means of non-native trout removal

Fish passage improvements were an integral part of a project that restored native trout and other native fishes in Rich County, Utah. Before the project, only non-native Brook Trout and Brown Trout with native non-game fishes were present in Otter Creek. A plan was developed to chemically remove the non-native trout and restore Bonneville Cutthroat Trout and Northern Leatherside Chub to about twenty miles among the three branches of the creek. However, numerous man-made barriers were found throughout that prevented the movement of fishes within and among these branches. Fish passage improvements were made at 9 irrigation diversions and 5 road culverts on the south and middle branches of the creek in 2010 and at 4 irrigation diversions and 5 road culverts on the north branch beginning in 2014. A conservation fish barrier was constructed just downstream from where the branches come together to prevent the reinvasion of non-native trout. Rotenone treatments to remove non-native trout occurred in 2015 and 2016. Thereafter, Bonneville Cutthroat Trout were reintroduced and are now widely distributed and self-sustaining throughout the three branches, whereas the reintroduction of Northern Leatherside Chub has resulted in a relatively limited distribution in the creek. We attribute successful restoration to a strong partnership of state, federal, and non-profit partners that were able to work in a coordinated and step-wise fashion with local officials and landowners over many

years. The upfront investment in fish passage infrastructure not only reconnected stream habitat, but also provided operational improvements to ranchers that was critical to social and political support of the overall project.

*Ryan Easton**

Fish passage monitoring and remediation in a highly modified New Zealand ecosystem

The Murihiku [Southland] region of Te Waipounamu, Aotearoa [South Island, New Zealand] is a landscape dominated by agriculture – in particular dairy – which has led to a freshwater ecosystem fragmented by road crossing culverts, weirs and fords. Southland has a diverse range of native and non-native freshwater fish species, with the majority considered taonga [treasured], that is, holding cultural significance for Māori (the Indigenous peoples of New Zealand). The diversity of these species and differences in life-history (migratory v. non-migratory), swimming ability and climbing ability means that each species, and each life-history stage within these species, has different challenges when presented with a migration barrier. Therefore, in order to maximize river connectivity, different species/life-stages will need to be considered, requiring different remediation efforts to fully remove the barrier. Multiple remediation methods have been encouraged for use in New Zealand, however the effectiveness of these remediation methods have yet to be tested at a large scale in-situ. One method to test the efficacy is to compare the community assemblage upstream and downstream, before and after barrier remediation, their genetic connectivity, or potentially even similarity of viral/parasite communities. The methods to achieve these assessments all have limitations. For example, traditional monitoring efforts like electrofishing can be time and cost intensive, leading to limited spatial application by governmental agencies which has caused some waterways to be overrepresented, and some species underrepresented. However, newer methods such as eDNA sampling have issues involving limits of detection, are currently unable to provide relative abundance metrics, and can be costly to process. Here we cover our efforts to develop a prioritization and monitoring plan to assess barrier remediation effectiveness, including eDNA collection method testing and fish virome investigation, and present some preliminary data on species distribution upstream/downstream of identified barriers.

Stephanie Hallock

Outcomes from a Forest Road and Fish Passage Assessment on the Coeur d'Alene Reservation: A 15 year retrospective

In 2008, the Coeur d'Alene Tribe Fish and Wildlife Program completed a major forest road and stream crossing assessment within important spawning and rearing areas for Westslope Cutthroat Trout. The study encompassed 335 miles of road and 407 road crossings within 4 target watersheds. The objectives were to: 1) evaluate road segments within proximity to critical areas for spawning and rearing habitat; 2) identify any complete or partial barriers that may limit Westslope Cutthroat Trout access to critical seasonal habitats; and 3) draft a planning document to identify priorities for restoration/enhancement treatments based on the study results. The results from this study, along with other watershed assessments and long-term monitoring data, were used as the basis for developing and ranking future habitat projects to address watershed process impairment for sediment, flood hydrology, riparian and channel function and water quality. The resulting project list included treatments for approximately 21 km of road and 18 fish passage projects. Significant progress has been made to implement these projects from 2012-2022. High-priority projects implemented since 2012 have opened 24.4 km of stream habitats to fish passage and reduced sediment delivery by 75% from 7.49 km of hydrologically connected roads. Agreements have been negotiated to implement projects with all major industrial landowners, local governments as well as with several smaller private landowners. These agreements have helped to build relationships that will facilitate implementation well into the future and set the stage for addressing other restoration needs and opportunities. Flexible cost shares were used as a mechanism to facilitate implementation by taking into consideration funding sources and the needs of partners. This work is part of the on-going effort by the Tribe to recover harvestable and sustainable populations of native trout.

Emily Heaston

Tools for tracking road stream crossings and streamflow permanence - feature mapping with mobile data collection

Intersections between stream and road networks represent billions of dollars of decisions related to managing infrastructure, hydrologic processes and ecological connectivity. Despite the importance of road-stream crossings, there are countless gaps in knowing where and what they are. To address this need, two new tools have been developed and applied across the western United States: FLOwPER and RoadxStr. These tools are designed to map key features of stream and road networks and to be applied at thousands of locations across large geographic extents.

FLOwPER (FLOw PERmanence) was developed by a team of scientists from the U.S. Geological Survey, U.S. Forest Service, and Bureau of Land Management. FLOwPER allows rapid collection for observations to characterize stream channels and flow permanence. RoadxStr (Road x Stream) is a survey tool that effectively characterizes road-stream crossings. This tool was collaboratively developed with inputs from a national and regional (Pacific Northwest) group of biologists, hydrologists, geomorphologists, and road engineers representing government agencies and non-governmental organizations. The broad range of experience and expertise incorporated into RoadxStr ensures the data collected meets management needs while being transferable across existing road-stream crossing datasets.

Preliminary results from field surveys indicate that FLOwPER and RoadxStr function as intended. Our objective with these feature mapping efforts is to create usable and accessible peer reviewed, publicly available datasets. This data can dramatically improve regional assessments, decision tools for identifying management priorities, and fuel new research to better understand how road and stream networks interact.

Amy Horstman

Transformational aquatic connectivity restoration through the Bipartisan Infrastructure Law and beyond

The Bipartisan Infrastructure Law (BIL) provided multiple federal agencies with over $2 billion in funding to remove instream barriers and restore fish passage and aquatic connectivity nationwide. Since June 2022, federal and non-federal partners have been engaged in ongoing efforts to coordinate the delivery of this funding to ensure strategic and transformational investments into our nation's waterways, infrastructure, and communities. These collaborative efforts included an initial federal agency leadership discussion in June, a multi-stakeholder workshop in July, a series of facilitated small group discussions aimed at developing a set of options to promote effective implementation of BIL funding related to barrier removal and fish passage, and a federal agency staff-level meeting in early November to consider options and develop a set of recommendations for agency leadership consideration. In December 2022, federal agencies involved in fish passage funding under the BIL established a working group to serve as the primary mechanism for the strategic implementation and coordination of BIL fish passage funding. The group seeks to lay the groundwork for a more holistic, collaborative, and efficient approach to implementation of not only BIL funding but future years of funding for aquatic ecosystem restoration. The group seeks to direct the BIL funding in such a way that makes it easier for partners to access, has a broader conservation impact in the field, and changes the way federal agencies work together, and with non-federal partners, for the better. This forum for decision-making across federal agencies has and will continue to include robust engagement from Tribes, States, and other non-Federal stakeholders to ensure the funding creates big conservation wins, organizational efficiencies, and delivers inclusive and equitable project benefits.

Helen Neville

Incorporating non-summer growth potential elevates the importance of downstream habitats in aquatic connectivity decision making

Alarming losses in biodiversity coupled with mounting impacts from climate change add urgency to the strategy of reconnecting aquatic habitats. Current evaluation of aquatic organism passage (AOP) opportunities involves balancing the financial costs and logistics of barrier management (placement or removal) with estimated benefits, typically extrapolated from observed characteristics of upstream habitats or populations (additional # fish/mile to be gained, e.g.). For coldwater species such as trout, summer temperature suitability is often emphasized as the limiting factor in the decision process, with warm downstream habitats discounted or removed entirely from consideration. Recent studies have highlighted the importance of warmer temperatures in seasons other than summer for extending individual growth opportunities and thus boosting population productivity with seasonal access to these habitats. Yet currently this growth regime is not generally incorporated into AOP evaluation, which may be leading to suboptimal decision making. Drawing on a completed AOP project involving the threatened Lahontan cutthroat trout, we characterize thermal benefits of reconnecting 'core' headwater stream habitats to a warm, apparently inhospitable-in-summer mainstem river. We suggest that observed population responses – a 3x increase in densities and the generation of large, migratory individuals – arose not only from traditionally assumed benefits of reconnection (demographic and genetic exchange provided by the newly-established migratory corridor) but also from the additional growth supported by this downstream habitat in seasons other than summer. Further, we show how outputs from a growth regime model can be added readily to existing temperature visualization tools to assess and communicate the benefits and tradeoffs of reconnection. With recent infrastructure funding driving aquatic connectivity projects at unprecedented pace and scale, accurate estimation of the fulsome biological benefits is critical.

Shane Scott

Use of flexible baffles to improve Aquatic Organism Passage (AOP) through culverts in North America

Culverts and other conveyances are second only to dams in blocking passage of fish and other aquatic organisms. These barriers impede passage to spawning grounds and adversely affect habitat connectivity for many species. High water velocities and/or shallow water depths create hydraulic conditions that limit aquatic organism passage (AOP). Culvert weirs and baffles have long been used to improve hydraulic conditions in culverts and other conveyances to improve AOP. However, these structures are typically rigid which reduces the hydraulic capacity of the conveyance. Also, debris is often trapped in the culvert behind the baffle which requires costly and expensive maintenance. Recent advances in materials have allowed development of a flexible yet very durable culvert baffle that improves AOP similar to solid baffles but allows passage of debris at higher flows with a minimal effect on the hydraulic capacity of the culvert. In this presentation we will provide information on the use of flexible culvert baffles to improve AOP. We will also demonstrate how Computational Fluid Dynamic modeling is being used to properly size and configure the flexible baffles to meet conservation needs.

Cory Sipher

Restoring fish passage in the Tillamook Bay and Nestucca Watershed

The Nestucca River and its tributaries, are home to federally-threatened Oregon Coast (OC) Coho salmon as well as spring and fall chinook, summer and winter steelhead trout, Pacific lamprey and resident coastal cutthroat trout. The Nestucca River is also a designated Wild and Scenic River and a State Scenic Waterway, all of which create unique challenges to implementing large-scale restoration projects. A 1995 GAO audit directed the BLM to identify fish barriers, and evaluate costs and habitat accessed by these structures. After compiling this data, the Tillamook Field Office completed an Environmental Assessment (EA) to address some of these identified culverts in 2004. This EA covered seven existing culverts of which six AOP structures were replaced by 2013 opening access to 2.2 miles of habitat for OC coho. In 2006, the BLM and Tillamook Estuaries Partnership completed an assessment of stream crossings and fish passage culverts on the Nestucca and Neskowin watersheds on both federal, state, private industrial and private ownerships. This was followed by a Fish Passage assessment in the Tillamook Bay Basin in 2013. Another project level analysis was completed by the Tillamook Field Office in 2016 to address 41 miles of the Nestucca Back Country Byway in the Nestucca River. Since 2016, eight additional AOP culverts have been replaced providing improved anadromous access to over 10 miles of habitat of which about two miles were critical habitat for OC Coho. Post-project surveys, which include eDNA sampling, have documented native and anadromous access was restored at all these sites. Projects planned for the remaining six culverts will improve or open access to 4.5 miles of OC coho Critical Habitat.

Shane Vatland

Lessons learned from a decade of monitoring adult Chinook movement in the Lostine River, Oregon

We synthesized movement data of adult Spring/summer Chinook Salmon in the Lostine River from 2008 to 2021. We assessed three key factors: 1) fish passage at irrigation diversion structures before and after restoration, 2) passage at fixed monitoring sites relative to stream discharge, and 3) movement patterns of fish through the system from tagging at the weir to final spawning location. Each year, 50-75 fish were radio-tagged at the Lostine River weir, and their movements were tracked using four fixed monitoring sites and weekly mobile antenna tracking. Fixed sites included paired antennas to assess passage success, direction, and duration. One station with no irrigation diversion structure was used as a control site, and other monitoring sites were located to collect data before and after restoration activities for at least three years. Three roughened-channel irrigation diversion rehabilitation projects improved upstream passage success and reduced passage duration for adult Chinook. This resulted in improved access to spawning habitat and reduced migration stress. However, low flows, especially at Poley Allen diversion, a priority site for future restoration work, decreased the probability of successful upstream migration. Overall, these empirical movement data provided a foundation for identifying problem areas, prioritizing restoration efforts, and evaluating instream flow management.

Symposia:
Non-permanent Rivers and Streams in the Western USA

Organizers: Bob Hughes, hughes.bob@amnisopes.com

Non-permanent rivers and streams comprise 79% of USA stream networks and they provide important habitat, ecological functions, and fisheries for downstream rivers, lakes, and coastal waters. Commercial and recreational fisheries, which are dependent on non-permanent streams, are important for local and regional economies. Many of the 33% of streams in the conterminous western USA mapped as perennial were found to be intermittent or ephemeral. Impairment, loss, or destruction of non-permanent streams under a weak Waters of the U.S. Rule will have severe and long-lasting negative consequences for aquatic ecosystems, fish& fisheries throughout the western U.S. Therefore, this session is intended to highlight some of the values and threats to western U.S. non-permanent rivers and streams.

*Niall Clancy**

Identifying potential climate-change refugia for fishes in the face of warming, drying, barriers, and invasive species

Determining where species will be able to persist in the face of climate change and increasing water withdrawal is critically important for the conservation of native fish assemblages. Climate-change refugia are areas where climate-vulnerable fishes will be able to persist despite declines in other parts of their range. Previous refugia studies have examined how increasing stream temperatures are likely to impact vulnerable trout species but have not incorporated stream intermittency, instream barriers and invasive species. Further, few studies have attempted to identify climate-change refugia for whole fish assemblages, including game and nongame species. We present a basin-scale approach to identify climate-change refugia that accounts for multiple variables including temperature, streamflow intermittency, invasive species, and barriers and integrates the system-specific knowledge of local biologists. We used fish-species presence data from the Judith River basin of Montana and the upper Tongue River basin of Wyoming, to examine vulnerability of native fishes to stream warming, stream intermittency, and invasive species. We then use this information to delineate potential climate-change refugia and identify instream barriers that could prevent access to refugia. This information will provide local managers with a list of actionable, potential projects to benefit climate-vulnerable fishes. We further hope the methodology can be applied elsewhere to generate similarly useful information across the West.

Konrad Hafen

Using lidar and spectral imagery to identify and model streamflow in small streams

Headwater streams comprise greater than 50 percent of streams worldwide by length and number. However, headwater and other low-order streams are underrepresented by stream gage networks and most monitoring programs. This dearth of data for small streams diminishes the ability of existing modeling frameworks to provide robust estimates of streamflow conditions (and uncertainty for estimated conditions) at these locations. In June and September of 2022, the U.S. Geological Survey collected observations of surface-water presence concurrently with very high-resolution aerial imagery and airborne lidar to quantify streamflow conditions in two Oregon watersheds. From these data and observations, we developed a model that uses climatic and topographic variables to estimate and predict surface-water presence at a daily timestep. The model implements Bayesian techniques to incorporate multiple data types (e.g., remotely sensed data, streamflow time series, water presence observations, process-based model outputs) and estimates the relative magnitude of streamflow throughout a stream network. The modeling framework demonstrated by this study can be expanded and adapted to improve estimation of streamflow presence and magnitude in other locations with different data availability.

*Cienna Hanson**

Evaluating the effects of intermittent flow on the resilience and vulnerability of fish assemblage structure

Supra-seasonal droughts are natural occurrences that can have economic and environmental consequences that are exacerbated by climate change and anthropogenic water use. These long-term droughts have a direct impact on fish and fisheries. Our study aims to assess the vulnerability and resilience of fish assemblages of the Colorado River Basin to drought-induced intermittent flows. Our objectives are to 1) document stream flow to determine the timing, duration, and severity of drying events, and 2) assess fish assemblage structure between intermittent and perennial stream reaches over differing seasonal flow conditions. Sites were sampled on four tributaries, focusing on logger deployment, habitat mapping, and fish assemblage surveys. HOBO loggers were converted to conductivity sensors, STIC loggers, to document water presence. The summer of 2022 experienced an extreme drought, whose onset was earlier than expected. Intermittent sites were identified via imagery and were confirmed with preliminary flow data ($F = 52.971$, $df = 1$, p-value = <0.001), and most were dry when our first round of sampling occurred. Only two of the four tributaries have regained connectivity. The South Llano experienced 60 days of disconnected intermittency and the Concho and Onion Creek have experienced 189 and 180 days (respectively) as recorded by our STIC loggers. Habitat surface area dramatically changed with the resumption of flow, almost doubling habitat availability on the South Llano at intermittent sites. In general, intermittent sites had lower mean site species richness (mean = 9.6 species, sd = 2.6) than perennial sites (mean=13.6 species, sd = 1.2), across both sampling periods, and the average difference was significant (t-value = -5.43, df = 8, p-value = 0.0006). Continuing data collection will allow us to assess how fish assemblages differ based on changes in flow and connectivity, providing valuable baselines to inform management and conservation for SGCN.

Zachary Hooley-Underwood

Non-permanent streams in the Colorado River Basin insulate against hybridization in catostomid species

Many fishes native to the Colorado River Basin use tributary habitats to complete portions of their life histories. Commonly, such tributaries are non-permanent and are easily overlooked by fisheries managers and conservationists. Over recent decades, effort has been dedicated to evaluating the role these non-permanent waters play in fisheries in the Colorado River basin. These evaluations have generally found that fish use of and reliance on these habitats exceeded expectations. Through a trapping study using a picket weir, we found that over 10,000 fish – primarily native catostomids – spawn in an intermittent tributary to the Gunnison River in western Colorado during seasonal runoff. Further, through larval catostomid collection and genetic evaluation, we identified that a difference in migration behavior exists between native and introduced catostomids. In these tributaries native suckers migrate farther upstream to spawn than non-natives. Hybridization between native and non-native catostomids has led to declines of the native species, so migratory differences between the two sustains genetically pure recruitment in some tributaries. Finally, we have identified intermittent tributary spawning runs as sites where hybridization rates can be manipulated through parental selection. We are attempting to use a resistance board weir to control which individuals are able to access spawning habitat, but have had mixed results in our ability to affect the hybridization rate in our study tributary. Unimpeded access to non-permanent waters has likely slowed declines of native catostomids in the Colorado River basin, and focused management and conservation of these waters going forward may improve abundances of these at-risk species.

Adam Price

Analyzing modeled representations of no- and low-flow in the Pacific Northwest

Globally, and within the Pacific Northwest, there are an abundance of non-perennial rivers and streams, which are predicted to increase due to climate change and anthropogenic influences. However, most modeled representations of streamflow have been constructed with perennial systems in mind, leaving a gap in our understanding and representation of non-perennial systems. To adapt to future challenges, there is a need to determine what modeled representations of low- and no-flow in non-perennial systems do well and where uncertainties may lie in the internal representations of hydrologic proxies and processes. Here we compare a suite of process-based hydrologic models to better understand these uncertainties, analyze how well these models represent low- and no-flow across space and time, and identify how to use flow/no-flow observations to benchmark process-based models. Preliminary results suggest that process-based models display varying degrees of accuracy at representing non-perennial systems and matching observations. The ability to accurately model non-perennial systems is paramount to understanding the connections between hydrologic characteristics of low- and no-flow and the potential ecological, biogeochemical, and societal implications of these important systems. Improving our predictive understanding of low- and no-flow periods in non-perennial systems within the Pacific Northwest will fill critical gaps and better target the timing and location of future research, management, and conservation efforts.

Leanne Roulson

What are non-perennial waters and why should we care? An introduction to the session

The Waters of the United States (WOTUS) rule defines perennial, intermittent, ephemeral, and non-permanent waters for the purposes of permitting resource development. The WOTUS rule has shifted over the years and the rule's definitions may conflict with biologist's field classification or understanding of these waters' ecological functions. However, in the realm of permitting and development, the WOTUS rule's wording can mean the difference between protecting a stream and its fishery or allowing it to be dewatered, channelized, or otherwise damaged without recourse. This introduction will provide an update on where the Waters of the US (WOTUS) rule and waterbody definitions are in May 2023, go over some general concepts on connectivity and headwater stream values, and will orient the session to the areas where each speaker's work is centered. Our session will cover research on stream values for waterbodies from the Oregon Cascades, across to eastern Montana, and through the Colorado River basin from its headwaters down to Texas. Although the ecological roles and observed changes may differ from watershed to watershed, the functional importance of these waterways is consistent and irreplaceable. The loss of protections for these waterways that may follow changes in how the Waters of the US rule is applied is a considerable threat to fisheries and water quality security for humans and would intensify stressors due to climate changes in the intermountain West.

*Skylar Rousseau**

Characterizing the availability of native salmonid spawning habitats in intermittent tributaries

Intermittent streams represent a significant portion of aquatic habitat available to native salmonids during their spring spawn, yet management plans and environmental protections undervalue the importance of non-perennial reaches to native species. Historical data suggest intermittent tributaries support extensive spawning by native Bonneville Cutthroat trout (Oncorhynchus clarkii utah; hereafter BCT) in high water years, but the extent to which they support spawning across years and amid changing flow regimes remains unclear. Here we describe preliminary results of ongoing research examining (1) the availability of viable spawning habitat in intermittent tributaries to the Logan River in Northern Utah across years and (2) the dominant physiographic controls on in-stream conditions that dictate suitability. Using a hierarchical cluster analysis on tributary-specific daily temperature data, we infer flow period for each stream. We then characterize the viable spawning window available in each tributary by comparing the potential degree-day accumulation prior to stream drying across a range of spawning dates to literature values of degree-days required for eggs to hatch. Our results suggest that even in a relatively low water year (2022), some intermittent streams represent suitable spawning habitat, though the length of the viable spawning window varied substantially among tributaries. We then examined the relationship between tributary spawning suitability and a suite of watershed characteristics to better understand the geomorphic mechanisms driving spawning habitat suitability. In subsequent field seasons, we will examine how the mosaic of suitable spawning habitat responds to changing thermal and precipitation patterns. Additionally, we will use environmental DNA and active capture techniques to characterize the spatio-temporal distribution and size-structure of BCT occupying non-perennial reaches. Ultimately, the results of this research can inform the targeted management of temporary aquatic habitat by identifying how and when intermittent streams contribute to native salmonid population productivity.

Christopher Walser

The effect of flow regime on the feeding ecology of Redband Trout *Oncorhynchus mykiss* in an intermittent stream

Climate change models for semi-arid western North America predict drier summers with decreases in mean annual streamflow and lower summer flows. This study investigated the impact of low summer flows on prey availability and feeding ecology of redband trout in an intermittent Idaho stream. From June to September 2021, we measured current velocity, water temperature, and macroinvertebrate (drift, benthic, and terrestrial) availability across 3 study sites during lotic and lentic conditions. We used underwater videography to record fish foraging mode (surface, pelagic, or benthic) and we used gastric lavage to determine trout diets during each of the two hydrologic conditions. Current velocity declined across the study period with lentic conditions (<0.01 m/s) appearing in early July. Rates of macroinvertebrate drift and terrestrial macroinvertebrate input declined during the study period. No clear temporal trend in benthic macroinvertebrate density was observed. During lotic conditions, trout primarily foraged in the pelagic zone. As flows decreased, trout fed less frequently across all foraging modes but foraged equally often in the pelagic zone and benthos. Trout rarely fed at the surface during lentic conditions. Diet analyses corroborated the foraging mode results. During lotic conditions, terrestrial macroinvertebrates (Orthoptera and Coleoptera) and aquatic macroinvertebrates (Ephemeroptera sp.) were common prey items in the diet. Few terrestrial macroinvertebrates (except Hymenoptera) were consumed during lentic conditions. Instead, fish consumed primarily aquatic macroinvertebrates (Chironomidae and Ephemeroptera sp.). Our results indicate that redband trout living in intermittent streams adjust their foraging as hydrologic conditions and prey availability change.

Symposia:
Filling the Void: Expanding Anadromous Fish into Historical Habitat through Hatcheries, Barrier Removals, and Reintroduction

Organizers: Marika Dobos, Anadromous Fisheries Staff Biologist, Idaho Department of Fish and Wildlife, marika.dobos@idfg.idaho.gov; Sammy Matsaw, Research Biologist, Shoshone-Bannock Tribes, smatsaw@sbtribes.com.

Anadromous fish species across the west coast have exhibited precipitous declines and extirpation from historic habitats. Factors of declines or extirpation include loss of habitat due to land and water use practices, construction of dams or other man-made barriers, and urbanization. Billions of dollars have been invested to improve fish passage and habitat, as a means to improve fish returns. The symposium highlights innovative practices that improved imperiled stocks, reintroduction of fish into basins where anadromous fish were historically extirpated, and large-scale barrier removals that opened watersheds back up to anadromous life history. As these opportunities will continue in the future this is an opportunity to share success and challenges to help guide ongoing or future projects.

Joseph Benjamin

Assisted migration of Coho Salmon: Stakeholder engagement in adaptive management

Assisted migration is a means of introducing a species into a previously unoccupied area. Although this idea is relatively new in the context of climate adaptation, there are many extant examples involving intentional introductions of fish that can be instructive. We studied a case of assisted migration in Lake Creek, a tributary to the Siuslaw River, Oregon. In this system coho salmon were historically absent from the upper watershed owing to an impassable barrier at Lake Creek Falls. Three ladders were installed at the falls and coho salmon now spawn and rear in the upstream habitat. We engaged stakeholders to discuss management concerns for coho salmon and passage to upstream habitat. Through a series of meetings, stakeholders adaptively identified management needs. Initial meetings identified concerns of variability of passage through the ladder, which instigated a telemetry study. The telemetry study suggested about 50% of the adults moved upstream to spawn while the rest spawned in habitat below the ladder. Subsequent meetings raised the question of the contribution of spawning locations to the population as a whole. Stakeholders co-created a population model to address this question. Preliminary modeling suggests an increase in population abundance of coho salmon as ladder passage increases, but only to a point. This result can be attributed to the importance of juvenile rearing conditions in the lake upstream of Lake Creek Falls. Overall these preliminary findings point to the importance of considering a full range of processes that can drive expected outcomes for assisted migration.

Joe Dupont

This history of spring and summer Chinook Salmon fishing in Idaho

Fishing for spring and summer Chinook Salmon in Idaho has suffered greatly due to historic commercial fisheries, dam building, and habitat degradation. Returns of wild spring and summer Chinook Salmon to Idaho pre-European settlement were estimated at about million fish, but since 1938, Columbia and Snake River dam counts indicate wild spring and summer Chinook Salmon returns have never exceeded 80,000 fish. Returns of spring and summer Chinook Salmon experienced a three-fold decline during the mid-1970 which was attributed largely to the construction of the four lower Snake River dams. The common strategy to mitigate for these lost fisheries due to dam construction was through hatchery programs. Hatchery programs focused on restoring lost fishing opportunities for spring and Chinook Salmon began in the mid-1960's and the first returns occurred in 1967. Starting in 1985, returns of hatchery spring and summer Chinook Salmon began outnumbering returns of wild fish. With the addition of hatchery salmon returns, the average number of spring and summer Chinook Salmon returning to Idaho from 2001-2022 (68,000 fish annually) outnumbered returns from 1939 to 1974 (45,000 fish annually). However, these returns are far from IDFG's return goals for wild (127,000) and hatchery (minimum of 90,000) spring and

summer Chinook Salmon. Prior to 1966, all non-Tribal fishing occurred on wild fish, but after 1978, fisheries targeting wild returns ended. Annual harvest of adult Chinook Salmon from 1954 to 1974 averaged about 13,000 fish annually, then dropped down to 800 fish annually from 1975 to 1999. During this 25-year period, non-Tribal fisheries were allowed for only 11 of these years. From 2000 to 2022, returns of hatchery salmon allowed fisheries to occur every year in Idaho, and annual harvested averaged 10,200 fish. In 1954, spring and summer Chinook Salmon fisheries were open in 1,709 miles of rivers and streams across Idaho. As access was lost (to dams) and wild returns declined, fishing only occurred where hatchery fish were returning, and from 1980 to 1996, only 35 miles or fewer miles of river was open to salmon fishing. Fishing opportunity increased steadily since 1996 as hatchery returns improved, and in 2022 spring and summer Chinook Salmon fisheries were open in 570 miles of river.

David Duvall

Okanagan Nation Alliance's Okanagan Basin Sockeye Salmon Reintroduction and Restoration Program (1995-2023)

Historically, the Okanagan Basin contributed substantially to Columbia Basin salmon production. Traditionally, salmon have been essential to Syilx People in the Okanagan Territory for subsistence, culture, and commerce. Due to anthropogenic factors (harvest, dams, river channelization, invasive species), Okanagan salmon stocks declined precipitously during the last century. McIntyre Dam construction in 1953 downstream of Skaha Lake blocked salmon migration to Skaha and Okanagan lakes. By the mid-1990s the Sockeye population was less than 3,000, and Syilx People of the Okanagan Nation feared potential loss of the stock. In response, the Okanagan Nation Alliance (ONA), partnering with Canadian Federal and Provincial governments, and mid-Columbia Public Utility Districts (PUDs) initiated efforts to increase sockeye production. Initial efforts with Douglas PUD included studies in the late 1990s, followed in 2001 by development of the FWMT decision-support model to assist managers in achieving fish-friendly water releases to minimize density-independent losses to Osoyoos (and later, Skaha) Sockeye. Partnerships with Grant and Chelan County PUDs implemented a 12-year Experimental Reintroduction of Sockeye into Skaha Lake beginning in 2004. The reintroduction comprised broodstock collection, gamete harvest, egg fertilization, and fry outplanting in nursery lakes. Since 2014, fry have been reared at the ONA owned kɬ cp̓əlk̓ stim̓ Hatchery, located on the Penticton Indian Reserve. In addition, ONA implemented habitat-improvements, including dam passage and spawning-bed construction. Early risk assessment and on-going monitoring is part of the adaptive management process ensuring reintroduction is not negatively affecting the aquatic ecosystem. Since program initiation, Skaha and Osoyoos lakes have supported self-sustaining Sockeye populations, with over 100,000 spawners in 4 of the last 10 years and comprise 70-90% of the total Columbia Sockeye run. Reintroduction efforts directly led to expansion into Okanagan Lake, with hatchery fry stocking and preliminary studies to address fish passage at Okanagan Dam, adult spawning locations, and survival.

Jeff Fryer

Lessons from the recovery of Columbia Basin Sockeye Salmon and implications for restoration into other subbasins

Over the past 30 years, Columbia Basin Sockeye Salmon have been an amazing success story. Despite losing over 95% of their historic lake habitat by 1943 and reaching a nadir of fewer than 9,000 Sockeye returning in 1996, the 2023 return at Bonneville Dam at over 663,000 was the greatest number returning since counting began with that dam's completion in 1938. This increase has been driven primarily by the Canadian-origin Okanagan run, although Wenatchee stock returns have also been strong. Okanagan Sockeye have benefited from an innovative flow/water management tool, restored Sockeye access to previously blocked Skaha and Okanagan lakes, habitat improvement, decreased harvest rates, and improved passage through the nine mainstem dams that the run must pass on their migration to and from the ocean.
The success of the Okanagan Sockeye run has contributed to an examination of the possibility of restoring Sockeye salmon to other former Sockeye lakes in the Columbia Basin. The Yakama Tribe has had some success in restoring Sockeye to Cle Elum Lake in the Yakima Basin while efforts to restore Sockeye to the Deschutes basin have been less successful. Efforts are also underway towards restoring Sockeye Salmon to Wallowa Lake in the Grande Ronde Basin as well as in the Canadian Columbia River above Grand Coulee.

This presentation will look specifically at some of the reasons for the recovery of Okanagan Sockeye as well as the possibility of applying lessons learned to Sockeye recovery efforts in other basins.

Jay Hesse

Heesu, the other anadromous fish: Restoring Snake Basin Pacific Lamprey

'Heesu' (also known as Pacific Lamprey or eels) are a culturally important species to the Nez Perce Tribe and an integral link in the Snake River ecosystem. Adult lamprey returning to the Snake Basin declined drastically with the construction of the mainstem Columbia River hydropower dams. This loss of lamprey in many of the Snake River tributaries prompted tribal elders to advocate for action which resulted in the Tribe's Pacific Lamprey Translocation Initiative. The Translocation Initiative is a collaborative effort between the Nez Perce Tribe and the Columbia River Inter-Tribal Fish Commission (CRITFC) and its member tribes. Translocation involves collecting adult lamprey that are stranded or not able to pass the fish ladders at three lower mainstem Columbia dams (Bonneville, The Dalles, and John Day) and transporting them upstream to the Nez Perce Homelands of the Snake River basin. Half of the transported lamprey are taken to the Nez Perce Tribal Hatchery and held for 10 months in holding tanks until the next spring when they're release into targeted streams. The other half are directly released into the Clearwater River to continue their volitional migration. Tissue samples are taken from each fish prior to release (and from larval fish electrofish sampled in the fall) and are analyzed by the CRITFC lab for genetic Parental Based Tagging (PBT) analysis. Recent studies (Hess, et al., 2022) find that this translocation effort boosted abundance of all life stages and has added to the understanding of the life history of this unique, and cool (very cool!) fish. Current trends indicate increased larval and juvenile populations in targeted translocation tributaries. While this effort appears successful in the short-term it is only a stop-gap measure against further declines until passage issues at the dams are identified and addressed.

Megan Hill

Lessons learned from a decade of salmon and steelhead reintroduction on the Deschutes

Chinook, sockeye and steelhead were extirpated from the upper Deschutes watershed with the construction of high-head hydroelectric dams in the 1960s. When relicensed by Portland General Electric (PGE) and the Confederated Tribes of the Warm Springs (CTWS) in 2005, one goal of the new FERC license was to reestablish sustainable and harvestable runs of salmon and steelhead to tributary habitats upstream of the dams. Out-planting of salmon and steelhead juveniles in tributaries was initiated in 2007, construction of juvenile fish passage facilities was completed in 2010, and the first returning adults were transported upstream in 2012. To-date, juvenile collection efficiencies and adult return rates are below license targets but improving through adaptive management actions. Studies conducted during the first 10 years of reintroduction indicated that power generation at the dam, hatchery operations, forebay guidance and fish passage facility operations are key factors influencing reintroduction success. Following principles of adaptive management, PGE and CTWS alongside Oregon Department of Fish and Wildlife and many other agency and NGO partners have made large-scale modifications to fish passage and reintroduction strategies. Within the last 5 years, we have initiated a smolt acclimation program, changed generation timing at the dam, installed a lead net on the juvenile collector, and begun releasing excess hatchery adults upstream of the dam to supplement smolt releases. While each program is unique, we will share lessons learned during our first decade of reintroduction that may be most applicable to other reintroduction programs.

Brian Knoth

Is trap and haul a viable, long-term management solution to passage issues at Big Bear Falls in the Potlatch River Basin, Idaho?

Trap and haul is an important management tool for providing salmonids access to historical habitats in the Pacific Northwest. The Idaho Department of Fish and Game (IDFG) will conduct a pilot study to assess the feasibility of using trap and haul techniques to provide wild steelhead Oncorhynchus mykiss access to additional spawning and rearing habitat upstream of Big Bear Falls in the Potlatch River basin. Big Bear Falls are a set of waterfalls that impede wild steelhead access to > 50 miles of additional spawning and rearing habitat in Big Bear Creek (BBC). Life cycle modeling exercises indicate enhanced passage at the falls could significantly improve steelhead smolt production in the watershed. From 2024-2026, IDFG will operate a temporary fish weir near the mouth of BBC to trap pre-spawn adult steelhead for upstream transport. Each adult will be radio-tagged prior to release upstream of the falls. We will use a combination of fixed telemetry sites and aerial surveys to document the movement patterns and spawning distribution of each adult. We will quantify the smolt production resulting from the transported adults by sampling steelhead smolts captured at a rotary screw trap at the mouth of BBC. We will collect tissue samples from each adult steelhead transported upstream as well as from each smolt captured at the screw trap in the subsequent years. Parentage-based tagging techniques will be used to assign the offspring collected at the trap to the parents transported upstream of the

falls. Therefore, we will be able to partition the production resulting from the transported adults from adults that spawned elsewhere in the watershed. Understanding the production potential of habitats upstream of Big Bear Falls will allow us to determine if trap and haul is a viable, long-term management solution to passage issues in BBC.

David Venditti

A case for sprawl: Encouraging salmon to move to the suburbs using targeted hatchery releases

Spawning habitat in the upper Salmon River and tributaries is likely not limiting anadromous salmonids. Chinook Salmon Oncorhynchus tshawytscha historically spawned almost to the headwaters as well as in major tributaries, particularly Alturas Lake Creek. Currently, spawning is limited to primarily the reach from Sawtooth Hatchery downstream to Redfish Lake Creek. Additionally, Sockeye Salmon O. nerka were historically found in five basin lakes. Currently, they are present in two. Hatchery programs are now operating to expand Chinook Salmon spawning into under-utilized, historically productive areas upstream of the hatchery and to rebuild Sockeye Salmon populations in the lakes where they remain. In 2019, we began releasing integrated Chinook Salmon smolts from Sawtooth Hatchery into the Salmon River near the mouth of Alturas Lake Creek with the intent that these fish, and their subsequent progeny, will home back this under-utilized habitat as adults. Conversely, the Sockeye Salmon program relies primarily on smolt and adult releases to seed the habitat. Adults may be from captive broodstocks or anadromous returns from Springfield Hatchery. The success of these releases into under-utilized habitats rely upon favorable environmental conditions to return sufficient adults to establish spawning aggregates. Additionally, previous research has shown that spawning salmon reduce fines in the substrate and may improve habitat condition for future generations. This implies that areas that have not been worked by salmon for long periods of time may yield lower initial productivity once fish are returned to the habitat. Both factors suggest long-term approaches will be required to see benefits from these activities. However, maximizing the use of potential spawning habitat has merit and should be considered when feasible.

Jason Vogel

Clearwater Basin anadromous fishes - Past, present, and future

Clearwater Basin in Idaho represents a significant portion of the Snake River basin and is home to spring/summer/fall chinook, coho, lamprey, and of course B-Run steelhead. This basin has a sordid history of habitat alterations, a dam that caused extirpations of some stocks, removal of dam in 1970s, re-introductions, habitat actions, and so on. The Nez Perce Tribe has been involved in the management and utilization of the fish resources since time immemorial, and has worked with Idaho many co-managers over the years working to improve/restore anadromous fishes in the basin. The Clearwater Basin today is integral to Tribal and non-tribal interests and requires co-management at all levels, to ensure that harvest opportunities, enhancement of natural spawning, responsible hatchery propagation, and habitat improvements continue into the future. These actions are working towards the restoration of populations to self sustaining healthy and harvestable levels for all seven generations into the future.

William Young

The case for effective hatchery management: Restoration of fall Chinook Salmon in the highly altered, secondary habitats of the Snake River

Historically, an estimated 500,000 fall Chinook salmon returned to the Snake River and supported significant harvest by area Tribes. Returns began to decline in the late 1800's due to over harvest in the lower Columbia River and other habitat alterations. The construction of Swan Falls Dam and later the Hells Canyon Complex blocked the major spawning habitats of the middle Snake River, leading to the functional extirpation of fall Chinook in the Snake River. Coordinated efforts of multiple Federal, State and Tribal agencies developed a hatchery program to prevent extirpation in the short-term and increase abundance and harvest opportunities in the long-term. Initially the program only released juveniles from Lyons Ferry Hatchery in the lower Snake River below Lower Granite Dam (LGR). The Nez Perce Tribe lead an effort to release juveniles above LGR at multiple release sites dispersed throughout the accessible habitats of the Snake and Clearwater rivers. The trends in both adult abundance and spawner distribution increased dramatically following the growth of the hatchery program beginning in the late 1990's. Adult abundance increased from an annual average of 1,000 adults prior to 1998 to greater than 30,000 adults presently. Natural-origin returns also increased significantly from an average of approximately 100 in the early 1990's to 6,000 today and currently make up greater than 20% of the total return. Although other restoration actions were implemented and contributed to the recovery, hatchery supplementation likely played a major role in the abundance increases and the significant expansion of spawner distribution throughout the basin. The positive

effects of supplementation on abundance and distribution of Snake River fall Chinook contribute to commercial, sport and Tribal fisheries, the maintenance of population viability and ongoing recovery goals.

Joe Zendt

Recolonization by steelhead and salmon in the White Salmon Subbasin following dam removal

Condit Dam on the lower White Salmon River in Washington state was breached in 2011 and completely removed in 2012, restoring passage for migratory fish for the first time in about 100 years. Following dam removal, various agencies have conducted efforts to document natural recolonization by anadromous salmonids: adult spawner abundance and distribution have been monitored via spawning ground surveys; juvenile abundance and distribution were monitored using smolt trapping, stream electrofishing, and Passive Integrated Transponder (PIT) tagging; and genetic analysis has helped characterize recolonization sources and other population traits. Steelhead and Coho Salmon spawners have been documented in all the major anadromous-accessible tributaries to the White Salmon River (all upstream of the former dam site). Chinook Salmon spawners (spring, tule fall, and upriver bright fall) have also been documented upstream of the former dam site in the mainstem White Salmon River, although heaviest spawner use since dam removal has been downstream of the dam site in river reaches with newly transported spawning gravels from the former reservoir. Juvenile steelhead and Coho Salmon rearing has been documented in most of the tributaries and outmigration estimates indicate successful within-subbasin production, with PIT-tagged fish from the White Salmon being detected at Bonneville Dam as smolts and returning adults. Population trends for adults and juveniles showed initial increases immediately following dam removal, but in subsequent years have likely been driven by out-of-subbasin factors. Preliminary genetic analysis of juvenile steelhead indicates primary influence from White Salmon populations and secondary contributions from Skamania and Hood River stocks. While additional monitoring funds and efforts are needed to answer questions that remain about the pace and extent of recolonization, it is clear that Salmon and steelhead are now using the restored passage and reproducing in habitat that is once again available in the White Salmon watershed.

Symposia:
Applying Research in Hatcheries

Organizers: Riley Brown rbrown@idahopower.com (208-859-6730); Eric Pankau pankauer@sd25.us; Thomas Lindenmuth Thomas.lindenmuth@idfg.idaho.gov

Fisheries research can play a vital role in the optimization and evaluation of fish culture programs, but there is often a disconnect between researchers and hatchery operators that can lead to stagnation and unachieved goals. This symposium will focus on the positive impact that research can have on hatchery programs and its importance in ensuring that artificial propagation is being utilized correctly in the manner of which it is needed. Speakers from both fisheries research and hatchery management will emphasize the collaboration needed to overcome obstacles and achieve programmatic goals, as well as provide case studies of research implementation into hatchery programs from around the Western United States.

Mark Elliston

Spontaneous autopolyploidy testing protocol for three-month-old Kootenai River White Sturgeon

Kootenai River White Sturgeon (KRWS) Acipenser transmontanus, are typically tested for Spontaneous Auto-polyploidy (SA) at 10 months at average length and weights of approximately 210 mm and 60 grams. The Kootenai Tribe of Idaho uses a Z2 Coulter Particle Count and size Analyzer with standard blood draw and 1 to 1 ratio consistent to normal practices and protocols developed in collaboration with University of California-Davis. With a 100-micron aperture tube upper threshold at 9 microns and lower threshold at 3 microns, with channelizers set to observe sizes between 3.695 microns and 6.664 microns. The purpose of this study was to determine the smallest juveniles that could be safely tested for SA using modified standards and procedures. The test group we used was an equal representation of each of the 4 groups discussed in the previous presentation by Mr. Michaels. 30 fish from each group; Treated McD Jars, Untreated McD Jars, Treated sub straight and Untreated Sub straight. Average length and weights of 121mm and 8 grams some as small as 82mm and 2.6 grams were observed. This presentation will overview protocols, rationale for protocol modifications used, and the resulting juvenile survival and whether accurate SA results were obtained. The modified protocols may allow pre-release screening before releasing KRWS at earlier developmental life stages; and allow for year-class evaluation earlier in the hatchery rearing cycle.

Rod Engle

An evaluation of rearing strategies for steelhead production at Hagerman National Fish Hatchery, Idaho - Can a Partial Recirculating Aquaculture System (PRAS) address the challenges of a large-scale steelhead mitigation program?

Faced with declining water availability the Hagerman National Fish Hatchery (NFH), a Lower Snake River Compensation Plan juvenile steelhead rearing facility, constructed a small-scale partial reuse aquaculture system (PRAS) to evaluate whether steelhead (anadromous Oncorhynchus mykiss) could supplement or replace production with more water-intensive traditional flow-through raceways. The Hagerman NFH PRAS uses circular tanks combined with a recirculating aquaculture system. In addition to water savings, putative benefits of PRAS systems compared to raceways may include higher smolt-to-adult return (SAR). To test this, six brood years of juvenile steelhead were reared in PRAS tanks and paired control raceways and subsequently released during migration years 2015-2020. Smolt outmigration survival and subsequent adult returns were compared. Apparent survival of PRAS juvenile steelhead from release to Lower Granite Dam on the Snake River – a migration distance of 747 km – was significantly lower than raceways for 5/6 years. Raceways outperformed PRAS adult recoveries by 1.5-8.9-fold difference. Causal factors for the large survival differences are not readily identifiable based on data collected from a host of physiological and water quality parameters, but a recent analysis has shown apparent survival of larger smolts (>200 mm) to Lower Granite Dam was reduced for the PRAS production when compared to raceway production. Consequently, the expected benefits of greater smolt survival and adult returns by steelhead reared in PRAS have not been observed at Hagerman NFH. Scaling up the PRAS tool to achieve all of the Hagerman NFH steelhead mitigation needs would gain moderate water savings (20-40% lower than raceways) and is also a function of smolt survival.

Eric Fetherman

Balancing feed costs and growth, health, and angler preference for catchable Rainbow Trout reared on the standard feeds from four commercial feed manufacturers

The purchase of commercial feeds for large-scale hatchery production often dominates the operating budget for many state-run hatchery facilities. Costs for diet formulations vary widely depending on ingredients. The use of alternative protein sources, as well as variety in other ingredients such as lipids/fats, micronutrients, and fillers, reduce cost, but may also reduce feed intake and increase feed conversion ratios. Therefore, lower cost feeds may not produce the best growth or healthiest fish, and fish reared on these feeds may be less desirable to the anglers for whom the fish are produced. We conducted two experiments at the Colorado Parks and Wildlife Bellvue Fish Research Hatchery to examine the growth, health, and angler preference for Rainbow Trout Oncorhynchus mykiss reared on the standard feeds from four commercial feed manufacturers. In the first experiment, the manufacturer's recommendations for feeding rates (% body weight/day) were followed. In the second experiment, feeding rates were standardized across the four feeds. Rainbow Trout reached catchable size sooner on the most expensive feed, taking several weeks longer to attain catchable size on the least expensive feed used by the State of Colorado at the time. More expensive feeds had higher feed intakes and lower feed conversions than less expensive feeds. Additionally, hepatosomatic and viscerosomatic indices, and fin quality, were higher with more expensive feeds. Anglers were more satisfied overall with both the appearance and taste of Rainbow Trout reared on the most expensive feed. However, the cost-per-fish was > 1.5 times higher on the more expensive feeds relative to the least expensive feed, but a small increase to a moderately-priced feed produced similar results to the highest cost feeds. This information has resulted in the State of Colorado changing its lowest-bidder feed purchasing requirements, and allowing multiple feed companies to be used for different production scenarios.

Sarah Hoffmann

Aquatic Gas Optimization: A novel oxygenation solution for fish hatcheries

Dissolved oxygen supply is one of the most critical water quality parameters in a fish culture setting, with known effects on health, growth, and survival. Hypoxia is associated with a range of deleterious effects ranging from impaired growth and performance in mild conditions, to asphyxiation and mortality under severe oxygen limitation. Throughout the literature, hyperoxia is also commonly associated with a range of negative effects on fish, most commonly the onset of gas bubble disease (GBD) resulting from formation of bubbles that may coalesce and cause tissue damage. Problematically, the root cause of GBD is the supersaturation of total dissolved gasses in a system, rather than hyperoxia alone. Traditional oxygenation technologies rely on the diffusion of gaseous oxygen in a system of water that may already be saturated with gasses, potentially increasing total gas pressure (TGP) and leading to the long standing association between hyperoxia and GBD. Alternatively, a novel methodology of oxygen infusion simultaneously removes dissolved gasses present in a body of water while replacing them with dissolved oxygen at a one-to-one rate. Consequently, infusion can achieve levels of hyperoxia up to 400% (freshwater) or 450% (saltwater) without significantly affecting TGP. Here we present data from a series of lab trials and field applications across several fish species, life stages, stocking densities, and production systems that document the effects of normbaric hyperoxia. Overall, we found that infused oxygen not only resulted in improved metrics of health, growth, and survival, but also reduced operational expenditures given the stability of dissolved oxygen throughout various systems. This method of oxygen infusion has profound consequences for fish culture practices, with specific emphasis on systems that face significant dissolved gas challenges.

Tien-Chieh Hung

Case studies of implementing research outcome into the operation of a conservation hatchery

The Fish Conservation and Culture Laboratory (FCCL) at the University of California, Davis was established in 1996 with the primary objective of serving as a conservation hatchery. The three main objectives of the FCCL are to maintain a genetically managed population of the fish in the lab, to produce fish for research projects and for supplementation of wild populations, and to conduct research. One of the primary research focuses at the FCCL is to enhance fish culture methods. In this presentation, we will review two recent studies conducted by the researchers at the FCCL and in collaboration with others. The first case discusses the negative outcome of implementing a new weaning strategy for endangered Delta Smelt in an established hatchery operation and emphasizes the importance of communication. The second case highlights

how research findings could aid in the development of the culture program for threatened Longfin Smelt. Through examining these cases, this presentation will explore potential research projects that could benefit established hatcheries and underscore the significance of properly implementing and managing research findings to ensure the long-term success of fish culture.

Ben Kennedy

The influence of fall body length and rearing conditions on smolt migration survival in relation to Columbia River migration conditions for spring Chinook Salmon reared at Leavenworth National Fish Hatchery from 2010-2020

Leavenworth National Fish Hatchery (LNFH) on the east side of the central Washington Cascades needs to reduce water usage and phosphorous discharge. Partial recirculating aquaculture systems (PRAS) were chosen as a method to achieve these goals over other alternatives including construction of a new hatchery facility elsewhere, ground water development, and chemical treatment systems. However, its use in rearing spring Chinook Salmon (Oncorhynchus tshwytscha) is very limited and spring Chinook Salmon are widely known as difficult to rear. This means studies are needed to address whether water conservation and discharge goals can be met while still producing a smolt of comparable performance to current conventional raceways. As part of a larger study, this presentation will focus on the use of fall fork length as a surrogate metric to understand how conventional raceway management has influenced overall program performance. Fall fork length was chosen because it is the most common individual characteristic measured at most hatcheries concurrent with tagging of fish with Passive Integrated Transponder (PIT) tags. This dataset consists of 188,589 spring Chinook Salmon that were PIT tagged and measured for fork length in October of each year from 2010 to 2020. These fish were released from LNFH each spring as 1-year-olds. Yearly Columbia River migration conditions including flow and water temperature will be used as covariates to account for year-to-year variation. Flow will be further divided into water transit time that is defined as the time it takes the average particle of water to passthrough a reservoir and powerhouse encounter rate that estimates the proportion of fish passing via the powerhouse at a given dam. These data will be analyzed each year using the Cormack-Jolly-Seber model in Program MARK. In future years these results will be used to guide comparisons between PRAS and conventional raceway rearing.

Will Lubenau

Collaboration of research and hatchery production staff to benefit management of hatchery trout fisheries

Integrating fisheries research and hatchery production operations within a state or provincial agency can produce new or improved tools in aquaculture that may benefit fisheries management. Furthermore, research in aquaculture can improve the cost-to-benefit ratio of hatchery operations. As such, the Idaho Department of Fish and Game has conducted a multitude of studies over nearly 70 years to evaluate hatchery rearing techniques, release strategies, and post-release performance. Several studies, including those pertaining to triploid Rainbow Trout development and post-release performance, techniques for evaluating return-to-creel (e.g., IDFG Tag! You're It! program), and development and application of YY Brook Trout, have produced results that led to major changes in IDFG hatchery operations and fisheries management practices. A hatchery research program cannot succeed without full cooperation and collaboration between research, management, and hatchery production staff. Research in aquaculture contributes to improving the efficient use of limited resources while increasing stakeholder satisfaction.

Michael Malick

Fecundity trends of Chinook Salmon in the Pacific Northwest

Fecundity is an important demographic parameter that contributes to the productivity of anadromous fish stock dynamics. Yet, studies on fecundity patterns in Pacific salmon (Oncorhynchus spp.) often only include a few years of data, limiting our ability to understand spatio-temporal trends. Here, we used data on 43 hatchery Chinook salmon (O. tshawytscha) populations in Washington State to evaluate whether average fecundity changed over the past three decades. We then used data from a subset of stocks (18) to evaluate the relationship between fecundity and body length. Our results revealed significant changes in fecundity across the 25-year study period with most stocks showing declines in fecundity over the past decade. Results further showed that Chinook salmon have decreased in length over this same period and that annual variation in mean length explains a majority (62%) of annual variation in mean fecundity. Specifically, we estimated that a 1 mm reduction in length results in 7.8 fewer eggs (95% CI = 6.6–8.9). Given that the majority of Pacific Northwest Chinook salmon in the environment and harvested in fisheries originate from hatchery releases and

that nearby hatchery and wild populations generally have similar ocean distributions, these results likely reflect patterns for many populations not included. Combined, our results highlight the need to consider changes in body size and egg production when assessing the dynamics of anadromous fish populations and designing management or conservation plans, particularly for depressed populations.

Brian Michaels

Investigating Kootenia River White Sturgeon natural substrate during egg incubation

In 1988 the Kootenai Tribe of Idaho (KTOI) recognized the lack of Kootenai River White Sturgeon Acipenser transmontanus and started an experimental aquaculture facility to reverse population decline. The Kootenai River Native Fish Conservation Aquaculture Program (KRNFCAP) began rearing fish in 1990. The Kootenai River White Sturgeon were listed as endangered in 1994. Using standard procedures (e.g. hormone injection, egg de-adheasion, and McDonald jar for incubation), the KRNFCAP has been successful in raising juvenile White Sturgeon. Although standard practices have been successful, recent studies suggest there may be potential negative effects of hatchery practices (e.g. poor growth, survival, and spontaneous autopolyploidy). During 2019-2022, KTOI has been experimenting with natural incubation techniques using natural river rock substrate. During 2020, KTOI amended protocols for fungal control to improve incubation, hatch, and early larval survival. Fertilized eggs were not de-adheased and broadcast directly onto rock substrate beds. Four tanks were set up with substrate and four tanks were set up with McDonald Jars. Two substrate tanks and two McDonald-Jars received hydrogen peroxide (1,000 mg/L) for fungal control. This presentation will highlight survival results from four years of experiments comparing McDonald-Jar vs. natural substrate incubation; fungal control vs. no treatment and effects of varying hydrogen peroxide concentrations for the various incubation methods.

Luke Oliver

Triploid Burbot *Lota lota* production: Optimization of thermal and hydrostatic parameters, tetraploid induction, and confirmation of triploid sterility

Experiments were conducted to optimize triploid induction parameters, and assess triploid sterility, in burbot. Hydrostatic shock experiments investigated duration of shock using 7,500 or 8,500psi at 180°C minutes post-fertilization. Thermal shocks investigated duration of shock and post-fertilization shock timing using a shock of 16°C. Sterility experiments determined survival of eggs when diploid males were crossed with triploid females and when diploid females were crossed with triploid males. A hydrostatic shock of 7,500psi for 10 or 20°C minutes can induce triploidy ≥ 90%, and exhibits survival that it statistically similar, $p = \leq 0.05$, to controls. A hydrostatic shock of 8,500psi for 5 or 10°C minutes yielded triploid induction of 93 and 100%, respectively, with survival that is statistically similar to controls, $p = \leq 0.05$. Thermal induction experiments indicated that shocks at 120°C minutes post-fertilization, for durations between 350 and 450°C minutes has potential to induce triploidy ≥ 90% while facilitating survival statistically similar to controls, $p = \leq 0.05$. Induction of tetraploidy was observed in hydrostatic and thermal experiments. Sterility experiments determined that triploid burbot are functionally sterile. Results of this study may allow production of burbot in locations where sterility is required.

Mark Roes

Hatchery propagation did not reduce natural steelhead productivity relative to habitat conditions and predation in a mid-Columbia River subbasin

For over 150 years, hatchery-origin anadromous salmon and trout have been reared and released throughout the Pacific Northwest to mitigate for lost habitat and sustain harvest opportunity. Some studies demonstrate that introgression of hatchery and naturally produced fish may constrain conservation efforts through maladaptive genetic processes including domestication selection and introgression. However, empirical demonstrations of the influence of these genetic interactions on population productivity are lacking, making it difficult to assess their importance relative to other drivers of productivity. We estimated the effect of the proportion of hatchery-origin spawners (pHOS), proportionate natural influence (PNI), and hatchery fish releases on natural adult winter steelhead recruitment in the Hood River, Oregon, over a 27-year period of record, thereby testing for hatchery effects associated with domestication, competition, and survival. Adult winter steelhead productivity was not associated with pHOS and PNI. However, natural winter steelhead productivity was positively associated with ocean conditions, stream flow, and hatchery fish release numbers, while negatively

associated with pinniped abundance. Our analysis highlights the importance of quantifying the influence of hatchery programs on fish production relative to environmental factors known to affect natural-origin anadromous fish recruitment. Recently, the Hood River winter steelhead hatchery supplementation program concluded with a final smolt release in 2021, providing a unique opportunity to continue monitoring for population responses using novel approaches including genetic sibship analyses.

George Schisler

Research in aquaculture: Strategic innovation

Challenges facing aquaculture and the goals of aquaculture facilities have changed over the years, and new techniques and approaches are critical to ensure the viability and efficiency of aquaculture over time. Aquaculture research is simultaneously driven by explicit needs identified by hatchery staff, and innovative ideas and methods developed outside the typical hatchery setting. Using the process of research in aquaculture, we can identify and test new ideas to ensure the greatest benefits are realized. Communication between hatchery managers and researchers, and integration of aquaculture operations with research activities, is needed to promote this cross-discipline coordination and achieve production goals. Examples of research in aquaculture that benefit both production and post-stocking performance of hatchery reared fish include feed formulation evaluations, rearing techniques for rare and unique species, and testing of species and strains for disease resistance and susceptibility. More recently, revolutionary techniques such as the creation of YY broodstock have been developed and implemented on a broader scale. All of these efforts require intentional collaboration by motivated and dedicated aquaculture and research personnel to become realities.

Jesse Trushenski

Bridging the gap between public and private aquaculture, collaborative research opportunities, and why we're better together

Aquaculture takes its name in the manner of agriculture, replacing "ager" (Latin for "field") with "aqua" ("water") and combining it with "cultura" ("growing", "cultivation") to describe a multitude of way by which we rear aquatic organisms. Like agriculture, aquaculture is immensely diverse in both practice and in purpose. Aquaculture began in the USA more than 150 years ago as both a commercial enterprise and a conservation activity. The first fish culturists raised fish as a for-profit business, but with the intention of replenishing fisheries that had been depleted by overharvest. The pioneers of American aquaculture didn't see food-fish production and fisheries enhancement as distinct disciplines—aquaculture could support conservation goals and the public good as well as provide economic opportunity to those who would seek it.

Today, there is something of a divide between public and private aquaculture. Hatcheries rearing fish for stock enhancement, imperiled species restoration, and other conservation goals are widely considered to represent a different type of aquaculture than that practiced by farms raising fish for the dinner table. In some ways, this is true: species, rearing systems, production goals, and operational norms can vary considerably between public hatcheries and private farms. However, commercial and conservation aquaculture have much more in common than they do not—increasingly intensive production methods, rising feed and energy costs, changing climate and water resources, aging infrastructure, staff recruitment and retention challenges, etc.–and could benefit greater communication and collaboration across the divide.

This presentation will highlight recent examples of collaborative research bridging the gap between public and private aquaculture and suggest future opportunities for public/private partnership in the aquaculture space.

Jesse Trushenski

Smoltification strategies: understanding a unique feature of salmonid biology and how to manage the process in aquaculture

Any aquatic organism transitioning between life in freshwater to saltwater must address divergent osmoregulatory challenges in these environments to maintain or quickly reinstate homeostasis. Freshwater is ion-poor, and fish living in freshwater systems expend considerable energy to acquire and retain needed sodium, chloride, and other electrolytes while combatting the continuous influx of water. Fish living marine systems face opposing osmotic challenges and must exert equal or greater effort to maintain sufficient body water and eliminate excess ions. Survival following the transition from freshwater to saltwater necessitates a reversal in the functioning of osmoregulatory organs/tissues, such as the gills, gut, and kidney. Among salmonids, these physiological changes are accompanied by morphological and behavioral changes that collectively define a transformation known as "smoltification". This presentation will review smoltification as unique feature of salmonid biology—what happens, when, and how—describe the various strategies that are used to manage parr-smolt transformation in production aquaculture, and suggest ways in which such strategies might have

value for enhancement hatcheries rearing anadromous salmonids.

Melissa Wagner

Starting at the source: How the College of Southern Idaho views teaching students to conduct research as an essential requirement of the aquaculture program curriculum

The College of Southern Idaho has been teaching students how to culture fish since 1977. The main reason for creating the aquaculture program was to prepare students to meet demands of the industry, which included developing a unique broodstock, branding fish using liquid nitrogen, inventing the demand feeder, and successfully breeding captive white sturgeon. Truthfully, the College of Southern Idaho has always paired answering the big questions with training the future workforce of aquaculture. The program proudly recognizes alumni in both fisheries research and hatchery operations, and the next programmatic phase aims to continue that model. With development of a new fisheries transfer degree and a need for connection between research and fish culture, the College of Southern Idaho looks to play a role in bridging the gap in fisheries management strategies before students even graduate. Future students in the Aquaculture Program will continue to learn the best practices of fish husbandry; but, moving forward, they will now design and conduct research on their own. Moving to a new location also means more opportunities to strengthen partnerships that the college values by providing space in which industry partners could potentially run projects parallel with students. Fisheries research and aquaculture are linked, and the College of Southern Idaho Aquaculture Program hopes to be a starting point in the collaborative effort between the facets of fisheries management.

Symposia:
Western Native Fishes Symposium

Organizers:Timothy D'Amico, Idaho Fish and Game, Nampa, ID, 208-854-8987, timothy.damico@idfg.idaho.gov; Luke Schultz, Wyoming Game and Fish, Pinedale, WY, luke.schultz@wyo.gov

Native fishes research and management often faces boundaries, both anthropogenic and natural. Our goal for the eighth-annual native fishes symposium hosted by the Western Native Fishes Committee is to provide an opportunity for those interested in native fishes to cross boundaries and meet at the intersection of native fishes. We encourage presentations that cross boundaries, both anthropogenic (e.g. multiple jurisdictions, cross-border collaborations) and natural (e.g. confluences, riparian-aquatic interfaces). In keeping with the mission of the Western Native Fishes Committee to provide a network for people with an interest and/or expertise in native fishes, this symposium will allow presenters to offer insights into diverse management approaches, concepts and constraints to native fish conservation across regions of North America.

*Sarah Barnes**

Exploring impacts of lake level decline on a critical native forage species in a large terminal desert lake

In endorheic saline lakes in arid regions increasing drought conditions, water diversions for agriculture, and development cause significant lake level decline, potentially resulting in fish littoral habitat loss. Pyramid Lake, a large, deep, endorheic lake on the Pyramid Lake Paiute Tribe reservation in Nevada, it is home to Lahontan Cutthroat Trout, Oncorhynchus clarkii henshawi, a unique sub-species of cutthroat trout listed as Threatened under the Endangered Species Act. In Pyramid Lake O. c. henshawi still relies heavily on their primary historical forage species, the Tui Chub, Siphateles bicolor. Tui Chub are a prolific, large-bodied, native minnow, whose abundance, according to long term gill net surveys, may be in decline. Here, we evaluated potential impacts of littoral habitat loss on S. bicolor spawning success. We combined S. bicolor abundance and habitat data, collected monthly at 9 sites from May to August, to investigate S. bicolor use of littoral habitat during spawning. We sampled spawning fish with gill nets set from 5-30 m of depth. We assessed substrate and vegetation from 5-30 m of depth using hydroacoustic transects conducted at every 500 m of shoreline, which were verified by SCUBA survey. Spawning adult catch-per-unit-effort (CPUE) was significantly higher at depths <10 m ($p < .001$) supporting our hypothesis that littoral habitat is important for S. bicolor spawning success. Spawning Tui Chub catch decreased with increasing silt percent, the most abundant littoral substrate type, indicating Tui Chub spawning may be limited by non-silt littoral habitat. Results from our elevation-explicit model of Pyramid Lake at full pool suggest continued lake level decline decreases inundated non-silt habitat which may further limit Tui Chub recruitment. Mitigation strategies could include securing more water for Pyramid Lake and altering O. c. henshawi stocking regimes to not exceed S. bicolor carrying capacity.

Aaron Black

History of Burbot monitoring in the Kootenai River - The power of PBT

Burbot were historically abundant in the Kootenai River basin, are culturally significant to the Kootenai Tribe of Idaho, and once supported both recreational and commercial fisheries. Burbot were functionally extirpated in the Kootenai Basin in the early 2000s with only 50 individuals estimated to remain in the system. Natural production of Burbot was limited by changes in the hydrological, thermal, and nutrient regimes caused by agricultural diking and the construction and operation of Libby Dam. Starting in 2009, a conservation aquaculture program was initiated by the Kootenai Tribe of Idaho to rebuild the Burbot population. Hatchery-produced Burbot were initially monitored with passive integrated transponder (PIT) tags to track movement, survival, and growth. The use of PIT tags is labor intensive and costly, resulting in less than 10% of hatchery fish being tagged at release. Parentage-based tagging (PBT) was implemented in conjunction with PIT tags beginning in 2011; by 2018 hatchery stocking events were evaluated exclusively with PBT. The use of PBT has allowed co-managers to evaluate experimental releases of Burbot stocked as eggs and larvae at various release

locations to better understand recruitment bottlenecks in the system. Life stages ranging from fertilized eggs to juveniles to have been stocked in the Kootenai River and its tributaries, off-channel habitats, and Kootenay Lake, British Columbia. Parentage-based tagging has allowed co-managers to estimate survival and growth parameters of these groups. Collectively, these findings have increased our understanding of recruitment limitation for Burbot in the Kootenai basin, and they are guiding discussion about future stocking and habitat restoration needs and efforts.

Zhongqi Chen

Plasticity and genetic basis of thermal tolerance and performance traits in Redband Trout

Redband trout Oncorhynchus mykiss gairdneri is native to the desert and montane climates of the Pacific Northwest and has been used as a model system to study thermal adaptation. In this study, we collected redband trout from contrasting climates in Idaho (desert, cool montane and cold montane) and reared them under 15°C, 18°C and 21°C in a common garden setting to partition genetic and plastic contributions to physiological traits involved in thermal adaptation including critical thermal maximum, maximum growth rate, critical swimming speed and cardiac performance. To explore the genetic architecture of thermal adaptation, we used a functional genomics approach by screening genomic markers associated with these physiological traits. Millions of SNP markers were generated using low coverage whole-genome sequencing for genome-wide association analysis. Results indicate phenotypic plasticity was substantial in most thermal performance traits, but several candidate genes/loci were also significantly associated with specific traits. Results from this study complement our previous study on the same populations that used a landscape genomic approach. Combining landscape genomics and functional genomics increases power to elucidate genetic mechanisms of adaptive phenotypic variation in redband trout. Findings from this study illustrated that a combination of genetic and environmental (GxE) factors influence thermal performance in this species. While more progress is still to be made towards a thorough understanding of thermal adaptation, results from this study provide a valuable resource in the conservation of O. mykiss populations that are vulnerable under future climate change.

*Joshua Heishman**

Age-structured survival rates of Burbot in the Kootenai River's hatchery-augmented fishery

Following system-wide population collapse of Burbot (Lota lota) within the Kootenai river, a supplementary hatchery program was launched to reintroduce the species within the mainstem of the drainage. State and provincial managers have documented rebound in Burbot abundance in the river; managers in Idaho subsequently reopened the state's recreational Burbot fishery alongside the ongoing supplemental hatchery program. The success of these rehabilitation efforts and fishery are jointly dependent upon accurate assessment of growth and survival of Burbot in the system. This study investigated demographic vital rates to facilitate the balance of species reintroduction and harvest opportunities. Using long-term monitoring records, we used Markov-chain Monte Carlo methods to estimate survival and encounter probabilities through an age-structured Cormack-Jolly-Seber model. We further incorporated abundance estimates to assess the influence of density-dependence upon survival-at-age. These estimates will be used to parameterize a population model to identify combinations of stocking and exploitation that are conducive to balancing the goals represented in this internationally-managed fishery.

Eric Larson

Conservation challenges for endemic crayfishes of western North America

Crayfishes of western North America have experienced substantial range and population declines as a consequence of displacement by invasive species and land use change. These interacting stressors have resulted in the extinction or Endangered Species Act-listing of 40% (2 of 5) described crayfish species in the genus Pacifastacus. Several under-studied crayfishes of western North America may be following similar trajectories to rarity or extinction. I identify conservation challenges and needs for these under-studied Pacifastacus crayfishes. First, the Pilose Crayfish (Pacifastacus gambelii) and Snake River Pilose Crayfish (Pacifastacus connectens) have experienced recent range declines due to displacement by non-native crayfishes. Conservation of these species will depend in part on their rapid, accurate identification by field biologists. I briefly review the latest knowledge on distributions, phylogenetic relationships, and morphology-based identification for the two pilose crayfish species. Second, past molecular work on the Signal Crayfish (Pacifastacus leniusculus) has identified several highly distinct phylogenetic lineages that merit elevation to species

status. These species descriptions are underway, and will likely be published in late 2023 or 2024. I report evidence for species status for two lineages of P. leniusculus, one distributed in central Oregon and the second distributed in interior Washington State and British Columbia. These newly described Pacifastacus species face conservation challenges consistent with the broader genus, including range declines due to displacement by invasive Rusty Crayfish (Faxonius rusticus) in Oregon and Virile Crayfish (Faxonius virilis) in Washington State. I conclude with management and conservation needs for Pacifastacus crayfishes in western North America, emphasizing prevention of new non-native crayfish invasions and intervention against secondary spread of already established invasive crayfishes.

*Paul Lee**

Assessing the genetic variation of Lahontan Cutthroat Trout in the Walker River Tributaries

The Lahontan Cutthroat Trout (LCT; Oncorhynchus clarkii henshawi) has been extirpated from 99% of the historic Walker Basin watershed. Walker River fluvial LCT populations face many challenges such as the construction of dams, genetic drift, and desiccation. In the 1990s, the Walker basin stream populations were refounded with LCT from By-Day Creek, a tributary of the East Walker River, but potential bottleneck effects and genetic drift remain an ongoing concern. To assess population health, samples were taken in 2020 from 6 different tributaries of Walker River (Slinkard, Wolf, Mill, By-Day, Silver, and Murphy Creeks) and sequenced using restriction-site-associated DNA sequencing (RADseq). The resulting Single Nucleotide Polymorphism (SNP) data will be used to assess genetic diversity, which is correlated to the fitness and adaptability of LCT. In order to gauge the genetic diversity within each creek, heterozygosity will be determined and genetic differentiation, quantified as FST, will be used to assess the relatedness of the populations between each creek within Walker Basin. The information gathered from this study will provide insight into whether these populations can be used for future translocations or genetic rescue endeavors.

*Alana Luzzio**

Harnessing genomic techniques to inform conservation management of the Lahontan Cutthroat Trout *Oncorhynchus clarkii henshawi*

Lahontan Cutthroat Trout (LCT), Oncorhynchus clarkii henshawi, have been extirpated from 90% of their historic waters due to habitat fragmentation, non-native trout species, climate change, drought and desiccation of lakes and streams prompting the species to be listed under the Endangered Species Act. An ongoing challenge to recovery efforts is the presence of non-native trout, as LCT populations that co-occur with non-native salmonids are decreasing in range and abundance due to loss of habitat, competition, and hybridization. Hybridization is of particular concern as non-native trout easily hybridize with LCT contributing to not only the loss of the two forms of LCT, fluvial and lacustrine, but hybridization can ultimately result in the extinction of the original source population. The ongoing presence of non-native trout suggests the long-term need for real-time high throughput monitoring to assess hybridization in LCT populations in order to create and execute effective management plans. We developed genotyping panels of identified SNPs to: 1) assess hybridization among LCT and Rainbow Trout and Yellowstone Cutthroat Trout and 2) assess genetic diversity of LCT populations to their respective bodies of water, range wide. Individuals will be collected and held for non-invasive sample collection for the duration of the assay run to determine which individuals are hybrids and simultaneously allowing genetic diversity assessment of LCT. Since non-natives are here to stay, creating a high-throughput assay, with a fast turnaround (<1 week) will allow for fast and succinct management decisions, resulting in better management outcome for the entire LCT population.

Aspen Nelson

Upper Columbia River Redband Trout in the midst of climate change

Columbia River Redband Trout Oncorhynchus mykiss gairdnerii are a subspecies of Rainbow Trout residing east of the Cascade Mountains in the Pacific Northwest. In 1942, the construction of Grand Coulee Dam at rkm 960 on the Columbia River created Lake Roosevelt and blocked the anadromous form (Steelhead) from returning to their natal tributaries. However, the potamodromous (fluvial, adfluvial, lacustrine adfluvial) forms continue to the present day. The Sanpoil River, located on the Confederated Tribes of Colville Reservation, supports the largest remaining Redband Trout population in Lake Roosevelt. In 2012, researches discovered that the genetic integrity of the native Redband Trout was still intact despite years of hatchery stocking events. Managers began to implement stock assignment projects to better understand genetic variability, recruitment, escapement, over winter survival, harvest trends and entrainment levels. The past ten years of data collection has enabled managers to implement conservation actions such as harvest regulation changes and mandatory hatchery fish marking. This long-term dataset has been used to monitor changes in abundance

due to wild fires and warming stream temperatures due to climate change. Critical habitats have been identified and habitat restoration and protection actions taken to support juvenile fish survival. Passive integrated tags (PIT) studies indicate Redband Trout entrain past Grand Coulee Dam with some migrating to the Pacific Ocean. Other fish appear to utilize mid-Columbia River reservoirs then attempt to migrate back to the Sanpoil River but become trapped below Chief Joseph Dam (rkm 877), which does not have a fish ladder. These data suggest the Redband Trout in Lake Roosevelt express multiple life history strategies, including anadromy, despite adults that entrain and cannot return to their tributaries. The complexity and resiliency of the upper Columbia River Redband Trout is remarkable, but will continue to require monitoring and protection to ensure their long-term persistence.

Nathan Tillotson

Effects of catch-and-release ice fishing on trout mortality in a highly pressured fishery

Understanding all aspects of fishing mortality is imperative for proper management of highly pressured fisheries. Few studies have investigated post-release ice fishing mortality, and fewer still have used salmonids as study species. Henrys Lake is a highly pressured, renowned trophy fishery for Yellowstone Cutthroat Trout (Oncorhynchus clarkii bouvieri; YCT), hybrid trout (Oncorhynchus mykiss x Oncorhynchus clarkii bouvieri; HYB) and Brook trout (Salvelinus fontinalis; BKT). Following a regulation change in 2021 that substantially increased catch-and-release ice fishing opportunities, some anglers expressed concern that the new regulations would lead to elevated post-release mortality rates. During the ice fishing seasons of 2021 and 2022, we caught trout using standardized terminal tackle (1/8-oz jig-head with cut bait) frequently used by ice anglers on the lake. Upon capture, we recorded hooking placement, presence of active bleeding, and fishing method (jigging/dead stick). We implanted captured trout with floy tags and held them for three weeks in a trap to monitor survival. We compared this experimental group (n=160) to a control group (n=150), which we collected by letting fish swim into our fish trap naturally. Similar to the experimental group, we floy tagged and held the control fish for three weeks. Of the 160 trout caught, there were 120 YCT, 21 HYB, and 19 BKT. The majority of fish were captured actively jigging (82%), as compared to using a passive dead stick (18%). When bleeding was noted upon hook removal (16%), no fish perished, and most were hooked in the mouth or lip area (95%). Of the trout hooked in the gill/gut area (2.5%), all experienced bleeding, but all survived. There was no significant difference in mortality rates between the experimental (0.63% mortality) and control groups (0% mortality; $p>0.05$). We found no evidence that catch-and-release ice fishing affects trout mortality at a population level in Henrys Lake.

Contributed Talks

Alexa Ballinger

Visualizing the core of Idaho Fish & Game's anadromous snorkel program

Abundance and spatial structure are key metrics for understanding the viability of Snake River steelhead Oncorhynchus mykiss. The Idaho Department of Fish and Game (IDFG) uses snorkel surveys to monitor the occupancy, density, and spatial distribution of Snake River Steelhead parr within and among populations. The agency's General Parr Monitoring program was established in 1985 to monitor long-term trends in parr density at "core" survey locations in Idaho's Snake River Basin (n=216). Here we summarize mean parr densities at survey locations over time and across the landscape. In 2022, mean steelhead parr density was 3.5 fish/100 m2 (SD = 4.0) in the Clearwater River Basin and 1.9 fish/100 m2 (SD = 3.9) in the Salmon River Basin. Densities have steadily declined over the last 36 years in the Clearwater River basin, and despite transient peaks in density, the five-year mean for 2016-2022 (2.3 fish/100m2; SE = 0.4) is roughly 50% of the 1985-1990 mean (4.8 fish/100m2; SE = 1.0). Mean parr density in the Upper Selway River subbasin (2.3 fish/100m2; SE = 0.3) has generally fallen below the overall basin average, while Lochsa River subbasin density (5.9 fish/100m2; SE = 0.6) has generally been higher than the basin average. Within the Lochsa subbasin, parr density in Crooked Fork Creek (2.4 fish/100m2; SE = 0.5) is generally lower than the subbasin average, while Fish Creek densities (12.3 fish/100m2; SE = 1.1) are generally higher than the subbasin average. Understanding the spatial and temporal variation within independent Snake River steelhead populations is necessary for managing localized spawning and rearing habitat for this declining species. Continuing to conduct snorkel surveys at core locations whilst developing a better understanding of steelhead life history and snorkel detectability across habitats will help provide a baseline for such management.

Carli Baum

Addressing the complexities of steelhead behavior when estimating adult abundance

The ecology and movements of adult summer steelhead compound the complexities of the steelhead life cycle, creating difficulties when estimating abundance. The adults enter freshwater many months before spawning for a temporally extensive migration with many individuals wandering, leading to behaviors such as overshooting natal tributaries and straying. For large interior basins, such as the Snake River, these behaviors create biases in estimates of abundance and stock structure that are needed to inform conservation assessments and fisheries management decisions. Lower Granite Dam (LGR) in southeastern Washington provides an opportunity to extensively sample adult Snake River steelhead migrating upstream. Large-scale data collection of these fish takes place at LGR in the form of daytime window counts at the fish ladder, systematic sampling of steelhead trapped and sampled throughout the run (i.e., genetics, sex, length, and age), and passive integrated transponder detections. The Estimating Adult Salmonid Escapement (EASE) model uses these data to generate total abundance estimates of hatchery and wild fish, which are then decomposed into estimates by sex, size, and age for each genetic stock. This model is an improvement over previous models in that it collectively accounts for three main sources of bias: 1) nighttime fish passage at the dam, 2) rates of stock-specific fallback and re-ascension, and 3) genetic stock identification uncertainty. The EASE model yields improved stock-specific steelhead abundance estimates and diversity metrics. For example, incorporating rates of fallback and re-ascension enables the ability to more effectively account for differences among stock groups, such as the Lower Snake River stock that is more prone to overestimation due to higher rates of fallback and re-ascension. Modeling methods that account for stock-specific differences in migratory behavior are needed to address the complexities of steelhead abundance estimation.

Zoe Brandt

Evaluating an egg supplementation program in the lower Boise River

Fish production and hatchery operations are utilized to achieve numerous fisheries management objectives, including increased recreational opportunity, threatened and endangered species recovery, repatriation or colonization, and general population augmentation. To achieve these objectives, different mechanisms and techniques can be applied, including stocking catchable or sub-catchable sized fish or fertilized embryos in an egg supplementation program. Idaho Department of Fish and Game (IDFG)

fisheries staff conducted a pilot study to evaluate the efficacy of egg supplementation in the lower Boise River, an urban tailwater fishery. We stocked fertilized triploid Rainbow Trout Oncorhynchus mykiss eggs into the lower Boise River at three sites in spring 2022. We collected juvenile trout via backpack electrofishing techniques in fall 2022 and evaluated ploidy via genetic analyses for all Rainbow Trout fry. Preliminary results indicate that eggs from the supplementation program hatched and developed into juvenile trout. Proportional catch of juvenile triploid Rainbow Trout was largely associated with proximity to egg stocking locations, suggesting egg supplementation may eventually contribute to the lower Boise River trout population.

Tucker Brauer

Trout management in the Big Wood River: Past and present

For decades, the Big Wood River has been one of Idaho's premier wild-trout fisheries. This fishery has long been renowned for producing quality wild trout that are targeted by anglers from across the country. Despite its storied past, biologists have observed marked changes in this population since the early 2000's including substantial increases in density, decreased size structure, and decreased growth rates. Observations based on a long-term dataset strongly suggest that the Big Wood River wild trout fishery is notably different than it once was from both population dynamic and angler-demographic standpoints. As such, the current regulation structure in place since 1990 may no longer be appropriate to manage the fishery going forward. The current mosaic of complex regulations in the Big Wood River may also play a part in limiting angler participation. Efforts to readdress and simplify regulations system-wide could benefit the quality of the fishery and potentially improve angler participation. This talk covers the history of the Big Wood River wild trout fishery, its current population status, and potential challenges associated with its management going forward.

Rebecca Buchanan

PIT-tag analysis tools from Columbia Basin Research

PIT tags have been a critical element of salmon and steelhead monitoring in the Columbia River basin for a quarter century. Their small size and long life make them attractive tools for extracting performance measures encompassing multiple life stages, and nearly 57 million fish have been PIT-tagged since 1987. However, a considerable amount of data processing and interpretation is needed to effectively learn from PIT-tag data: dealing with multiple data sources, adjusting for known removals, estimating detection probabilities, and accounting for the effects of complex spatial and temporal structure in the observation data. The University of Washington's Columbia Basin Research provides several PIT-tag analysis tools to support researchers and natural resource managers in the basin. This talk will provide an overview of three analysis tools for the release-recapture framework. PitPro processes raw PTAGIS data into detection histories for migration survival estimation and provides survival estimates. Program Branch aids users in designing and fitting release-recapture models for temporal- or spatial-branching systems (e.g., tributary or estuarine networks). Basin TribPit estimates cohort survival from tributaries to the mainstem river for populations with variable age at migration. All software is freely available at www.cbr.washington.edu. We hope to foster discussion of analysis needs for modern PIT-tag studies.

Sara Cassinelli

How to tell fish stories and reach a broader audience

How can scientists communicate their research and reach a broader audience? Idaho Fish and Game has been sharing their fish stories using a variety of digital media channels to communicate their science to the public. From blogging to long and short-form video on social media, people are learning more about their favorite fishery, what it's like to be in a fisheries position, and how research is being conducted. These posts have sparked human interest, sometimes reaching thousands of people and gaining large video views on multiple platforms.

In this presentation, you'll hear how IDFG fisheries staff are working with their communications department to produce engaging content and reach audiences beyond the scientific community. You'll also learn what topics resonate with general audiences and how you can begin to share your own stories.

Chris Caudill

Toward empirical assessment of adaptive capacity in aquatic populations across scales: From genomes to landscapes in native Rainbow Trout populations in Idaho

Assessing ecological and evolutionary effects across multiple scales remains a key challenge to predicting the response of populations to environmental change. We examined populations of native interior rainbow trout (Oncorhynchus mykiss gairdneri) across a landscape-scale thermal gradient using an interdisciplinary approach. We evaluated: 1) genomic structure and genome-environment associations; 2) physiologic thermal capacity in a common garden; 3) growth and habitat quality using a bioenergetic framework; 4) current and future flow and thermal regimes by integrating climate and hydrological models; and 5) spatially explicit agent-based models (ABMs) for a subset of populations to integrate data sources across scales and evaluate fitness-based elements of adaptive capacity at the demographic-genetic interface under alternative climate, land management, and translocation scenarios. Population genomic structure across the landscape was associated with geography and thermal environmental parameters, including metrics of thermal variability. Physiological and thermal performance was associated with acclimation experience and candidate adaptive loci. Habitat surveys and drift foraging models revealed higher productivity in desert streams, but predicted warming will decrease habitat capacity, especially for larger fish. Riparian vegetation and fire management were unlikely to buffer effects of climate warming on modeled montane thermal regimes. ABM models with warming predicted trout abundance decreased (desert) or was neutral/increased (montane), that the relative importance of plasticity and genetic adaptation depends on the strength of natural selection and nature of the plastic response, and that dispersal strongly affects demo-genetic dynamics. In combination, we are evaluating the contribution of genetic and plastic traits to adaptive capacity (i.e., persistence), identifying key scale(s) and uncertainties affecting eco-evo dynamics, and evaluating the relative potential for management actions to ameliorate impacts during the synthesis phase of the program. Overall, this multi-scale and interdisciplinary approach can be applied in other systems to evaluate population responses to environmental change, including complex effects of demo-genetic feedbacks.

Timothy Copeland

Assessment of current smolt production and smolt-to-adult return rates for RAD management of Snake River spring/summer Chinook

Rational goals and objectives are a critical part of effective fisheries management. A corollary is that operational objectives must be consistent with the potential of the focal resource. Recently, the Columbia Basin Partnership (CBP) described the desired outcomes for abundance of salmon and steelhead throughout the Columbia River Basin. Concurrently, the Northwest Power and Conservation Council (NPCC) has an objective for smolt-to-adult returns (SARs) averaging 4% (range: 2%–6%). In practice, one might expect that the CBP benchmarks and the NPCC goals would be related. In this paper, we asked, given contemporary levels of smolt production, what SARs are needed to achieve CBP goals for spring/summer Chinook salmon in the Snake River basin? We examined information at the basin scale and for select populations. We found a logical progression in SARs needed to achieve goals that followed the degree of anthropogenic impact on natural populations. Wilderness populations can avoid the threat of extinction and even support sustainable fisheries at SARs lower than indicated by the aggregate results (i.e., abundance needed for de-listing is possible at SARs <2%). In populations targeted for habitat restoration, the SARs necessary to achieve long-term goals are higher than historically observed (i.e., SARs needed for healthy and harvestable populations >10%), showing the need for management to achieve better egg-smolt survival. Currently, aggregate natural smolt production would avoid the threat of extinction at smolt-to-adult return rates (SAR) near 3% and would achieve intermediate goals at SARs above 6%, which is consistent with NPCC objectives. Our results are useful for managers to decide among Resist, Accept, or Direct management approaches for these and similar populations.

Ian Courter

The quest for fisheries-specific salmon and steelhead hooking mortality estimates

Efforts to recover depressed stocks of salmon and steelhead in North America include implementation of mark-selective recreational fisheries, whereby anglers are allowed to harvest hatchery-origin fish but must release natural-origin fish. Catch and release (C&R) is generally thought to be an effective tool for conservation due to high survival of released fish. However, estimates of C&R mortality are necessary to determine how many fish are killed post-release. Previous studies designed to estimate C&R mortality have produced highly variable results among species and size classes of fish, gear types, and environmental conditions, leading to diverse regulations

with varying levels of empirical support. We conducted a three-year mark-recapture study in the Cowlitz River, Washington to estimate effects of a variety of factors hypothesized to influence salmon and steelhead C&R survival using a treatment-control design. Three species of anadromous salmonids were captured and released as treatments using various angling techniques and terminal tackle. Non-angled fish were captured in a trap and released back into the fishery to serve as controls. Hooking mortality rates were generally very low. Recovery rates of Coho Salmon differed less than a percent between angled and non-angled fish across multiple gear types. Angled Spring Chinook Salmon were predicted to experience 3.6% to 10.2% C&R mortality relative to non-angled fish. Barbless hooks were associated with higher survival than barbed hooks for both Chinook and Coho Salmon, although differences were small for Chinook and negligible for Coho. In contrast, steelhead angled on barbed hooks were recovered at slightly higher rates than those caught on barbless hooks. We also found strong evidence for a reduction in landing rates while using barbless hooks, particularly for steelhead. Finally, use of bait increased the probability that fish would be hooked in a critical location such as the esophagus or stomach.

Dennis Daw

The demise of salmon and steelhead in the Upper Snake River Basin: A chronological history of dam blockage

Prior to European colonization of the northwestern United States, anadromous fish had access to much of the Columbia River Basin with an estimated 17 million salmon and steelhead returning annually. Due to anthropogenic influences such as overfishing and dam building, salmon and steelhead runs are a fraction of what they were historically. Further, due to the construction of dams lacking fish passage, many areas within the Columbia River Basin have been blocked.

The Upper Snake River Basin is one of those blocked areas. Construction of the Hells Canyon Complex (HCC) was the nail in the coffin for anadromous fish in the Upper Snake River. Historically, an estimated 1.7 million salmon and steelhead would have migrated into the Snake River and its tributaries upriver of the HCC. Blockage in the Upper Snake River dates far before the HCC was constructed, with the first tributary dam built in the early 1890's. Over the course of the next 50 years dams were built in nearly all Snake River tributaries, including the main stem. A majority of those dams did not have fish passage.

The Upper Snake River Tribes Foundation has assessed each tributary when it was blocked and who constructed the dam. While not a comprehensive look at all blockages, it does describe chronologically major dam construction and blockages and if there has been mitigation for anadromous fish losses.

Tributaries in the Upper Snake River have the high elevation cold water refuges that will be important to the survival and recovery of anadromous fish in the Columbia River Basin.

*Jessica Diallo**

Optimizing invasive species eradication in time and space: A case study of Green Sunfish removal in intermittent streams

The continued and growing impacts of invasive freshwater fishes has prompted many natural resource agencies to implement control programs with the goal of population suppression or eradication. Mechanical removal is the favored control method with respect to cost and reduced likelihood of collateral damage, yet its past success in achieving species management goals varies substantially. Control programs that optimally allocate removal effort across space and time offer promise for improving invasive species suppression or eradication, especially given the limited resources available to these programs. Here we leveraged two intensive fish eradication programs for green sunfish (Lepomis cyanellus) in intermittent streams of the Bill Williams River in Arizona, USA, to explore alternative management strategies involving variable allocation of removal effort in time and space and compare static versus dynamic decision rules to guide actions. We used Bayesian hierarchical modeling to estimate demographic parameters using existing removal data. We show strong evidence that both removal programs led to successful eradication, with 0.35 and 0.34 probability of eradication (i.e., <2 individuals remaining) in McGee Wash and East Ash Creek, respectively. Simulated alternative management strategies revealed that population suppression could be achieved with ≥50% of locations randomly sampled, but only required 30% of locations sampled via dynamic management based on catch rate. High removal frequency and program duration, including continued collections even after no fish were previously captured, contributed to eradication success. A dynamic simulation strategy in which locations were no longer visited after zero fish were caught once resulted in a final population of 3,612 on average, compared to 11 individuals when removal ceased after zero fish were caught three consecutive times. This research demonstrates that invasive control efforts are more efficiently and effectively allocated in both space and time when using dynamic management that responds to invasive species abundance in real time.

*Matea Djokic**

Fish in the city: Urban runoff alters the gut microbiome and physiology of Western Mosquitofish Gambusia affinis

Many important watersheds in Southern California are unrecognizably altered from anthropogenic activities that negatively impact native fish. Water discharged from urban runoff contains metals and chemicals from various sources and impact fish health. Contaminants can affect fish gut microbiome bacterial composition. A fish's gut microbiome can influence their immune response and digestive efficiency, affecting overall performance of an individual. However, the interaction of the gut microbiome and physiology of fish in response to urban runoff is not well understood. I tested the effects of persistent runoff pollutants on the gut microbiome and physiology of mosquitofish in the San Diego Creek watershed by comparing measurements on populations from six sites (5 wild and 1 captive) of varying pollution levels. Pollution level detrimentally affected physiological measures, increased prevalence of parasites, and influenced gut microbial diversity. In the most polluted site, female hepatosomatic index ($F(5,112) = 7.221$; $P < 0.001$) and relative gut length ($F(5,114) = 30.27$; $P < 0.001$) were significantly elevated and male relative gonopodium length ($F(5,105) = 8.619$; $P < 0.001$) was significantly lower when compared to other populations. Alpha and beta diversity of the gut microbiome significantly differed among sites and indicator species analyses revealed microbial species potentially protective to individuals in the face of pollution. The combination of microbiome and physiological measures poses a powerful tool in understanding how fish are endure stressful conditions brought on by pollution.

Marika Dobos

Diversity in life history movement and survival of juvenile steelhead in Idaho

Early life history strategies of movement and rearing of steelhead Oncorhynchus mykiss is diverse and varies across their distribution. Steelhead plasticity lends to the species resiliency to persevere through environmental stochasticity and anthropogenic events that affects the riverscape. Complexities in life history also creates complications in monitoring and comparing population status trends, specifically in freshwater environments. We examined large-scale freshwater movement and survival of wild juvenile steelhead from select Idaho rotary screw trap sites to Lower Granite Dam. Juveniles trapped and PIT tagged at the screw traps ranged in age from 0 to 4 years old. Juvenile age composition and mean length at age varied among systems and across years and movement patterns also varied. Some fish directly migrated to the ocean while some held in freshwater habitat downstream of trapping sites often times in large mainstem rivers for up to three additional winters before migrating to the ocean. Holdover movement patterns were prevalent in all systems with higher prevalence in Fish Creek compared to the other systems examined. Ontogentic shifts in rearing habitat are advantageous to spread cohorts across space and time, reduce risk to ice conditions in small streams during the winter, and can buffer density-dependent mechanisms that can occur in smaller tributary rearing habitat. Age-specific survival of juveniles from screw traps to Lower Granite Dam were highly variable across the trapping sites examined and generally increased with age but was not associated with travel time to the hydrosystem. We continue to expand our understanding of steelhead early life history by applying these methods to other locations. Understanding diversity of early life history strategies of steelhead can help identify freshwater system needs and inform management of tributary restoration actions. Moreover, managing for diverse early life history portfolios of steelhead is essential for the species' resiliency.

Jonathan Ebel

Strategic evaluation of goals for spring/summer Chinook Salmon hatcheries in the Snake River Basin

Hatcheries are a common feature of freshwater fisheries management in North America. Salmon fisheries in the Columbia River basin offer a complex example of this management tool. We examined the ability of hatcheries in the Snake River subbasin to achieve regionally accepted hatchery adult Chinook salmon return goals. We asked two questions. 1) Given contemporary levels of smolt production, what SARs are needed to achieve Columbia Basin Partnership (CBP) goals for spring/summer Chinook salmon hatcheries in the Snake River basin? 2) Given contemporary levels of SARs, what levels of smolt production are needed to achieve CBP goals? We developed a simple life cycle model that allowed us to vary the size of smolt release groups, smolt survival from release to Lower Granite Dam (S_release), and the smolt-to-adult return ratio (SAR), while linking broodstock requirements to smolt release group size. Applying this model to seven hatcheries, we found that assuming release group sizes underpinning the goals combined with the observed S_release and SAR from the past 10-20 years would have achieved the goals 9 times out of 119 total releases. The minimum SAR to achieve return goals when S_release = 1 varied among hatcheries from 0.38-1% and exceeded their specific SAR threshold in 27% of

the combined dataset. We also examined the probability that hatcheries achieve their adult goals under different levels of production and found that under current survival patterns some hatcheries would need to more than quintuple production to meet goals 50% of the time. Evaluation of the linkage between smolt production and SAR is crucial to understanding the potential of hatchery stocks, as well as the management options needed to increase adult abundances. Management that improves SARs, increases of current smolt release group size, or some combination of both are needed to reliably achieve hatchery abundance goals.

*Robert Eckelbecker**

A species on the edge: Can intraguild predation explain Burbot decline

Predatory fishes are often valued as game fishes due to their aggressive feeding behaviors and large body sizes. These same traits often lead to success in becoming established as an introduced species. As freshwater ecosystems are among the most imperiled ecosystems in the world, understanding the ecological interactions of non-native species is imperative to the conservation of native species. In the Torrey Creek Drainage of Wyoming, three apex piscivorous predators interact in a potential intraguild predation interaction. Burbot, Lota lota, are the native apex predator to the system whereas Brown Trout, Salmo trutta, and Lake Trout, Salvelinus namaycush, are the non-native predators. Using diet data obtained from gastric lavage, frequency of occurrence and mean proportion by weight were used to describe diet composition and per capita consumption of Burbot. Lake Trout and Burbot displayed a piscivorous diet with fish occurring in 82% and 48% of diets and representing 0.82 and 0.36 mean proportion by weight, respectively. Brown Trout displayed a more generalist feeding pattern with Trichoptera in 65% of diets representing 0.27 mean proportion by weight. Diet overlap was high between Burbot and Brown Trout (Schoener's index = 0.66). Conversely, diet overlap between Burbot and Lake Trout (0.50) and Brown Trout and Lake Trout (0.34) was low. Similarly, per capita consumption of Burbot by Brown Trout was 33g/year/individual and 29.5kg/year when extrapolated to the population abundance of Brown Trout. Conversely, no evidence of predation of Burbot was observed in Lake Trout diet samples. These data indicate that intraguild predation is not the mechanism for the decline of Burbot in the Torrey Creek Drainage.

Laurel Faurot

Investigating the role of network complexity in sustaining biodiversity in meta-food webs of a wilderness river

Free-flowing, unfragmented river networks are increasingly rare and their study is vital to understanding natural river ecosystems including the fish populations they sustain. We studied network complexity and its consequences for aquatic meta-food webs and biodiversity across four tributary confluence complexes (multiple tributaries entering a mainstem in close proximity) in a wilderness river. We hypothesized that these complexes create mosaics of habitats, biodiversity, and complexity in meta-food webs, each of which contributed to food web traits that confer community and food web stability. We performed aquatic vertebrate surveys and habitat measurements, and collected fish and amphibian gut contents and samples for stable isotope analyses across 13 tributaries and 7 mainstem sites. We analyzed these at nested spatial scales using an iterative, aggregation simulation to investigate the effect of increasing habitat complexity on biodiversity and food web metrics linked to its maintenance. Our results indicate that aquatic vertebrates are supported by a wide array of resources, as evidenced by a large range of δ13C contributing to their tissues, and a diversity of food web linkages shown by gut content analysis. Moreover, within any given confluence-complex, no single habitat encompassed as much space on a C-N isotope biplot nor contributed the same diversity of unique food web links as all the habitats combined. We sequentially increased the suite of habitats included via the simulation which led to increases in habitat heterogeneity, vertebrate diversity, and the complexity, proportion of unrepeated food web links, and trophic niche space of the resultant meta-food webs. Additionally, our analysis of fish gut contents revealed as much variation within single species among all sites sampled, as among all species present within any single site, pointing to high trophic plasticity within species linked to the natural complexity of habitats preserved in this wilderness network.

*Susie Frawley**

Growth and food habits of Walleyes in the Lake Pend Oreille system, Idaho

Walleye Sander vitreus was first introduced into the Lake Pend Oreille (LPO) system, Idaho-Montana, in the 1990s. The LPO system supports populations of ecologically and recreationally important salmonids including Bull Trout Salvelinus confluentus, Westslope Cutthroat Trout Oncorhynchus clarkii lewisi, and kokanee O. nerka. This project focused on evaluating the effects of an established Walleye population on the LPO system using stomach content and stable isotope analyses. In total, 1,157 Walleyes

were caught during April 2020 to May 2021. Walleye total length varied from 175-822 mm, and ages ranged from 0-20. Relative growth values indicated that Walleyes in the LPO system were in the 50-75th percentile of growth compared to populations across the United States. Walleye growth was related to kokanee abundance. Walleyes exhibited variability in individual growth rates. On average, δ15N values were higher and δ13C values were more depleted for slower-growing individuals. Stomach content analysis revealed kokanee was an important prey item across all ages, regions in the system, and across all seasons. Per-capita consumption of kokanee by a Walleye from age-0 to age-7 was approximately 257 individuals. At an estimated density of 4.2 Walleyes per hectare, population-level consumption of kokanee by Walleye was approximately 2.4 million kokanees (~13% of the 2018 estimated abundance of kokanee). The total consumption of kokanee by Walleyes likely will directly influence abundance of kokanee in the future and influence growth and survival of other piscivores in the LPO system.

*Barrett Friesen**

Characterizing the fish assemblage in the Lake Powell forebay and identifying the potential for nonnative fish escapement into the Lower Colorado River

In the Colorado River basin, USA, management agencies are concerned low water in Lake Powell may increase the likelihood of nonnative fish entrainment through Glen Canyon Dam, adversely affecting imperiled native fishes downstream in the Grand Canyon. Our goal in this study is to estimate the probability of nonnative fish entrainment and survival through Glen Canyon Dam. Preliminary data suggest entrainment risk varies by season and lake stratification and is greatest when fish occupy the forebay at the depth of the penstock intakes. When the reservoir was cold (<10 °C) and well mixed in early 2022, the forebay was sparsely occupied by three species of nonnative coolwater fish restricted to the top 11 m of the water column. Following reservoir warming (>20 °C surface temp.) and formation of the epilimnion, we collected an additional three species of nonnative warmwater fish down to 23 m depth, overlapping the penstock intakes. Gillnet catch per unit effort in the forebay increased between March and August 2022, from 0.4 fish/net-night to 4.7 fish/net-night, indicating greater fish abundance, movement, or likely both. In October 2022, we implanted 30 nonnative fish with depth sensitive acoustic transmitters and have observed an average depth selection of 6.9 m (SD 8.8) for Smallmouth Bass Micropterus dolomieu and 21.4 m (SD 13.2) for Channel Catfish Ictalurus punctatus between implantation and March 2023. To measure conditions experienced by entrained fish, we passed a Sensor Fish device through the dam penstock and turbines, which over 17 trials recorded average peak acceleration of 182 g, average maximum pressure of 1,630 KPa, and an average maximum rate of pressure change of 5,860 KPa/sec. These data will be used to model survival of dam passage and combined with entrainment probability to inform dam operations as managers seek to minimize the risk of entrainment.

*Courtnie Ghere**

Using microchemistry to inform growth dynamics of Kootenai River White Sturgeon

The Kootenai River flows through British Columbia, Montana, and Idaho and is home to several native fish species, including an endangered population of White Sturgeon Acipenser transmontanus. The decline of this White Sturgeon population has largely been attributed to Libby Dam, the uppermost dam on the Kootenai River. Changes to discharge and temperature regimes caused by Libby Dam have influenced habitat quality and White Sturgeon population dynamics (i.e., recruitment). Several mitigation strategies have been enacted (i.e., flow augmentation, habitat restoration, hatchery supplementation), but White Sturgeon continue to demonstrate poor recruitment and growth. To assess changes in growth of White Sturgeon over time, fin rays from 182 known-age hatchery fish were collected in 2015. Because the first Kootenai River hatchery began production in 1990, this dataset represents relatively young fish (i.e., age 2 to 23). Modeling growth for this population has proven challenging because of the slow growth observed in the Kootenai River and the lack of information about White Sturgeon life history. We expect mixed effects models representing growth by calendar year to provide a more descriptive analysis than typical growth curves because we will be able to account for changes in fish growth by age and environmental characteristics. However, life history is an important consideration that is difficult to account for in long-lived species such as White Sturgeon. Strontium isotopic signatures have shown promise in assigning fish to locations in watersheds with diverse geology, allowing inferences about life history. This study will pair microchemistry and growth analysis to better understand the growth dynamics of White Sturgeon in this system by identifying habitats (i.e., lake or river) associated with annual growth rates. Results of this research will help managers identify the most effective conservation strategies for White Sturgeon.

Sean Gibbs

Evaluation of fish assemblage in the Grande Ronde Valley, OR, underscores potential threats to local Chinook Salmon and steelhead populations

ESA-listed Chinook salmon and steelhead in the Grande Ronde River and Catherine Creek (major tributary to the Grande Ronde River) must pass through the Grande Ronde Valley, a low-gradient section of the river that has been heavily impacted by historic and current land use practices. Juvenile salmonids emigrating through the Grande Ronde Valley experience disproportionately high mortality rates relative to adjacent river reaches. Although the sources of juvenile mortality within the Grande Ronde Valley are largely unknown, predation by native and non-native fishes has been identified as a possible limiting factor. As the first step toward determining if the fish assemblage within the Valley could be contributing to poor juvenile salmonid survival, we conducted extensive sampling throughout the 23.5 rkm of Grande Ronde River and 37.6 rkm of Catherine Creek during August and September 2022. Six different active and passive gear types were used to sample for a total of 1,544 hours. We captured 14,649 fish including 15 species, seven of which were non-native to the subbasin. Catch-per-unit-effort was standardized to account for gear selectivity, providing an unbiased assessment of species composition. We found the Grande Ronde Valley was dominated by non-native species including pumpkinseed, brown bullhead, common carp, largemouth bass, smallmouth bass, yellow perch, and white crappie. Given the spatial extend, abundance, and size distribution of species captured during the study, it is likely that predation and interspecific competition with juvenile salmonids is prevalent throughout the Grande Ronde Valley; however, efforts to directly quantify impacts on salmonid populations are lacking for many of these species. Here, we discuss the potential impacts of non-native species often overlooked by the scientific community, and the need for additional research.

Jennifer Gosselin

PIT tag data tools on the Columbia River DART website

Columbia River Data Access in Real-Time (DART; www.cbr.washington.edu/dart) has provided online access to fish, river, and ocean data since the mid-1990s. DART serves as a second-tier, centralized repository of data in historical, real-time, and predicted timeframes for public access. The value-added tools available to decision makers, managers, biologists, public citizens and other interested parties include data summaries, data visualizations, and interactive queries. In this presentation, we highlight some of these value-added tools for passive integrated transponder (PIT) tag data, accessed from PTAGIS, PSMFC, www.ptagis.org. These DART tools include: 1) filters applied to the PIT data (ESU/DPS, Life Stage, and Transportation), 2) estimates of smolt-to-adult survival, and 3) adult metrics (adult project delay, fallback and conversion rates). We will describe where and how we have sought to maintain reliability and transparency in our online tools and services in the last few decades. We have learned and continue to learn that collaboration is a key ingredient in developing and maintaining DART tools and services. Moving forward, we are striving to better meet the FAIR (Findability, Accessibility, Interoperability and Reusability) and CARE (Collective Benefit, Authority to Control, Responsibility, and Indigenous Peoples' Ethics) principles. We look forward to opportunities to discuss how we can better align these principles to DART, in practice and with place-based understanding.

*Maggie Harings**

Using quantitative PCR to estimate Chum Salmon *Oncorhynchus keta* abundance with environmental DNA on the Chena River

The Chena River historically supported one of the largest Chum Salmon (Oncorhynchus keta) runs in the Yukon River Basin. Since 1986, the Alaska Department of Fish and Game (ADFG) has estimated run timing and abundance to guide in-season fishing regulation modifications, update spawner-recruit relationships, and inform biological escapement goals for this species. However, in recent years an increase in the frequency of high streamflow events has resulted in periodic gaps in salmon escapement estimates when increased water levels limit the ability to conduct visual counts and use sonar technology. Simultaneously, severe declines in Chum Salmon abundance have led to subsistence fishing closures, further highlighting the importance of continuous salmon count datasets to estimate annual escapement. In response, we are testing a complementary method to assess adult salmon abundance measuring the concentration of DNA shed by salmon into the environment. During the summer of 2021, ADFG personnel collected daily temperature and flow measurements as well as 202 filtered eDNA samples over 45 days. Using validated species-specific quantitative PCR assays, we are quantifying Chum Salmon DNA from filtrates of river water. While other studies in Alaska have demonstrated the ability to implement similar methodology, this study is the first to assess the feasibility of such efforts at counting tower and sonar sites in systems with relatively low salmon densities. This

project is part of a larger initiative to analyze Chinook (O. keta) and Chum Salmon DNA in the East Fork Andreafsky River, Gisasa River, Henshaw Creek, and Salcha River whose salmon runs contribute significantly to Yukon River Basin salmon populations. Our long-term vision is to build capacity to support cost-effective monitoring of fish populations and enhance climate change resilience in salmon assessment and fisheries throughout Alaska.

Audrey Harris

Adaptive haplotypes associated with age-at-maturity in Dworshak National Fish Hatchery steelhead

Recently discovered candidate regions in anadromous salmonids provide a genetic tool to potentially predict phenotypes of great interest to managers, such as run timing and age-at-maturity. One such region, the SIX6 gene on chromosome 25, is associated with age-at-maturity in steelhead and may drive some life history variation exhibited by hatchery broodstocks. Previous research has demonstrated that ten single nucleotide polymorphisms (SNPs) on chromosome 25 are associated with ocean duration and body length, with individuals possessing either “short” or “long” haplotypes. Individuals with “short” haplotypes tend to spend one year in the ocean and return at shorter body lengths, while those with “long” haplotypes tend to spend two or more years in the ocean and return at longer body lengths. Steelhead returning to Dworshak National Fish Hatchery (NFH) have historically been older at return and attained larger maximum body sizes than other steelhead hatchery broodstocks in the Snake River basin In Idaho. However, haplotype and genotype frequencies for candidate markers on chromosome 25 have not been previously assessed for this for this hatchery stock. We used ten SNPs associated with age-at-maturity to statistically phase adaptive haplotypes and then calculate haplotype and genotype frequencies for Dworshak NFH broodstock. To assess potential temporal shifts in haplotype and genotype frequencies, we included individuals from the 1969 founding wild stock, subsequent broodstocks from 1970-1976, and contemporary broodstocks from recent spawn years (2014-2016; 2019-2022). Our results demonstrate that Dworshak NFH broodstocks possess adaptive haplotypes previously observed in other interior-lineage steelhead, but frequencies for the “long” haplotype are generally greater in magnitude than those observed elsewhere in the Columbia River basin. Our work constructing adaptive haplotypes for an iconic broodstock with high environmental, cultural, and economic value provides information for managers regarding the genetic basis of life history diversity in steelhead.

John Heckel

Investigating angler use and harvest using creel surveys and fish tagging

The Big Lost River tailwater downstream of Mackay Dam consists of a popular, year-round, wild Rainbow Trout Oncorhynchus mykiss (RBT) fishery. Anglers began voicing their concerns of overharvest in 2018 after RBT abundance declined from historical levels. We used two methods to investigate harvest and angler use in the fishery. We conducted a roving creel survey to investigate angler use, catch rates, and harvest in the Big Lost River tailwater from 2021 to 2022, and we tagged 20% of the estimated RBT population in the tailwater in 2021 with t-bar anchor tags and used tag return data to estimate angler use and harvest. In this study, a model-based estimator was used to estimate angling effort and catch instead of a traditional design-based estimator. Data collected from creel suggests that catch rates for RBT were 1.01 fish/hr for all tackle combined. Fly anglers reported 1.16 fish/hr, lure anglers reported 0.78 fish/hour, and bait fisherman reported 0.43 fish/hr. The majority (57%) of anglers interviewed said that they would rather catch big fish instead of more fish when fishing the Big Lost River tailwater, and 79% of anglers interviewed reported that the size of fish they caught met or exceeded their expectations. Based on the number of RBT reported as harvested during the creel survey, we estimated that about 10% of RBT caught were harvested. No t-bar anchor tags were reported from harvested fish, however, based on the number of tags that were reported we estimated that 5% of all tagged fish were caught and released throughout the duration of the study. Angler satisfaction appears to be met in the Big Lost River tailwater despite abundances that are less than historical levels. Furthermore, we do not believe that current harvest levels are having a population level effect on wild RBT.

Shannon Hennessey

Assessing the utility of coral reef indicators for evaluating ecosystem-based management thresholds

Ecosystem-based fisheries management (EBFM) is increasingly recognized as a management priority, especially in systems with dynamic components that have integrated responses to interacting drivers. Management targets therefore need to incorporate these complex dynamics, which may be accomplished by establishing targets based on indicators. Following a protocol developed in the California Current Ecosystem, we leverage existing data to evaluate the use of indicators as ecosystem reference

points for nearshore ecosystems in Hawai‘i. We screened for potential nonlinearities in the spatial relationships between ecosystem indicators and remotely-sensed metrics of environmental drivers over a 10-year period, and assessed commonalities in identified indicator-driver thresholds. To understand how the ecosystem indicators related to commonly used metrics in single-species assessments, we also tested whether these relationships were consistent across species, species complexes, and functional groups. Gradient forest and Generalized Additive Mixed Model analyses revealed strong threshold relationships across five environmental drivers and multiple indicators, with some common thresholds apparent, especially for habitat complexity (rugosity) and wave forcing. Several indicators with nested species, species complex, and functional group relationships had comparable thresholds with a common driver, while certain related environmental drivers also showed similar importance to a given indicator. However, this was not the case for other indicator species, highlighting the need for careful consideration when selecting indicators for management applications. The use of multimodel inference that incorporates multiple statistical methods to define the relationship between an ecosystem indicator and driver offers a quantitative basis for ecosystem management, with our results providing a rubric for testing for the existence of thresholds in indicator-driver relationships across spatial gradients.

Rebekah Horn

Utility of parentage-based tagging for monitoring Coho Salmon *Oncorhynchus kisutch* in the interior Columbia River basin

After decades of diminishing abundance in the mid 1900’s, Coho salmon (Oncorhynchus kisutch) were considered extirpated from the interior Columbia River by the 1980s. In the mid-1990s, the Confederated Tribes of the Umatilla Indian Reservation, the Confederated Tribes and Bands of the Yakama Nation, and the Nez Perce Tribe began successful reintroduction programs of Coho salmon upstream of Bonneville Dam, which were initially sourced from lower Columbia River hatcheries. While genetic sampling for parentage-based tagging (PBT) is not implemented at all Coho hatchery programs in the interior Columbia River basin, a PBT baseline including coho hatchery broodstock was first instituted in 2012 with two participating programs and has since expanded to include eight programs. Here we present the first Coho salmon PBT baseline from seven hatchery programs located in the interior Columbia River basin, and two sites at or downstream of Bonneville Dam, composed of over 32,000 broodstock samples. Analyses of baseline collections revealed genetic structure followed a temporal pattern based on three-year broodlines rather than geographic location or stocking history, and similar levels of genetic diversity across hatchery programs. The effective number of breeders per hatchery and spawn year ranged from 110 (CI: 58-745) to 410 (CI: 384-437). The PBT baseline provided multiple direct applications such as detecting the distribution of hatchery-origin fish on the spawning grounds in the Methow River basin and identifying the origin for Coho salmon collected in a mixed stock at Priest Rapids Dam (PRD). In two collection years at PRD, 93% of sampled Coho salmon could be assigned to a hatchery of origin, providing total age, location, and sex information. The Coho salmon PBT baseline requires additional yearly samples from lower river hatcheries to be used for basin-wide applications, but with wide-spread support, can be a useful tool in the management of Coho salmon.

Tien-Chieh Hung

The role of a university-operated conservation hatchery on a multiple agencies involved experimental supplementation project

Beginning in December 2021, the U.S. Fish and Wildlife Service, in partnership with several agencies, including the U.S. Bureau of Reclamation, California Department of Water Resources, California Department of Fish and Wildlife, U.S. Geological Survey, and University of California, Davis, initiated an experimental supplementation project. The primary objective of the project is to release lab-bred, endangered Delta Smelt (Hypomesus transpacificus) to supplement the wild population for the very first time. Among the agencies, the UC Davis Fish Conservation and Culture Laboratory (FCCL) is serving as a conservation hatchery responsible for producing the fish for the project. Additionally, the FCCL plays a vital role in genetic management, fish marking, and fish transportation. This presentation will provide an overview of the FCCL’s role in the project. We will discuss the laboratory's evolution, including its history and how it has adapted to better serve the project's goals. We will also explore the limitations and challenges faced by the FCCL in producing the target number of fish and future directions to support the project.

Gregory Kaltnecker

Side channel restoration at the Diane Moore Nature Center, Boise, Idaho

We restored a historic side channel of the Boise River at the Intermountain Bird Observatory’s Diane Moore Nature Center in Boise, Idaho, to improve water quality,

enhance fish and wildlife habitat, conduct community outreach, and manage public access. After more than 10 years of planning, fundraising, design, permitting, and implementation, wildlife and habitat response to this restoration effort was immediate. Establishment of community partnerships allowed for completion and expansion of the project, while volunteer efforts continue to be an invaluable contribution. Managing public access is an ongoing challenge and threatens long-term suitability of this area for wildlife. Knowledge gaps were identified and an adaptive management approach is being embraced. Long-term goals for the nature center are to demonstrate best practices in urban habitat restoration and conduct community outreach to provide information about coexisting with wildlife in an urban setting.

Muhammad Naeem Khan

Community based regional cooperation for effective monitoring, control and surveillance of Arabian Sea fisheries of Pakistan: A case study of international cooperation for capacity building, training and sustainability

Fishery plays a significant role in the national economy of Pakistan. Pakistan's marine fishery resources include 250 demersal fish species, 50 small pelagic fish species, 15 medium-sized pelagic species and 20 large pelagic fish species. In addition, there are also 15 commercial species of shrimps, 12 of cephalopods and 5 of lobsters. With Arabian Sea coastline of about 990 km, Pakistan has rich fishery resources that are threatened by Illegal, Unreported and Unregulated (IUU) fishing, industrial fishing, municipal wastes and untreated industrial effluents. Most of the population of the coastal areas of Sindh and Balochistan provinces of Pakistan depends on fisheries for livelihood as 300,000 strong traditional Sindhi fishing community famous for employing sustainable fishing practices are engaged in low tech artisanal fishing. The livelihood and sustainability of this traditional fishing community is threatened not only by over fishing but by continued IUU fishing.

The paper will highlight the challenges to the sustainability of Arabian Sea fishing, which is further jeopardized by poor law enforcement capacity and/or low priority of Pakistani agencies coupled with heavy shipping and global oil tanker traffic originating from Persian Gulf and oil rich Middle East. The sustainability of fishing is further compromised by the illegal fishing by foreign vessels from Far East Asian countries, often routinely found fishing in Pakistani maritime jurisdiction, thereby challenging the capacity and will of the relevant Pakistani agencies like Pakistan Maritime Security Agency (PMSA) and Pakistan Coast Guards (PCG).

Among these agencies the PMSA, under the administrative control of Ministry of defense is tasked with the responsibility of protecting the Exclusive Economic Zone (EEZ) of Pakistan which is up 350 NM (290,000 square Km) in the international waters and has jurisdiction in both domestic and international waters including the operation in deep sea. Whereas, PCG is charged and mandated to protect the coastal areas of Balochistan and Sindh provinces of Pakistan through littoral patrolling along 990 Km Pakistani coast line from the Indian coast in the East to Iranian coast in the west, in north Arabian Sea.

The mighty River Indus system originating in Himalayan mountains in north near Chinese border dominates the water resources of Pakistan, transporting enormous quantities of untreated municipal & industrial effluents, aquatic pollutants, nutrients and sediments during its 3000 Km journey to the south to the continental shelf of Arabian Sea, thereby damaging the coral reefs and rich fish breeding grounds in the coastal mangrove forests.

Despite the fact that the fishing capacity of Sindhi artisanal fishing community is limited, the use of high tech fishing tools & gears by commercial fishing trawls, high demand and profitability of IUU fishing has placed this traditional fishing community at a very disadvantageous and marginalized position where the fisheries resources of these communities are fast depleting. The paper recognizes these artisanal Sindhi fishermen as one of the major stakeholders, who should be given a prominent role in the monitoring, enforcement and management of their historic fisheries resources.

Ilana Koch

A current review of epigenetic effects associated with salmonid supplementation and domestication

Several studies have demonstrated lower fitness of salmonids born and reared in a hatchery setting compared to those born in nature, yet broad-scale genome-wide genetic differences between hatchery-origin and natural-origin fish have remained largely undetected. Recent research efforts have focused on using epigenetic tools to explore the role of heritable changes outside of genetic variation in response to hatchery rearing. We synthesized the results from salmonid studies that have directly compared methylation differences between hatchery-origin and natural-origin fish. Overall, the majority of studies found substantial differences in methylation patterns and overlap in functional genomic regions between hatchery-origin and natural-origin fish which have been replicated in parallel across geographical locations. Epigenetic differences were consistently found in the sperm of hatchery-origin versus natural-origin fish along with evidence for maternal effects, providing a potential source of multigenerational transmission. While there were clear epigenetic differences in gametic lines between hatchery-origin and natural-origin fish, only a limited number explored the potential

mechanisms explaining these differences. We outline opportunities for epigenetics to inform salmonid breeding and rearing practices and to mitigate for fitness differences between hatchery-origin and natural-origin fish. We then provide possible explanations and avenues of future epigenetics research in salmonid supplementation programs, including: 1) further exploration of the factors in early development shaping epigenetic differences, 2) understanding the functional genomic changes that are occurring in response to epigenetic changes, 3) elucidating the relationship between epigenetics, phenotypic variation, and fitness, and 4) determining heritability of epigenetic marks along with persistence of marks across generations.

*Andrea Kokkonen**

Using de novo transcriptomes to decipher the relationships in Cutthroat Trout subspecies *Oncorhynchus clarkii*

For years, taxonomists have grappled with the number and identity of North American cutthroat trout (Oncorhynchus clarkii) subspecies due to inconsistencies between morphological and genetic data. These inconsistencies stem from several known factors: polyploidy, historic drainage changes, and unintentional hybridization. Despite thorough morphological, geographical, geological, and molecular studies, the relationships of these subspecies remain unclear, especially the subspecies found in the Great Basin interior. Using de novo assembled transcriptomes of 11 cutthroat trout subspecies, we provide new insight on the evolutionary relationships of cutthroat trout. We highlight the difficulty in identifying homologous genes between these subspecies. We find that transcripts annotated as the same gene between subspecies can be identified as orthologs and/or paralogs depending on which subgenome the transcript comes from. We also find that these subgenomes can have different evolutionary trajectories within the same subspecies. We provide additional insight into these relationships, which will inform future conservation efforts of cutthroat trout.

Moses Koroma

Challenges of implementing marine ecosystem based management

Many services provided by coastal and marine ecosystems are in decline in Sierra Leone. Awareness of these declines and the need to improve existing management has led to a shift toward ecosystem-based approaches to marine management and conservation.

Marine ecosystem-based management (EBM) involves recognizing and addressing interactions among different spatial and temporal scales, within and among ecological and social systems, and among stakeholder groups and communities interested in the health and stewardship of coastal and marine areas.

We discuss some overarching principles of marine EBM and highlight key challenges facing implementation. We then recommend ways in which natural and social scientists can advance implementation of ecosystem-based approaches in the oceans by addressing key research needs, building interdisciplinary scientific capacity, and synthesizing and communicating scientific knowledge to policy makers, managers, and other stakeholders.

Functioning coastal and marine ecosystems provide services, such as food, fuel, timber, mineral resources, and pharmaceuticals, and play key regulating and supporting roles (eg climate regulation, nutrient cycling, and storm protection). These systems also provide opportunities for trade, recreation, tourism, research, and education, and have considerable cultural, aesthetic, and spiritual value.

Ecosystem-based management (EBM) is an integrated approach that considers the entire ecosystem, including humans (POC 2003; USCOP 2004; McLeod et al. 2005). Marine EBM differs from current approaches that usually focus on a single species or sector, and includes consideration of the interactions among ecosystem components and the cumulative impacts of multiple activities. Approaches to implementing marine EBM vary, but all focus on protecting ecosystem structure, function, and key processes. There are two primary reasons why ecosystem-based approaches are preferable to the status quo.

First, scientists have found overwhelming evidence that ecological interactions in coastal and ocean systems are vital to the resilience and health of these systems. When these connections are broken or severely degraded – through species loss or decline, destruction of key habitats, or change in disturbance regimes – the ability of coastal and marine systems to recover from disturbances, and to continue providing valued ser vices, declines.

Marine EBM is about interactions: interactions among different spatial and temporal scales, within and among ecological and social systems, and among stakeholder groups and communities interested in the present and future health of coastal and marine areas. During a number of recent meetings focused on marine EBM, four key principles have been broadly agreed upon by both academics and practitioners.

What can the scientific community do?

Natural and social scientists can respond to these challenges in a multitude of ways. Here, we highlight three key approaches: addressing crucial research needs, building

interdisciplinary scientific capacity, and synthesizing and communicating scientific knowledge.
Research
We need to understand how the world works in order to manage human activities and maintain or, in some cases, restore the ecosystem services that people value. Relevant scientific investigations may be classified into three categories: efforts to understand the social and eco- logical dynamics of coastal and marine systems, monitor ing of those dynamics, and the development of tools that enable learning and adaptive management. Setting prior ities within and among these three research areas is criti cal, and requires collaboration among scientists, practitioners, and other stakeholders.
Investigations of system dynamics may employ quanti- tative or qualitative approaches, including case studies, experiments, and models, or a combination of these and other methods. Developing an integrated understanding of the dynamics of coupled social and ecological systems requires bridging these approaches and extending them to broader geographic scales. One means of doing so is through adaptive management: models are developed to answer outstanding research questions that cannot be directly addressed by field investigations; these models, in turn, inform large-scale “experiments” that integrate eco- logical, economic, and social issues

*Micshael Lant**

Angler typologies revealed using license purchasing histories

Angler behavior information is a critical component of fisheries management and conservation efforts. Much of our understanding of angler behavior is associated with the period after an angler has purchased a fishing license, yet little is known about how an angler makes the decision to purchase a license and what can be inferred from license purchasing patterns. Interannual license purchasing patterns related to license type, sequence of purchases, timing, and duration could reveal unique angler typologies. Such unique angler license typologies may further reveal specific sociodemographic characteristics of the angler population that could be used to predict future changes in overall license sales. Once these license typologies have been identified it could facilitate targeted efforts for the allocation of limited resources to improve recreational fishing opportunities for the diversity of anglers on the landscape. Our objective was to identify the number of North Dakota resident angler license typologies and associated sociodemographic characteristics. Angler license typologies were constructed using North Dakota Game and Fish angler license sales from 2009 to 2018. We identified three distinct angler license typologies based on differences in the sequences, timing, and duration of license types purchased. Each angler license typology was represented by unique sociodemographic characteristics. Angler license typologies can be used for strategic marketing, survey design, and to reveal anglers with different levels of commitment and expectations.

*Samuel Lewis**

An experimental test for coexistence with the freshwater invader, Western Mosquitofish

Invasive species are a major threat to freshwater conservation. Species coexistence in invaded habitats depends on the relative strength of intra- versus inter-specific competition, where inter-specific competition from invasive to native species is often stronger than intra-specific competition, jeopardizing their coexistence.
In this study, we conducted a laboratory experiment to test for the relative competitive strength between native plains topminnow (Fundulus sciadicus) and invasive western mosquitofish (Gambusia affinis) at three experimental temperatures. Intra- and inter-specific competition was quantified using an isodar approach, which assumes that animals are ideally distributed to maximize their fitness and thus their distributions measure the quality and quantity of habitat patches. This was supplemented by behavioral observations of intra- and inter-specific competition.
Contrary to our predictions, we did not find evidence that competition was asymmetrical from the invasive mosquitofish to the native plains topminnow. Instead, more individuals occupied their shared preferred habitat (a slow-moving pool) in sympatry compared to allopatry, and the isodar analysis demonstrated that intra-specific competition was significantly stronger than inter-specific competition at all temperature levels. This analysis of habitat selection was corroborated by behavioral observations that aggression was most frequent among plains topminnow in sympatry.
This study provides evidence that aggression might not always be the key mechanism of invasion, even for one of the most successful aquatic invasive species widely known for aggressive behavior. In mosquitofish, other ecological traits such as rapid reproduction and environmental tolerance might be responsible for their invasion success globally. This suggests that mosquitofish aggression is one of several factors for their invasion success, and additional investigations are warranted to determine whether their invasions directly affect native species, or they invade degraded ecosystems opportunistically.

Dayv Lowry

Research across an international border: Partnering to assess a shared at-risk species

Management of species with ranges that span international boundaries are complicated by differing regulatory priorities, capabilities, and timelines. Collaborative efforts that standardize survey tools and methods can expand the scope and utility of data available to support conservation within each country. Historical fisheries assessments indicated that Yelloweye Rockfish abundance in the Salish Sea declined precipitously in the 1970s, ultimately leading both federal governments to recognize this population as imperiled under their respective species conservation laws, the Endangered Species Act and Species at Risk Act. The Washington Department of Fish and Wildlife (WDFW), with support from NOAA Fisheries, and Fisheries and Oceans Canada (DFO) manage and conduct assessments for Yelloweye Rockfish separately within their respective waters. In 2017, the WDFW conducted a focused survey of rocky habitats for Yelloweye Rockfish throughout the San Juan Islands using a remotely operated vehicle (ROV) – right up to the Canadian border. In 2018, DFO cleared administrative hurdles to allow the WDFW to conduct a parallel survey in the Canadian Gulf Islands. Surveys using the same habitat-focused design had previously been conducted elsewhere in the southern Salish Sea, allowing for a true apple-to-apples, transboundary comparison of encounter rate, density, size distribution, and abundance. The success of this sampling led to a survey of a much broader areas of the Canadian Salish Sea later in 2018 using DFO's VECTOR as a survey platform, the WDFW's ROV, and staff from DFO, the WDFW, and NOAA Fisheries. In this presentation, we describe the development, status, and results of this international partnership, as well as lessons learned, including bureaucratic challenges, survey development and design, and equipment and data-sharing. Not only did these surveys provide crucial data for conservation, but they also demonstrated the value of reaching across legal and geographic borders to achieve a common goal.

Dorene MacCoy

Habitat suitability assessment of Loggers Creek

Loggers Creek is a multi-use urban side channel of the Lower Boise River, located in Boise, Idaho. Historically, the creek was used for lumber transportation, but currently it delivers irrigation water to public users and neighborhoods in southeast Boise. The creek is known to support Rainbow Trout, Brown Trout, Mountain Whitefish, suckers, minnows, sculpin and freshwater mussels. The City of Boise is looking for opportunities to improve habitat conditions as part of the City's water quality program and initiatives to enhance the river and has identified Loggers Creek for side channel habitat enhancement. Using a 2D hydrologic model, the Boise River Management Tool (BRMT), and habitat suitability curves (depth and velocity), the Lower Boise River and tributaries were mapped to determine habitat available for different life stages of resident fish and mussels. The BRMT lacked resolution to identify critical habitat in smaller tributaries such as Loggers Creek. A field survey was completed to provide finer scale information to verify model depth and velocity and provided information on fish cover, spawning gravel availability, and fish and mussel occurrence. The BRMT, habitat suitability mapping, and field surveys were all needed to make informed decisions for habitat improvement design.

*Bryce Marciniak**

Interactions among Yellow Perch, Northern Pikeminnow, and Smallmouth Bass in Lake Cascade, Idaho

Yellow Perch (YEP) Perca flavescens was successfully introduced to Lake Cascade, Idaho in the 1950s. Since then, Lake Cascade has become a nationally recognized destination for YEP angling. Throughout its history, Lake Cascade has had a cyclic YEP population. Recently, annual surveys have detected declines in juvenile YEP which may indicate a bottleneck in YEP recruitment. One possible mechanism contributing to recruitment declines is predation. The three most abundant predators in Lake Cascade are YEP, Northern Pikeminnow (NPM) Ptychocheilus oregonensis, and Smallmouth Bass (SMB) Micropterus dolomieu. Northern Pikeminnow contributed to historic collapses in the YEP population; subsequent removals allowed the YEP population to recover. Conversely, SMB is a recently established predator in Lake Cascade. Gill nets were deployed monthly from April 2022 through April 2023. Diagnostic data were taken from all captured fish, and a subset of five fish per centimeter length bin were sacrificed for otolith and stomach extraction. Catch of all three species varied spatially and temporally. Catch per unit effort (CPUE = fish per net night) of YEP was highest in the spring in the southern and northern portions of the lake. After spring, CPUE of YEP and SMB increased in the eastern portion of the lake but remained variable across the other regions for the remainder of the open-water season. Catch rates of NPM were highest in the fall in the northern, eastern, and southern

portions. In the winter, catch of NPM and SMB was substantially lower than the rest of the year. Of 2,914 captured YEP, 70% were greater than 250 mm. Mean total length of captured YEP was 271 mm (STD = 61.0) and the largest fish captured was 396 mm. Mean relative weight of captured YEP was 91.3 (STD = 12.6). Information from this study will be used to inform future management decisions about Lake Cascade and provide insight on the ecology of YEP in reservoir ecosystems.

Brian Maschhoff

A re-interpretation of radio tag data for passage of adult salmonids past dams in the Columbia and Snake rivers

The natural upstream migration behavior of salmon and steelhead in the Columbia and Snake rivers has been altered by the presence of multiple dams which the fish must pass thru as well as the reservoirs behind them. It is important to understand the various factors that influence the ability of fish to efficiently navigate these structures so as to better predict the impact of changing conditions in the future, either from climactic effects or e.g. altered operations. Much has been learned over the last few decades from radiotracer studies of fish tagged at Bonneville Dam and subsequently detected at multiple locations upstream, and this legacy dataset is still being mined for more insights. One relatively recent study has claimed to identify a time-shifting bimodal distribution (termed fast and slow modes) for Chinook salmon moving through a dam tailrace and up the fishway to the dam forebay. In this talk, I will show that this purported behavioral bifurcation is not real but is rather an artifact of the data analysis method. The data is more simply (and correctly) interpreted as the result of fish arriving at the tailrace (and shortly thereafter at the foot of the dam) late enough in the day such that dam ascension before nightfall becomes less probable and the fish are delayed in their passage to the top until the next day.

Brian Maschhoff

PIThy: A web-based application for processing and analysis of PIT-tag data

Fish tracking experiments using passive integrated transponders (PIT-tags) often generate a large amount of data, presenting challenges in processing and its interpretation. PIThy is a powerful yet lightweight web browser-based application for local loading, processing, and visualization/analysis of PIT-tag data. The current development version is specifically designed to work with raw data exports from PTAGIS, a regional database of fish marked with PIT tags by fisheries management agencies and research organizations in the Columbia River Basin. In this talk, I will first consider the complications that arise when working with large quantities of PIT-tag data and then demonstrate the usage of PIThy, highlighting several PIT-tag specific visualization techniques which greatly aid in interpreting and communicating a rich yet complex data set.

Donavan Maude.*

White Sturgeon population dynamics and demographics of a hatchery-established population

White Sturgeon ¬Acipencer transmontanus is important recreationally and economically throughout its distribution. In Idaho, managers have increased opportunity for anglers to target an iconic species through a stocking program where the Idaho Department of Fish and Game has established a population upstream of Shoshone Falls, outside its native distribution. From Minidoka Dam upstream to Upper Idaho Falls Dam, around 7,500 White Sturgeon have been stocked since 1990. Increased participation in the fishery by anglers and guides have prompted a thorough investigation of White Sturgeon in the upper Snake River. Information on the population dynamics and demographics is necessary for effective management; thus, this project aims to describe the distribution, abundance, age structure, and growth rate in the upper Snake River system. In total, 235 White Sturgeon were captured from June-October, 2022, using angling and setlines. Individuals were captured throughout the study area and varied in size from 54–187 cm FL. Catch rates were highest at the outflows of major impoundments (i.e., American Falls Dam, Gem State Dam). The mean relative weight for captures was 107.7 (SD = 14.6) suggesting relatively high body condition. Capture histories from 132 known-age White Sturgeon were used to inform age and growth analysis. Information from this investigation will provide important insight on the ecology of White Sturgeon that can be used to guide management of the fishery.

Darcy McCarrick

Effects of using natural-origin Chinook Salmon in hatchery broodstocks

Naturally produced populations of anadromous salmonids in Idaho and throughout the Pacific Northwest have declined precipitously since the 1950s, and hatchery supplementation programs have been developed as one way to address the declines and recover populations. An integrated broodstock program is a novel approach that uses primarily natural origin adults in an effort to minimize genetic divergence between hatchery donor stocks and recipient wild stocks. However, natural origin salmon are not adapted to the hatchery environment and their progeny may display differential mortality or life-history trajectories than traditional (i.e., segregated) hatchery stocks when reared in a hatchery. Our objective was to provide a more complete understanding of the effects of incorporating natural-origin Chinook Salmon into hatchery broodstocks. To accomplish this, we evaluated pre- and post-release survival metrics for integrated fish relative to their segregated counterparts. Additionally, we evaluated phenotypic characteristics of returning natural-origin, integrated, and segregated adults. Eye-up to release survival was similar between segregated and integrated fish with differences up to 5%. Annual smolt survival to Lower Granite Dam varied among years but was similar between integrated and segregated stocks. Arrival timing and length distributions were similar across origins within a study area (i.e., hatchery). However, the proportion of jacks in the integrated and segregated programs was much higher than in the natural origin stock. Despite this apparent difference in integrated and natural origin fish life-history characteristics, results from the present study are encouraging and suggest minimal survival consequences exist for a hatchery program that uses natural-origin adults in the broodstock.

Joshua McCormick

Using state-space models to estimate recreational angling effort and infer processes that regulate angler dynamics

State-space models are commonly used to estimate abundance of animal populations through time or to estimate parameters that regulate abundance such as population growth rate or carrying capacity. State-space models are an effective tool because they leverage the temporal dependence of the population allowing for modeling of ecological processes separate from the observation process. Similar to animal abundance, recreational angling effort is also generally temporally autocorrelated but design-based methods, which are generally used to estimate angling effort, treat the state of the angling population as temporally independent. In this study I demonstrate how to adapt a variety of state-space models to on-site creel survey data for several trout fisheries in Idaho. In addition, I estimate angler “carrying capacity” for each fishery using density-dependent models and evaluate factors influencing carrying capacity as well as population growth rate of the angling population. Angler catch rate had little effect on angler carrying capacity, but carrying capacity was 2.27 times higher for fisheries with high levels of public access than fisheries with little access. Population growth rate varied from 1.8 to 3.3 among fisheries when transitioning from a weekday to a weekend (i.e., the population size increased 1.8 to 3.3 times). Population growth rate was generally less than one (i.e., the population sized decreased) when transitioning from a weekend to a weekday, and was near one (i.e., no change in population size) among adjacent day types. The models presented here can be extended to evaluate additional hypotheses regarding angling dynamics or to improve estimates of angling effort.

Stacey Meyer

Evaluating Chinook Salmon and steelhead response to tributary reconnection

Habitat rehabilitation efforts are common practice across the Pacific Northwest for the conservation, management, and recovery of ESA-listed Chinook Salmon Oncorhynchus tshawytscha and steelhead Oncorhynchus mykiss from the ESA. In the Salmon River basin, habitat actions are being implemented in historically important tributaries that are disconnected from mainstem rivers through a combination of factors, such as insufficient flow due to irrigation demands and the existence of road culverts, diversion structures, and other fish passage obstacles. The purpose of this study was to describe Chinook Salmon and steelhead response to the reconnection of Little Springs Creek in the Lemhi River basin, Idaho. We focused on describing life-stage specific fish response to restoration efforts following flow augmentation, barrier removal, and instream habitat rehabilitation efforts. Fish monitoring was conducted over a nine-year period using mark-recapture electrofishing efforts and integrated passive transponder detection systems. Post-treatment monitoring and evaluation has provided insight on species abundance, species habitat use, movement, distribution, juvenile retention, and production. Results from this study provide life-stage specific fish response to habitat restoration that will help guide the implementation of future habitat projects for the conservation of Chinook Salmon and steelhead.

Haley Ohms

Steelhead populations show modest response to 2012-2016 California drought

Conservation funding and other resources are limited, so resource managers understandably want to prioritize ecosystems and species that will persist into the future. Yet, there is often inadequate data to make accurate predictions required for prioritization.
To address this data gap, we examined how eight steelhead (Oncorhynchus mykiss) populations on the north-central California coast responded to a multi-year, severe drought from 2012 to 2016 using dynamic factor analysis. We considered the impacts that could have occurred to spawner, smolt, and juvenile life stages, and predicted reductions in population productivity from 2012 to 2019 (the `drought impact years'). We observed synchrony among population productivity from 2006-2019, including during the drought impact years. Counter to expectations, the overall impact of the drought on population productivity was relatively modest. A majority of populations had below average productivity in only 3 of the 8 of the drought impact years, and reductions in productivity were similar to non-drought impact years. The synchrony in population productivity, including the reduction observed during the drought, was best explained by spring flows that impacted the outmigrant life stage. We did not observe a relationship between population productivity and summer flows that impacted the juvenile life stage, or winter flows that impacted the spawner life stage. Marine conditions during the drought were largely unfavorable for steelhead, and there was limited evidence that they obscured a drought response. The overall modest response to the multi-year, extreme drought could be explained, in part, by variation in stream flow and drought severity over the course of the drought. Our results indicate that steelhead populations on the central California coast had a considerable amount of resilience to a multi-year, severe drought that makes continued investment in their conservation worthwhile.

Shubha Pandit

Effects of hatchery supplementation on natural production of a Pacific salmon population

Hatchery supplementation is being broadly used to increase salmonid abundance and harvest opportunity but information on long-term effects on natural populations remains limited. We evaluated supplemented (treatment) and un-supplemented (reference) natural-origin Chinook salmon population dynamics prior to and during a 20-year supplementation period in two major drainages of the Yakima River Basin (Washington, USA), a tributary of the Columbia River. We tested a hypothesis that natural-origin smolt production and natural-origin adult returns would exhibit greater decline over time in the supplemented population (the upper Yakima River) relative to two un-supplemented populations in the adjacent Naches River drainage. The study showed that smolt production, as measured by total annual outmigration, decreased over the 20-year period for both supplemented and un-supplemented populations, but the decline was significant only in the un-supplemented populations. We observed no significant change in natural-origin adult returns of treatment and reference populations after supplementation relative to the period before supplementation. Finally, we also observed synchrony in the annual fluctuation of both adult return with a similar out-of-basin population, Entiat, Washington, USA. These common demographic trends that occur across Columbia River sub-basin indicate that productivity in freshwater and particularly the marine environment can be primary drivers of declines in natural production throughout the Columbia Basin but supplementation can serve as a buffer to mitigate greater impacts.

*Nitsa Platis**

Trophic niche dynamics of Brown Trout and Mottled Sculpin in a regulated Rocky Mountain river

Trophic niches are dynamic and their structure can vary depending on quantitative or qualitative shifts in resource availability. In temperate ecosystems, such as those found in Colorado, environmental conditions and productivity vary throughout the year, leading to fluctuations in resource availability over time. The aim of this study was to evaluate temporal variation in trophic dynamics of small-bodied Brown Trout Salmo trutta and Mottled Sculpin Cottus bairdii in the Lower Blue River, near Kremmling, CO. We had four specific objectives: 1) assess temporal variation in diet composition, 2) evaluate temporal variation in trophic niche breadth, 3) examine temporal variation in trophic niche overlap between Brown Trout and Mottled Sculpin, and 4) investigate temporal variation in fish stomach fullness. We collected diet content samples from 75 Brown Trout and 75 Mottled Sculpin of varying sizes (80 - 200mm; 80 - 135mm) in May, August, and October of both 2021 and 2022 (total n = 900). We also measured macroinvertebrate abundance and species composition throughout the growing season each year. Our results are expected to demonstrate that trophic dynamics varied seasonally for both species, with changes in diet composition, trophic niche breadth, trophic niche overlap, and stomach fullness across seasons in response to changes

in prey resources.

*Daniel Rankins**

When digestive physiology doesn't match "diet": *Lumpenus sagitta* (Stichaeidae) is an "omnivore" with a carnivorous gut

Based on economic principles, Chemical Reactor Theory, and the Adaptive Modulation Hypothesis (AMH), suggest that digestive enzyme activities in an animal's gut should match with diet to ensure efficient digestion. Elevated carbohydrase activities in the guts of herbivores and omnivores, and elevated aminopeptidase activity in some carnivores, all support the AMH in a rich literature. Thus, an animal's digestive physiology shows what the animal is capable of digesting from what it ingests. In this study, we found that the "omnivorous" Lumpenus sagitta (Perciformes: Stichaeidae) does indeed consume considerable algal content, but their amylase activities are lower than other algal-consuming stichaeid fishes. Moreover, all stichaeids that eat algae consume more of it as they grow, and show positive allometry of gut size relative to body size; L. sagitta does not show positive gut allometry, more like carnivorous stichaeids. The microbial diversity of the hindgut shows that L. sagitta has an enteric community dominated by Pseudomonodota and Planctomycetota, unlike the algivores that have more Bacteriodota and Bacillota. Coupled to elevated pepsin activity (digests protein) in the stomach and N-acetyl-glucosaminidase activity (digests chitin breakdown products) in the intestine, all aspects of the L. sagitta gut suggest it is carnivorous in what it digests. Transcriptomic analyses of intestinal tissues are underway, but the overall dataset shows the power of examining digestive physiology as opposed to only gut content analyses to determine what an animal can actually digest from what it ingests.

*Peter Searle**

Exploring rockfish (Sebastes) diversification using a phylogenetic comparative approach: Depth, color, and pattern

Despite limited geographic barriers and significant gene flow between populations, marine species are often biodiverse. Rockfish (Sebastes) is a diverse genus of at least 113 species, that vary dramatically in habitat use, coloration, and color pattern. The goal of this proposed research is to understand how three isolating mechanisms (depth, color, and pattern) could be associated with the diversification of these species. I will assemble nuclear and mitochondrial genomes to generate a comprehensive phylogeny of rockfish and then map information on depth, color, and pattern to explore how these characteristics are associated with the evolution of these species. Understanding what drove the evolution of rockfish species in the past, will inform how these fishes will respond to future anthropogenic impacts.

Kevin See

Estimation of adult steelhead in a coastal river using SONAR

Steelhead spawning ground surveys in the Dungeness River basin on the coast of the Olympic Peninsula in Washington State are inherently challenging due to springtime snow melt and rain events which can lead to high, turbid water and unsafe survey conditions. In most years it is not possible to survey for steelhead through the entirety of the spawning season, and in some years poor survey conditions prevent an adequate number of surveys to estimate redd-based escapement. In 2019 the Washington Department of Fish and Wildlife (WDFW) installed and operated a stationary multi-beam SONAR unit in the lower Dungeness River to enumerate and gather run-timing information on winter steelhead (Onchorhynchus mykiss). To reduce the amount of review effort, the first 30 minutes of each hour were reviewed. Based on a subsample of hours when the complete 60 minutes were reviewed, we developed an expansion factor to be applied to the 30-minute periods. We also differentiated species detected with SONAR based on supplemental species composition data. As SONAR is an emerging technology being utilized or considered in more and more rivers, we hope to provide some guidance by discussing lessons learned over the past four seasons related to SONAR operation and data analysis, as well as present results from those four spawn years.

Brian Simmons

Evaluating Wallowa Lake's food web and potential limiting factors for Sockeye Salmon reintroduction

Wallowa Lake, located in northeastern Oregon, once supported one of only two spawning Sockeye Salmon (Oncorhynchus nerka) populations in Oregon. Native Sockeye Salmon runs began declining in the 1880s as European American settlers made detrimental anthropogenic changes, eventually extirpating the anadromous population in the early 1900s. The Nez Perce Tribe has long aimed to reintroduce Sockeye Salmon to Wallowa Lake, and several recent events and collaborations have increased the feasibility of reintroduction. In this presentation, we focus on recent assessments of Wallowa Lake's food web as the current food web differs from the one that supported Sockeye over a century ago. We will evaluate seasonal patterns in temperature, dissolved oxygen, zooplankton diversity and abundance, fish diet composition (stomach contents and stable isotopes), and thermal history of kokanee. Based on these preliminary data, we will discuss potential limitations in food availability to O. nerka and the effects of introduced species (Lake Trout and Mysis Shrimp). We will also discuss lessons learned and plans for future research, with the ultimate goal to successfully reintroducing Sockeye Salmon to Wallowa Lake.

Troy Smith

Evidence of reduced growth in Kootenai River White Sturgeon and implications for recovery

Kootenai/y River White Sturgeon (KRWS) are an imperiled, distinct population in the headwaters of the Columbia River Drainage. Human caused habitat modification to the Kootenai/y system has nearly eliminated natural reproduction of KRWS since 1960s. In 1992, the Kootenai Tribe of Idaho began a conservation aquaculture program to support the population. The success of that hatchery program has led to a current population of around 15,000 juvenile KRWS. However, data from population monitoring have indicated declining growth rates through time and among habitats. We constructed Von Bertalanffy growth curves from known age hatchery-origin fish. Fish that occupied the lake show a larger length at age and faster growth rate than those in the river. Additionally, average length at age for age-9 fish captured in the river declined from 64.0 cm fork length to 41.6 cm fork length over the last 20 years. However, age-5 length at age for river fish remained largely unchanged over that same time. This suggests that there is differential growth across habitats. Slow growing fish will likely mature later and may even die before reaching maturity leading to a smaller, less genetically diverse spawning population. This will reduce resiliency of future generations and hindering recovery of this imperiled population.

*Yingxin Su**

Conservation of the Paiute Cutthroat Trout: Discovering genetic markers to monitor multiple refuge populations and translocations

The Paiute cutthroat trout (Oncorhynchus clarki seleniris, PCT) is an extremely rare subspecies of cutthroat trout that is currently threatened by small population sizes and isolation. Its native habitat is a stretch of lower Silver King Creek, a tributary of the east fork Carson River, California, bounded by fish barriers. In 1912, PCT were moved above the barrier into Upper Silver King Creek. Subsequently, non-native salmonids were introduced into lower Silver King Creek, eradicating PCT due to out-competition and hybridization. Meanwhile, the pure PCT were translocated multiple times over decades, resulting in nine isolated refuge populations today: five of which are within the SKC watershed while four are outside. Translocations may be an essential component of PCT management into the future in order to boost effective population sizes (Ne) and reduce the loss of genetic diversity in each population and the species as a whole. This requires the creation of baseline genetic data in addition to monitoring the genetic changes after the translocation. Yet, PCT presents a challenge for marker discovery given their extremely low genetic diversity, whole genome duplication, and unshared local genetic drift in each refuge population. Here we discuss the method of discovering the markers across PCT populations that have low shared polymorphism. We then used these markers to explore population structures, genetic diversity, and the estimation of Ne in individual refuge populations over time. We also evaluated a translocation event from the out-of-basin North fork Cottonwood Creek refuge population to upper Silver King Creek, using parentage analysis. We found the combination of the SNP markers and genome wide dataset is likely the optimal solution for this subspecies. This work is relevant to the conservation of species with multiple genetically depauperate refuge populations where managers are considering long-term monitoring and translocations.

Yi-Jiun Jean Tsai

How non-native Wakasagi may threaten the persistence of endemic Delta Smelt in the San Francisco Estuary

Originating from Japan, Wakasagi (Hypomesus nipponensis) were introduced to California in the 1950's. Today, Wakasagi can be found throughout the San Francisco Estuary and are thought to pose a threat to endemic and endangered Delta Smelt (H. transpacificus) through hybridization and competition. However, little is understood about how Wakasagi and Delta Smelt interact, particularly in terms of reproduction. In this study, we examined the spawning behavior of Wakasagi in relationship to that of Delta Smelt. Five males and five females were introduced into tanks in all possible sex-species combinations (Wakasagi x Delta Smelt, Delta Smelt x Delta Smelt, Wakasagi x Wakasagi, Delta Smelt x Wakasagi) and assessed for spawning behavior and egg fertilization success. In within-species trials, Wakasagi spawned far more frequently and released many more eggs than Delta Smelt. In trials between Wakasagi males and Delta Smelt females, spawning frequency and egg fertilization success were similar to that among Delta Smelt males and Delta Smelt females. Trials between Delta Smelt males and Wakasagi females are forthcoming. Our findings illustrate 1) the capacity for Wakasagi to reproductively outcompete Delta Smelt and 2) that spawning behavior, physical capability, and zygotic compatibility between Wakasagi males and Delta Smelt females are not barriers to hybridization.

Tanner Van Orden

Positive selection and adaptive radiation in Rockfish

The connection between genetics and species adaptation are not completely known. Studying closely related species allows a glimpse into how species radiate over time at the genetic level. The rockfish, genus Sebastes, includes over 100 species that are distributed in the Eastern Pacific Ocean. These species fill many niches and express a wide range of morphological traits. This makes the genus an excellent candidate group for studying the genetic basis for adaptation. While rockfish have been widely studied due to their commercial value and long lifespans, minimum work has been conducted looking at widespread positive selection of genes across the genus. Using bioinformatics techniques, we are looking at positive selection of a wide variety of genes across 113 species of rockfish spanning the Pacfic Rim. This study provides insight into the molecular evolution of rockfish and will better help us understand why Sebastes is a wildly successful genus of fish.

Jennifer Vincent

Distribution and abundance of Redband Trout and nonnative trout in the Wood River basin of central Idaho

The Wood River Basin in central Idaho has been isolated from the surrounding Snake River Basin by Malad Gorge Falls for at least 50,000 years, and recent genetic analyses suggest that Redband Trout Oncorhynchus mykiss in the basin represent a distinct previously undescribed lineage. To assess their contemporary status, we revisited 22 stream reaches in 2021-2022 that were originally surveyed in 2003 and that were occupied by Redband Trout. Our objective was to assess changes in the occupancy and abundance of Redband Trout as well as nonnative trout. In 2021-2022, Redband Trout were present in 17 of the 22 originally occupied reaches, with all 5 extirpated reaches now entirely comprised of Brook Trout Salvelinus fontinalis. Brook Trout were originally present at 20 of the 22 reaches and were extirpated from two reaches, both of which are now entirely comprised of Redband Trout. Brown Trout Salmo trutta colonized one new reach since 2003 and were present at all reaches (n = 3) which exceeded 10 m average wetted stream width. Redband Trout were the dominant species (≥ 70%) in 12 of the 22 sites in 2003 but only 8 reaches in 2021-2022. Surprisingly, despite extensive hatchery stocking throughout the basin, introgression from non-native hatchery Rainbow Trout of coastal origin appears to be limited. The apparent invasion of non-native trout into waters occupied by Redband Trout poses a concern for their long-term conservation in the Wood River Basin.

*Ryan Vosbigian**

Two-year cycles in Snake River steelhead growth suggest competition with Pink Salmon in the Pacific Ocean

Steelhead (Oncorhynchus mykiss) grow rapidly and attain high fecundity using the rich food resources in the open ocean. Diet composition of steelhead is affected by competition with other Pacific salmonids, but connections to steelhead growth have yet to be assessed. We found a previously undocumented two-year cycle in the lengths of adult steelhead returning to the Snake River Basin. This cycle is present in both sexes of multiple stocks for individuals spending two years in the ocean. Steelhead lengths were significantly correlated with a well-known two-year cycle of abundance of Pink Salmon (O. gorbuscha) in the central northern Pacific Ocean. The lengths of

adult steelhead that spent two years in the ocean exhibit negative associations with the abundance of Pink Salmon originating from the Kamchatka Peninsula in Russia. Negative associations arise between all ages of steelhead and Pink Salmon originating from North America. We suggest that competition for gonatid squid, the primary component of steelhead diet, may explain the decreased growth of steelhead in years when Pink Salmon are more abundant. Collectively, our results suggest transmission of ecological interactions from Russia to North America that is consistent with density dependence in the Pacific Ocean at the salmonid trophic level.

*Hayden Wall**

Seasonal post release survival and movement of Brown Trout in a southern hydropeaking tailwater

The catch and release process can affect survival and movement of Brown Trout, especially during stressful times. High summer temperatures and winter spawning activities might both be stressful for Brown Trout. These conditions could negatively affect survival and might also affect post-release movement patterns. Using hook and line sampling, we collected and monitored 20 fish in the summer (June 9-17) and 15 fish in the winter (December 1-9). We conducted gastric implantation of radio tags at the time of capture, and then immediately released fish. We relocated fish each day for four days following release. Survival was verified by daily movements and from movements at the time of relocation. We used survival curve analysis to compare survival between seasons. Survival curves were not significantly different between seasons. We used a fishers exact test to compare distributions of home ranges and average distances traveled. The frequency distribution of distances traveled in the summer was significantly different than in the winter. The frequency distribution of home ranges were significantly different between winter and summer. Greater distance traveled was observed in the winter (median=543.26 m/day) than the summer (median=221 m/day). Home range was higher in winter (median=1104.32 m) than summer (median=801.17 m). Following release, trout appeared to transgress more shoals and pools during winter than during summer. This information should inform management decisions and might influence angler attitudes about Brown Trout survival and behavior within and outside of the spawning season.

Timothy Walsworth

Interactions between runoff volume, timing, and annual temperatures shape adfluvial sucker spawning migration schedule

The efficacy of management actions to protect and promote spawning migrations depends on an understanding of how potential environmental triggers impact migratory behaviors. Recovery efforts for June sucker (Chasmistes liorus), a federally threatened adfluvial lake sucker endemic to Utah Lake, UT, include hydrologic manipulations to improve access to, and conditions within, their tributary spawning habitats. However, uncertainty about the effects of environmental conditions on the timing and duration of spawning activities may limit the ability of managers to effectively target their manipulations. Here, we use a Bayesian hierarchical modeling framework to analyze the timing of upstream and downstream migrations of PIT-tagged June suckers in their primary spawning tributary from 2008-2022. We then examine the relationships between annual environmental (i.e., hydrologic and thermal) conditions and peak migration timing, among-individual variation in migration timing, and in-stream residence time. Our results indicate that annual migration behaviors varied among years, with peak upstream migration dates ranging from May 7 to May 27 and run durations ranging from 30 to 70 days. Peak migration date was negatively related to annual temperatures, with later peak migration dates in cooler years, though this effect was weakened in years with early peak runoff flows. Both among-individual variation in migration timing and residence time were positively associated with spring discharge and peak flow timing, with more variation among individuals in migration timing and longer residence time during years with larger and later spring runoff flows. Residence time was also positively related to annual temperatures, with individuals remaining in the river longer in warmer years. These results can directly inform hydrological manipulations by allowing managers to predict how supplying supplemental flows at different times of year are likely to impact June sucker migration timing and duration.

Stuart Willis

Population structure of White Sturgeon *Acipenser* transmontanus in the Columbia River inferred from single nucleotide polymorphisms

White sturgeon (Acipenser transmontanus) are the largest freshwater fish in North America, with reproducing populations in the Sacramento-San Joaquin, Fraser, and Columbia River Basins. Of these, the Columbia River is the largest, but it is also highly fragmented by hydroelectric dams, and many segments are characterized by declining abundance and persistent recruitment failure. Efforts to conserve these fish require an understanding of the spatial genetic structure. We assembled a large set of samples from throughout the Columbia River Basin, along with representative collections from adjacent basins, and genotyped them using a panel of 325 single-nucleotide markers. Results indicate that white sturgeon in the upper most Columbia River Basin, in the Kootenai and upper Snake Rivers, are the most distinct, while the

remaining populations downstream in the basin can be described as a genetic gradient consistent with an isolation-by-distance effect. Notably, the population in the lower reaches of the Columbia River is more distinct from those further upstream and suggests higher recent gene exchange through coastal routes than with populations in the interior Columbia Basin. Nonetheless, proximal reaches were only marginally or non-significantly divergent, and we also inferred several examples of dispersal between reaches via direct or close-kin genetic mark-recapture, indicating movement between nearby reaches still occurs and suggesting that transplanting larvae or juveniles from nearby sources poses relatively little risk of outbreeding depression. Samples from the Kootenai and upper Snake Rivers exhibited notably lower genetic diversity than the remaining samples. These observations of genetic structure provide the basis for ongoing investigations into genetic diversity and ploidy variation in natural and hatchery origin cohorts of annual recruits across reaches, how these compare to the adult population in reaches with strong or limited natural recruitment, and the opportunities and challenges imposed by alternative conservation strategies.

Ignite Talks

Jan Boyer

A portable riverbank photo studio: How to take better fish photographs despite muddy water

Photography can be a powerful tool to show the public how amazing native fish are and build support for fish conservation, and to teach species identification to field crews. However, out of water photos fail to show fish at their best and cause stress by extending out of water handling time, and snorkeling photos are not always an option due to safety concerns, poor lighting, or turbid water. A portable field photography studio can solve these problems. I will explain how to set up and build a portable field studio, pack it into a backpack or rocket box for transport into remote field sites, and use it to get clear photos of fish in water - even when the fish live in turbid rivers. And I will show my field studio photographs of native fish that inhabit the continent's two deepest canyons, Hells Canyon and the Grand Canyon.

Carlos Camacho

Fall Chinook stocking in Coeur d'Alene Lake: Enough is enough

Purposeful sport fish introductions can improve recreational fisheries, but do not always follow a planned script and can be difficult to manage. In 1982, Idaho Fish and Game introduced Fall Chinook Salmon (Oncorhynchus tshawytscha) into Coeur d'Alene Lake as a biomanipulation tool to improve kokanee size structure and diversify the fishery. Initial assessments concluded that available Chinook spawning habitat was poor and would result in a population that could be controlled exclusively through stocking. These assessments were incorrect, and the population quickly became self-sustaining. However, wild production has been variable and typically leads to low adult abundance. Chinook have not influenced kokanee as intended but were abundant enough to support a popular trophy fishery that makes up about 40% of lakewide angler effort. Despite the popularity, anglers are often dissatisfied with catch rates because of the low abundance and inconsistent natural recruitment. Stocking has occurred since introduction to supplement natural recruitment and provide a consistent fishery. Despite nearly 40 years of adaptively managed hatchery practices, recruitment of hatchery Chinook to the fishery has been largely unsuccessful. Thus, the long-term stocking program was discontinued in 2022. The cessation of stocking will have negligible impacts to the fishery, but anglers may perceive a negative effect. Angler outreach has been and will continue to be important to manage expectations for this popular trophy fishery.

Cindy Nau

An evaluation of Lake Trout natural reproduction potential in Bear Lake

Bear Lake is located in northeast Utah and southeastern Idaho, roughly bisected by the state line and jointly managed by these two states. Bear Lake's native fish community includes four endemic species and one of only two remaining stocks of adfluvial Bonneville Cutthroat Trout Oncorhynchus clarkii utah. Lake Trout Salvelinus namaycush were introduced to Bear Lake in 1911 to provide sport fishing opportunity and have sustained a popular fishery. In response to concern for the endemic species populations and with technological advancement, stocking of sterile triploid Lake Trout began in 2002 in an attempt to mitigate the threats to endemic species while maintaining the popular Lake Trout fishery. In conjunction with the Utah Department of Wildlife Resources' standard gillnetting survey at static sites, Idaho Department of Fish and Game completed an identical standard gillneting survey at random sites across Bear Lake in the spring, summer and fall seasons of 2022. Tissue samples of the 102 Lake Trout captured by the two agencies over the three surveys were genotyped to determine ploidy (sterile or fertile) and an otolith or pectoral spine was taken to determine age. Individuals were also examined for fin clips previously used to classify sterile Lake Trout by stocking cohort. The genetic analyses found that 68 individuals or 67% of the Lake Trout sampled were fertile and 34 individuals or 33% were sterile. In addition, the 14 smallest Lake Trout were not fin clipped, which suggests that they were likely naturally recruited in Bear Lake. The implications of these findings to the endemic species of Bear Lake are currently being evaluated.

Dan Scurfield

Surfing the tidal wave: Use of transiently aquatic habitat by juvenile Pacific salmon and other fishes in estuaries

Aquatic ecosystems can be incredibly dynamic, with habitats suitability changing across different temporal scales. Understanding the response of mobile species, such as fish, and their reaction to fluctuations in their spatial and temporal environment is an important research priority for effective conservation and management of aquatic systems. One extreme example of these dynamics are tidal estuaries, where habitats can oscillate between terrestrial and aquatic multiple times throughout the day as the tide rises and falls. It is possible that fish move across the tidal cycle such as to access forage and decrease predation risk. Here we used underwater cameras to characterize the usage of different habitats across the tidal cycle, including the use of habitats that are only transiently aquatic. Specifically, we examined fish use in tidal channels in the Salmon River estuary (Vancouver Island, BC) and quantified how use and movement patterns varied across common taxa-- Pacific salmon (Oncorhynchus spp.), as well as Threespine stickleback (Gasterosteus aculeatus) and sculpin (Cottus spp.). We discovered that as the tide rose, waves of fish entered newly inundated habitats, representing a mobile wave of consumers. However, different species had different usage patterns, with Pacific salmon being the first wave, and stickleback and sculpin as a second and third waves as the tide rose. Characterizing intertidal channel use and movement patterns by resident and migratory fishes highlights the importance of local-scale habitat connectivity in the ecological function of estuaries for future restoration efforts.

Joe Thiessen

Logging for Largemouth

Spring Valley Reservoir is the most fished Community Fishery in the Clearwater Region of Idaho. Over exploitation of Largemouth Bass resulted in a fishery comprised with small, young bass and stunted Bluegill. Regulations were changed to limit harvest of Largemouth Bass and protect larger size classes. Initial angler compliance was poor and despite the new regulations, harvest of all size classes persisted. To combat this, IDFG dropped 34 large conifer trees from the waters edge to create submerged habitat structures. These structures are intended to function as sanctuaries for bass to escape heavy angling pressure, allowing for older, potentially larger fish to remain in the fishery until reaching a harvestable size of 16 inches.

Jane Trujillo

Effects of introduced Northern Pike on a managed Rainbow Trout fishery in a southwestern reservoir

Unlawful introductions of nonnative fish complicate fisheries management. The introduction of Northern Pike into Eagle Nest Lake in Northern New Mexico, USA, affected the availability and public's perception of a put, grow, and take Rainbow Trout fishery. Our goal was to inform sportfish management actions and maximize Rainbow Trout

hatchery resources and angler return at Eagle Nest Lake. To this end, we investigated the predatory effects of Northern Pike Esox lucius on a Rainbow Trout Oncorhynchus mykiss fishery in 2020 and 2021. We quantified Northern Pike diet via stomach contents and bulk carbon and nitrogen stable isotopes. Northern Pike stomach contents contained primarily fish (99%) during seasonal surveys, however stable isotope values indicated a greater reliance on invertebrates. Northern Pike consumed more Rainbow Trout in 2020 when the species' relative abundance was higher (catch per unit effort = 16 – 58 in 2020 versus 2 – 6 in 2021), indicative of opportunistic feeding. The probability a Northern Pike consumed a Rainbow Trout was positively correlated with temperature, indicating increased predation in warmer months. Northern Pike relied on fish and affected hatchery-reared Rainbow Trout directly through predation, especially when stocked Rainbow Trout were less than 213 mm, total length. We recommend stocking larger (> 213 mm) hatchery-reared Rainbow Trout in spring months to maximize survival from the predatory effects of Northern Pike.

*Claire Vaage**

Towards a better understanding of invasive crayfish impacts on salmonids

Salmonidae, constituting salmon, trout, char, whitefishes, graylings, taimens and lenoks, have widely-recognized ecological, cultural, and socio-economical value. Numerous factors are responsible for dramatic declines in salmonid populations in many parts of their native ranges, including substantial impacts of invasive species. The widespread introduction of nonnative crayfish, accompanied by their often high local densities and remarkable polytrophic feeding habits, has raised concerns regarding the potential detrimental impacts of these invaders on salmonids. Despite this, research investigating this topic has been slow to accumulate. Here, we provide the first systematic review of the ecological effects of nonnative crayfish on salmonids. By synthesizing results from lab- and field-based studies, we evaluate evidence for direct impacts that differ across species and life-history stages of salmonids, as well as different environmental contexts. We found that the majority of the field-based research studies have been implemented in lakes of the Midwestern United States and lowlands of the British Isles, ignoring the broad scope of crayfish invasions worldwide. Additionally, studies are predominately limited to lab-based experiments and early life histories of specific salmonids, including Lake Trout (Salvelinus namaycush) and Atlantic Salmon (Salmo salar). Studies reported wide-ranging rates of egg predation and fry mortality, in addition to variance among temperature, substrate type, and density relationships. Results from our synthesis revealed a number of large knowledge gaps and confirmed a general lack of understanding of the magnitude and context-dependency of interactions between crayfish and salmonids. Future research should integrate lab- and field-based experiments to quantify per-capita effects of crayfish on different life-history stages of salmonids, and scale these impacts to forecast the implications for recruitment, survival, and population productivity. Such knowledge will help guide future management practices that seek to conserve or recover threatened and endangered populations of salmonids.

Posters

Erika Alvarado

Revisiting the mitochondrial DNA phylogeography of Mountain Whitefish *Prosopium williamsoni* in Idaho

This study is an expansion upon previous work assessing the mitochondrial DNA (mtDNA) variation of an often-overlooked salmonid, mountain whitefish (Prosopium williamsoni). Samples were collected from various watersheds in Idaho and adjacent drainages to determine genetic divergence within and among mountain whitefish populations. Including the complete cytochrome B larger region of the mtDNA genome revealed well-defined genetic assemblages across the range of the species in Idaho. In comparison with other salmonids, mountain whitefish in Idaho have equal or greater mtDNA sequence divergence between genetic assemblages. These results paired with a concurrent study examining nuclear DNA diversity and structure of the same populations, should assist managers with preserving diversity and divergence among mountain whitefish assemblages in Idaho.

*Luke Anderson**

What can divergent long-term monitoring efforts tell us about small scale salmonid habitat restoration in the Pahsimeroi River, Idaho?

The Pahsimeroi River in central Idaho is the focus of basin-wide restoration efforts. As a tributary to the Salmon River in the Columbia River basin, the Pahsimeroi River provides essential habitat to anadromous Chinook salmon (Oncorhynchus tshawytscha) and steelhead (O. mykiss), as well as year-round resident species such as rainbow trout (O. mykiss), brook trout (Salvelinus fontinalis), and mountain whitefish (Prosopium williamsoni). Initial restoration efforts focused on expanding spawning habitat access for Chinook salmon by barrier removal (e.g., road culverts and fish screens) and reconnecting large reaches. Subsequent efforts have sought to address impacts from agricultural practices (e.g., livestock grazing and removal of water for irrigation). Reduction in irrigation withdrawals has been identified as critical for maintaining minimal flow rates. Habitat improvements have included adding structure to the stream channel (e.g., large woody debris and partial impoundments) to create cover and diversify habitat. Select stretches of stream have been left out of the restoration work to serve as references to assess restoration efforts. Prior studies have demonstrated restoration increased spawning distribution of adult Chinook salmon and increased in growth of juvenile Chinook salmon in reconnected reaches. This study looked at whether the restoration efforts have changed community composition and relative abundance of salmonids. We used a decade of backpack electrofishing data from pre-existing sites (established to evaluate flow restoration) in the Pahsimeroi River and snorkel survey data from one of its tributaries, Patterson Big Springs Creek. We found that the restoration has had a limited impact on salmonid community composition. However, we identified several potential challenges with the existing monitoring data that have limited our ability to fully understand the site-specific impacts of the restoration work. Addressing these issues may improve future habitat restoration studies and allow for more detailed evaluations of restoration actions.

Michael Briggs

A novel method to map channel units using non-spatial field data to develop scalable summaries and inform restoration design

Bockman Creek drains approximately 4.5 square miles of the Olympic Mountains in Washington and is a critical tributary of the Sol Duc River, which is a known stronghold for Chinook Salmon (Oncorhynchus tshawytscha), Coho Salmon (O. kisutch), and steelhead (O. mykiss). However, the ecological and morphological health of Bockman Creek has been compromised due to legacy land management practices. In an effort to restore the watershed, the Wild Salmon Center and partners aim to utilize low-cost and low-tech restoration methods, which could be replicated in similar watersheds. We conducted a modified USFS Level II Stream Inventory survey on Bockman Creek using a custom tablet app to update habitat data and inform the development of restoration design concepts. We analyzed the survey results and combined them with remote sensing analysis in GIS to produce an updated stream inventory report. We also created several functional products from LiDAR data including a relative elevation model, valley bottom and channel polygons, and a complete classification of channel and floodplain morphological units. These combined products were used to develop reach-based summaries of the current stream and riparian functions throughout the watershed. We developed a novel approach, using a combination of GIS analysis and stream inventory data, to accurately map and visualize the complete census of channel units from non-spatial field data acquired during the Level II Inventory. The survey analysis findings highlight the potential for accelerated stream inventory surveys to aid in the generation of spatially explicit summaries of stream and riparian functions, which can inform restoration design and support conservation efforts in similar watersheds.

*Jillian Campbell**

Conservation of imperiled native *Catostomus suckers* using a barrier intervention

Non-native species are a leading threat to fish biodiversity. They pose risks to native populations through competition, predation, disease, and hybridization. Following human-mediated introductions of non-native species, native and non-native species can hybridize to the detriment of the imperilled native species. Catostomus fishes in the Upper Colorado River Basin are an example of this. Recent evidence has shown extensive hybridization between non-native white suckers (C. commersonii) and native flannelmouth and bluehead suckers (C. latipinnis and C. discobolus). This system provides a suitable model for testing the efficacy of an intervention to reduce the abundance of non-native species and their hybrids. This study implements a Resistance Board Weir (RBW) as a fish barrier across Roubideau Creek, a tributary of the Gunnison River in Colorado (USA), to restrict non-native fish access to spawning habitat. Conducted over four years, the study gathers genetic data from larval fish samples, pre- and post-implementation of the RBW. Genetic evidence allows us to determine the efficacy of a RBW at controlling non-native species access to spawning locations. In addition, geographic data collected alongside larval fish allows for analysis of spatial spawning preferences in both the native and non-native sucker fish. Combined this information can help provide the most accurate recommendations regarding conservation and management interventions going forward.

We captured a subset of spawning adults and their progeny (larval fish) in 2019 through 2022 and used tissue samples to extract DNA and generate high resolution genomic data. Preliminary analyses of genomic data show that hybridization was extensive in this region pre-implementation of the Resistance Board Weir in 2021. We expect that the abundance of white suckers and their hybrids will decrease significantly during years of controlled access. This work contributes novel information to understanding how effectively conservation efforts using fish barriers can reduce non-native species and prevent hybridization.

Katharine Coykendall

Phylogeography of *Prosopium* species in Idaho

Idaho is home to 38 native fish species, 10 of which belong to the salmonid family. Lesser known members of this family include species in the genus Prosopium: P. spilotus, P. gemmifer, P. abyssicola, and P. williamsoni. The former three species are endemic to Bear Lake on the Idaho-Utah border. Prosopium williamsoni, mountain whitefish (MWF), exhibit a much larger range, broadly distributed throughout Western North America from the Lahontan Basin in California and Nevada, north to the Yukon-British Columbia Border in Canada. Previous phylogenetic studies using mitochondrial DNA, allozyme, and microsatellites found that MWF from major drainages group together (Upper Snake River, Columbia/Lower Snake River, Missouri River, Bonneville Basin, Lahontan Basin). In Idaho, MWF also are found in two geographically isolated watersheds; the Big Lost River and Big Wood River. Despite these watersheds being adjacent, MWF from the two rivers appear genetically diverged from each other with Big Lost River populations appearing more similar to populations in the Upper Snake River, and MWF from the Big Wood appearing more similar to populations in the Columbia/Lower Snake River. In this study, we used Restriction-Site-Associated DNA Sequencing of 519 Prosopium samples collected from 32 populations from Idaho and adjacent states. Our objectives are to evaluate the genetic diversity within populations of MWF and Bear Lake endemics and the genetic divergence between sampling groups. We aim to provide additional genetic information regarding population structure and evolutionary history of Idaho's Prosopium species from which future conservation efforts in Idaho could be developed and effectively evaluated.

*Elizabeth Crowther**

The drying of Dry Creek: Influence of springs on headwater stream intermittency

The presence of springs strongly influences flow intermittency in headwater streams because reliable groundwater sources can often sustain flow even during droughts and in arid or semi-arid climates. Therefore, knowledge about the distribution of springs and their relationships to flow permanence is important for managing headwater catchments. However, springs are not always accurately mapped by the National Hydrography Dataset (NHD) and stream drying predictions in spring-dominated catchments are a known limitation of the USGS Probability of Streamflow Permanence (PROSPER) model. In this study, we sought to improve the understanding of stream drying in spring-dominated vs. non-spring-dominated catchments. To do so, we examined relationships between streamflow permanence and the active flow network

length, annual hydrograph characteristics, and geomorphologic properties of two adjacent catchments: one dominated by springs and the other largely without springs in the Dry Creek Experimental Watershed in southwestern Idaho. We mapped the active channel network in both catchments from wet to dry conditions and quantified the relationship between length and outlet flow rate. The spring-dominated catchment exhibited more stability in stream network length across a range of discharge measurements, whereas the non-spring-dominated catchment exhibited more contraction and disconnection throughout its stream network. However, in the non-spring-dominated catchment that dried seasonally at the outlet, the length-discharge relationship did not represent catchment network dynamics well because the streams continued to contract and expand even after the outlet dried. This work emphasizes the importance of in-field stream network mapping for intermittent streams since it reveals areas of both more and less reliable flows than otherwise predicted, and highlights the need for an accurate large-scale spring database to improve prediction models and water management decisions in a changing climate.

*McKay Curriden**

Effect of climatic variation on spawning migrations of Utah Sucker and Green Sucker

Climatic variation influences spawning migrations of fish species that can have subsequent effects on recruitment and population dynamics. We report on run timing of Utah Sucker (Catostomus ardens) and Green Sucker (Pantosteus virescens) at a fish trap on the South Fork Teton River, Idaho, from March to June in 2018, 2019, 2021, and 2022. During this period, southeastern Idaho experienced drought conditions that resulted in spring runoff occurring at successively later dates. Each year we captured Utah Sucker with total annual catch ranging between 854 and 2,002 individuals during spring spawning migrations. Utah Sucker began their migrations early during spring runoff conditions and we observed few migrating spawners after the peak of discharge. Utah Sucker arrived progressively later each successive year with median run date occurring on the following dates: 29 April 2018, 12 May 2019, 17 May 2021, and 27 May 2022. We also captured Green Sucker annually with total annual catch ranging between 15 and 88 individuals. Green Sucker migrations occurred later than Utah Sucker with median run dates on average 14 days later than Utah Suckers. For Green Sucker, median run dates occurred 15 May 2018, 2 June 2019, 18 May 2021, and 2 June 2022. Variation in spawn timing can influence summer growth of young-of-year fish and consequently influence over-winter survival. Further studies examining how climatic variation affects recruitment patterns of catostomids are needed to help managers better understand population dynamics of Utah Sucker and Green Sucker in the Teton River.

James DeRito

Opening rivers for the movement and migration of native fishes in the Bear River Basin

A recent focused effort by numerous partners has resulted in the removal of many fish passage barriers in the Bear River Basin (Utah, Idaho, and Wyoming). The Bear River is the epitome of a “working river” in the west with numerous irrigation diversions, hydroelectric dams, and road/stream crossings. This infrastructure has fragmented habitat for native Bonneville Cutthroat Trout throughout the Basin. Beginning in 2018, the basin was chosen by the Bonneville Cutthroat Trout Coordinating Committee and the Western Native Trout Initiative as a focal area to address fish passage by means of the Open Rivers Fund, a program of the Resources Legacy Fund. These funds were directed at the planning, design, and removal of fish passage barriers, and to benefit local economies. To date, a total of 19 projects have been funded with over $1.4 million coming through the Fund and a total project value of nearly $6 million. These projects are removing 24 barriers to fish passage and opening 144 miles of rivers and streams to upstream fish passage throughout the basin. This case study provides an example where a focused fish passage effort has dramatically increased the scale and pace of habitat reconnection to benefit native fishes.

*Thomas Doolittle**

Annual flows and spatial distribution of Bull Trout

Coldwater fishes are increasingly at risk from altered habitat conditions resulting from ongoing climate change, including elevated stream temperatures and reduced summer flows. Bull Trout (Salvelinus confluentus) have experienced substantial reductions in both range and abundance and are listed as threatened under the Endangered Species Act as warming water temperatures and reduced stream flows put their populations in growing peril. Understanding how changes in stream flow impact the

abundance and distribution of Bull Trout populations is critical to their effective conservation. Here, we examine the relationship between annual stream flow, Bull trout spawning abundance, and spawner distribution in Rapid River, a tributary of the Salmon River, Idaho, which provides both spawning habitat and thermal refuge. We fit linear and generalized linear mixed effects models to fifteen years of annual, spatially-explicit snorkel stream survey data and stream flow data to characterize how the local Bull Trout population responds to changes in flow conditions. We found that years with increased flows supported more total Bull Trout entering the stream in search of spawning habitat. We also found that Bull Trout did not distribute evenly across space within the tributary, as some sites became occupied and filled more quickly than others as the total number of spawners increased. Our results suggest decreasing flows in cold water spawning tributaries for Bull Trout could lead to reduced reproductive output and reduced diversity of spawning habitats. Together, these changes may reduce annual recruitment, and increase recruitment variability across years as the portfolio of suitable spawning habitats is weakened. As climate change and drought in the Western United States continue to threaten the thermal refuge and spawning opportunities that streams like Rapid River offer to coldwater fishes, maintaining access to and the suitability of diverse spawning tributaries becomes increasingly important to long-term population stability.

*Alonso Longoria**

Effect of temperature in growth, survival, and chronic stress responses of juveniles of Arctic Grayling *Thymallus arcticus*

Arctic grayling (Thymallus arcticus) is a Holarctic species and is exclusively native to the Big Hole River in the contiguous United States. This river's water temperature fluctuates annually between 8-18 °C. However, over the past two decades, a gradual increase in water temperature has been observed due to climate change. We hypothesized that exposure to higher temperatures would result in lower survival rates, decreased growth, reduced feed efficiency, and increased stress responses in Arctic grayling. To evaluate the effects of increasing water temperature on juvenile Arctic grayling, we conducted a 144-day trial with water temperatures ranging from 8-26 °C. We assessed growth, feed intake, survival rate, gene expression, and enzyme activity. Fish growth increased with water temperature up to 18 °C (100 g) but decreased at 22 °C (50 g). Survival rates significantly declined (<40%) at 22 °C, with no survival above this temperature. We observed a 3-fold and 1.5-fold increase in gene expression of Superoxide Dismutase (SOD) and Glutathione Peroxidase (GPx), respectively, at temperatures above 16 °C. However, no significant differences were detected in the gene expression ratio of Heat Shock Protein 70 (HSP70) and Heat Shock Protein 90 (HSP90). Additionally, enzyme activity of SOD and GPx increased at temperatures above 16 °C. Conversely, Catalase (CAT) gene expression and enzyme activity decreased with rising temperatures, suggesting a preference for the GPx pathway. Thiobarbituric Acid Reactive Substances (TBARS) levels increased concurrently with temperature elevation. Our findings indicate that even minor to moderate changes in water temperature in the Big Hole River can induce oxidative stress in Arctic grayling. Further temperature increases will have a direct, negative impact on their survival, highlighting the importance of addressing climate change to preserve this unique species.

Dorene MacCoy

Lower Boise River mussel surveys

The City of Boise (City) recently discovered several populations of Western Pearlshell Mussels (Margaritifera falcata) in the Lower Boise River. The City sampling and monitoring team (SAM) began searching for the presence of mussels to provide background information for Idaho negotiated rulemaking for ammonia aquatic life criteria. After confirming the presence of the mussels in the Lower Boise River, the City shifted to a conservatory role. The SAM utilized several different methods including environmental DNA (eDNA) water sampling along with visual surveys to locate and measure the mussel populations within the mainstem and some side channels of the Lower Boise River. The highest numbers of individuals were found in side-channels of the river where most trout continually spawn. While continuing to search for additional populations in the Lower Boise River, SAM has also collected mussel shells for aging and has PIT tagged mussels in existing populations for life stage, growth, and movement information. The SAM will be using Western Pearlshell Mussels findings to help preserve and protect existing populations and identify areas for habitat rehabilitation in the Lower Boise River.

*Bryce Marciniak**

Comparison of pectoral fin rays and lapilli for estimating age of Northern Pikeminnow in a montane reservoir

Northern Pikeminnow (NPM) Ptychocheilus oregonensis is native to much of the Pacific Northwest and intermountain west. Historically, NPM inhabited medium to large slow-moving rivers and preyed on juvenile salmonids. Recently, dam construction across much of its native distribution has created ample lentic habitat where NPM is an effective predator. Researchers and managers across the distribution of NPM are contending with declining sportfish populations due to NPM predation. Although research efforts have described NPM diet, movement, and biological characteristics, one important knowledge gap is an evaluation of ageing structures. Sagittal otoliths are widely considered the “gold standard” of ageing structures, but they cannot be extracted or aged consistently from cyprinids. Lapilli are commonly used to age other ostariophysian fishes such as Common Carp Cyprinus carpio, Utah Chub Gila atraria, and Blue Sucker Cycleptus elongatus. Lapilli will be compared to leading pectoral fin rays. Fin rays are a common, non-lethal method of collecting age information from fishes. Northern Pikeminnow were collected via experimental gill net from Lake Cascade, Idaho, in April and May 2022. Structures will be aged by two individuals to evaluate between-reader variation and compare estimates among structures. In total, both ageing structures were extracted from 155 NPM. Sacrificed fish varied from 174-520 mm total length. Mean total length of captured NPM was 348.9 mm (STD = 91.9). The results of this study will provide fisheries professionals with key information on NPM ageing structures and life history.

*Jon Masingale**

The heart of the issue: What drives interpopulation differences in physiological and behavioral plasticity?

Temperature governs physiology and behavior in ectotherms and limits the distribution of coldwater fishes such as trout. We are evaluating how a suite of genetic and plastic traits influence the adaptive capacity of redband trout (Oncorhynchus mykiss gairdneri, RBT) to changing thermal regimes, including how diel variation in stream temperature affects traits. We evaluated physiological and behavioral traits in RBT collected as fry from nine streams throughout Idaho spanning a thermal gradient from desert to cold montane forest. We reared fish in a common garden setting using three constant temperature regimes (15, 18, and 21°C) and three matching diel fluctuating temperature regimes (±2°C). Cardiac function is a limiting factor in thermal performance and tolerance because higher temperatures elevate metabolic demand for O2 and decrease O2 solubility. Trout also exhibit thermal habitat selection behaviors that mitigate losses in physiological performance as temperatures become physiologically stressful and we expected preferred temperatures would correlate to ‘home’ environmental conditions and acclimation history. To evaluate how physiology and behavior were affected by population, acclimation temperature, and diel thermal regime, we measured cardiac function in response to acute warming and quantified thermal preference using a ‘shuttle box’ apparatus that allowed individual fish to select their preferred temperatures. We hypothesized that desert populations will exhibit optimum cardiac performance at higher temperatures than montane populations as a consequence of interpopulation genetic differences. We also hypothesize plastic responses in physiological optima associated and behavioral thermal preference across acclimation temperatures. Finally, we hypothesized that diel fluctuating temperatures will widen the scope of thermal tolerance, increasing the upper thermal range of optimum physiological performance. These data will assess the relative contribution, importance, and interactions among genetic and plastic traits and feed into climate change models to predict adaptive capacity of RBT at watershed scales developed as part of concurrent research efforts.

Darcy McCarrick

Evaluation of non-lethal genetics sampling techniques for fry

Advancements in genetic tools have greatly improved biologists’ ability to monitor and manage fish populations (e.g., parentage-based tagging, genetic stock identification, introgression evaluation). Generally, a small tissue sample, such as a fin clip, is taken to provide DNA for analysis. On most fish this has little to no negative effect on survival. However, sampling a piece of fin tissue may have a larger effect on juvenile fish compared to their adult counterparts. We evaluated the effects of two methods of DNA collection on 1) the post-sampling survival of hatchery-reared Rainbow Trout Oncorhynchus mykiss and Chinook Salmon Oncorhynchus tshawytscha fry and 2) the genotyping success of these samples. Three treatments were evaluated: control (no sampling for genetics); swabbing; and caudal fin clip. Controls were anesthetized and handled. For the swabbing treatment group, an OmniSwab was used to collect the external mucus from the fish. For the fin clip group, a small piece of caudal fin tissue was sampled from the fish and stored on Whatman paper. Daily mortality was monitored for 12 consecutive days. Survival was high in both species for all groups.

Rainbow Trout survival was 98% for the control group, 99% for the fin clipping group, and 93% for the swabbing group. Survival of Chinook Salmon fry was 100% for the control and fin clipping groups and 99% for the swabbing groups. Preliminary genotyping results indicate that fin tissue on Whatman paper is twice as successful as swabbed mucus. Results from this study are encouraging and suggest sampling fin tissue does not negatively affect fry survival and the small tissue samples still produce successful genotyping results.

*Jessica Moon**

Precision of age determination using pectoral fin rays removed with or without the articulating process

Pectoral fin rays can be used as a nonlethal technique to determine age of fish. The standard technique for fin ray removal is to excise the fin ray at the articulating process. However, this technique results in an open wound that could become infected and lead to mortality. We conducted a study in the South Fork Teton River to determine if Utah Sucker, Catostomus ardens, pectoral fin rays removed at the body wall would provide a precise alternative to removing fin rays at the articulating process. We removed pectoral fin rays from 103 Utah Sucker (150-550 mm TL); first pectoral fin rays were removed from both sides of the fish with one fin ray removed at the articulating process and the other removed at the body wall. We mounted fin rays in epoxy and obtained thin sections with a slow-speed saw. Three thin sections were obtained from fin rays removed with the articulating process: standard section distal to the articulating process, a section that was 2 mm distal to the standard section (Distal 1), and a section that was 4 mm distal to the standard section (Distal 2). Thin sections from the fin ray removed at the body wall occurred between the standard and Distal 1 sections. Agreement within one year was 67.0% between the standard section and Distal 1, and 49.5% between the standard section and Distal 2. However, agreement within one year was 78.6% between the standard section and the fin ray removed at the body wall. Age estimates from fin rays removed at the body wall were not systematically biased relative to age estimates from standard sections according to McNemar and Evans-Hoenig symmetry tests. We have provided evidence that removal of pectoral fin rays at the body wall provide a precise determination of age for Utah Sucker.

Caitlin O'Brien

Biological carryover effects from juvenile migration on age at maturity in wild spring/summer Chinook Salmon in the Snake River, USA

Understanding variation in age at maturity is important for endangered species recovery because older, larger spawners contribute disproportionately to the next generation. Conditions encountered during juvenile life stages, such as downstream migration in anadromous salmonids, may have an underappreciated impact on age at maturity. We aim to investigate such factors in the context of carryover effects, where sublethal juvenile experiences affect performance in subadult and adult life stages. Our study objectives are to: 1) characterize long-term trends in the adult age structure of PIT-tagged wild Snake River Chinook Salmon outmigrating 1998-2018, and 2) examine relationships between individual adult age and covariates measured during juvenile or subadult stages (river temperature and flow, juvenile length, migration timing, hydrosystem passage type, and large-scale ocean indices) in a hierarchical Bayesian ordinal probit regression model. Preliminary results show consistent effects of juvenile length on age at maturity, with larger smolts maturing at younger ages. We also detected effects of some riverine and marine covariates, such as smolt migration timing and oceanographic indices in the fall-winter prior to adult return, albeit weaker and more variable than those of juvenile length. Because maturation is the outcome of complex developmental processes occurring over large spatial scales during marine residence, identifying a parsimonious set of measurable predictors is challenging. Likewise, while river conditions during downstream migration may have indirect carryover effects, smolt body size directly integrates conditions throughout freshwater rearing up to that point. Investigating adult age structure and associated environmental and biological covariates will contribute to our understanding of population dynamics for applied conservation.

*Samuel Owens**

Drivers and consequences of Chinook Salmon *Oncorhynchus tshawytscha* juvenile migratory diversity in a wilderness river

The importance of maintaining a portfolio of migratory strategies has been well documented for salmonid populations. The diversity of migratory behaviors, partially expressed by juvenile migration timing, can promote population resilience in highly heterogeneous aquatic environments. For spring and summer Chinook salmon in Idaho, contrasting yearling migratory strategies, downstream rearing (DSR) and natal reach rearing (NRR), have been observed within populations that spawn in the high

elevation mountain rivers. DSR type fish are characterized by their dispersal to large rivers within their first summer, where they overwinter before emigrating to the ocean as 1-year old smolts. In contrast, NRR type fish remain in natal habitats for the entirety of their freshwater rearing stage before spring migration that coincides with DSR individuals. The use of downstream overwintering habitat is often the more productive migratory strategy, illustrated by greater abundances and rates of survival. However, the maintenance of a natal reach strategy suggests that a high elevation overwintering strategy must be advantageous in some conditions. The aim of this research is to explore the relationship between these two strategies by examining how overwinter growth, timing of migration towards the sea, and abundance of returning spawners vary between NRR and DSR emigrants in a population rearing in pristine freshwater habitats. Additionally, we assess if variability in performance between DSR and NRR emigrants is associated with selected environmental variables (e.g., discharge and water temperature) across 15 years of outmigration data.

*Kristen Reece**

Using environmental DNA to assess spatiotemporal variation in Arctic Grayling and Chinook Salmon throughout the Chena River

Chinook salmon (Oncorhynchus tshawytscha), an important subsistence species, have been declining in the Chena River, Alaska since the 2010's, with the lowest run on record reported in 2022. The impact of this decline on their ecological relationship with Arctic grayling (Thymallus arcticus), however, is not well understood. We are using environmental DNA (eDNA) to assess spatiotemporal variation in Arctic grayling abundances at seven locations located above, within, and below Chinook salmon spawning grounds on the Chena River throughout the period of adult salmon migration. This project leverages Chinook salmon count data produced during a Yukon River Basin salmon eDNA study collected in partnership with the Alaska Department of Fish and Game.

At the University of Alaska's Museum of the North, we are developing and implementing eDNA studies relying on species-specific qPCR assays. We filtered eDNA samples from seven sites in the Chena River during three sampling events in the summer of 2022 that coincided with periods of time before, during, and after the Chinook salmon run, respectively. We anticipate finding an abundance of Arctic grayling during the Chinook salmon spawning area of the Chena River. With these findings, we would have a better understanding of how to utilize eDNA sampling as a lower-cost, less-intensive approach to salmon monitoring. This tool has the ability to develop and fine-tune river-specific training and sampling protocols that state, federal, and tribal entities can sustainably employ as part of their long-term salmon monitoring projects.

Phil Saporito

Evaluating the need for regulation change in a popular fishery

Lower Salmon Falls Reservoir (LSFR) is a run of the river hydropower reservoir located on the Snake River approximately 3 km west of the town of Hagerman, Idaho. Lower Salmon Falls Dam impounds water upstream for approximately 11 km, providing a surface area of approximately 292 ha. A lowland lake survey was performed on LSFR from May 3 – 5, 2022 to assess the status of the fish community. In conjunction with the lowland lake survey, sport fish (i.e., Largemouth Bass Micropterus salmoides, and Smallmouth Bass Micropterus dolomieu) were tagged with T-bar anchor tags to evaluate angler use and exploitation rates. Bass collected in the survey exhibited slow growth, yet maintained good body condition (i.e., mean Wr of 112 for Largemouth Bass and 101 for Smallmouth Bass) and quality size structure (i.e., PSD of 40 for Largemouth Bass and 65 for Smallmouth Bass). Lower Salmon Falls Reservoir has been managed for quality bass since 1996 through a seasonal harvest restriction (catch- and-release only from January 1 – June 30), reduced creel (limit of two bass; both species combined), and 305 – 406 mm protective slot limit. Recently, fisheries managers and biologists have been encouraged to simplify regulations where appropriate with the hope of increasing angler participation. Based on survey observations and tag-return data, there may be a chance to amend and simplify portions of the current bass regulations on LSFR and maintain quality fishing.

Sara Schwarz

Effects of domestication practices on genetic variation associated with reproductive traits of Rainbow Trout

Selective breeding programs are commonly used to improve production of commercial aquaculture stocks by selectively enhancing growth, nutritional utilization, fillet quality, etc. However, farming practices can also secondarily enforce selective pressure on other characteristics such as reproductive timing. Historically, commercial

stocks originated from native stocks that spawn in the spring with diverse migration timing but since domestication, commercial stocks have been selectively spawned during fall and winter seasons for many generations which has likely selected for alleles associated with multiple traits related to early reproductive timing. Studies have shown that in native rainbow trout (Oncorhynchus mykiss), adult migration timing for anadromous fish is largely associated with a gene region on chromosome 28 (GREB1L/ROCK1) and subsequently 13 single nucleotide polymorphic (SNP) markers have been discovered to accurately differentiate adult migration timing between individual native trout. However, migration timing has never been assessed for commercial aquaculture stocks. After many generations of domestication selection for early spawn timing (fall/winter), we predicted that commercial aquaculture fish will show more genetic fixation of early migration alleles on Chr28 than typical native coastal trout populations. We also predicted that since anadromous migration timing is not a primary selection target for captive trout, commercial aquaculture fish may have distinct patterns of early versus late allele frequencies than a known native conservation hatchery population that was intentionally selected for early migration and spawning. To investigate the effects of domestication practices on genetic variation associated with reproductive traits of rainbow trout, we used 13 SNP markers on chromosome 28 to evaluate marker diversity in a commercial trout strain across two year classes, in comparison to reference groups that included two summer migrating native strains, two winter migrating native strains, and one summer migrating hatchery strain that has been selected for early reproductive traits (migration and spawning).

Brandy Smith

Does stream connectivity and species assemblage affect fish diet composition in headwater streams?

In northern Yellowstone National Park, tributaries of the Lamar and Yellowstone rivers exhibit an extreme range of confluence gradients and network connectivity, such that fish movement between tributaries and mainstems ranges from negligible to considerable. Degree of fish species sympatry among streams has been shown to influence foraging behavior and diet depending on species-specific traits (e.g., mouth morphology, body size, territoriality). However, investigations of how sympatry varies through time within a stream and the consequences for fish-centered food webs remain limited. Here, we compare two streams representing extremes of network connectivity to evaluate variation in fish diets with species composition, density, and size structure.

During summer and fall 2019-2022, we evaluated monthly fish population demographics and diet contents in Rose and Lost Creek (high and low connectivity, respectively). Lost Creek contains only Yellowstone cutthroat trout (YCT-Oncorhynchus clarkii bouvieri), while Rose Creek hosts YCT, rainbow trout (Oncorhynchus mykiss), mountain suckers (Catostomus platyrhynchus), and longnose dace (Rhinichthys cataractae). In Lost Creek, we observed fish composition, density, and population size structure remained stable over the study period, and YCT diet composition principally varied with fish size. In contrast, the fish assemblage of Rose Creek was highly dynamic. For example, dominance switched between longnose dace and Yellowstone cutthroat trout from summer to fall, and to juvenile mountain suckers in October 2022. Ongoing analyses suggest diets of the Rose Creek fish assemblage vary with species traits, but also assemblage structure and interactions that change seasonally and interannually.

Network connectivity is recognized as a critical factor in the conservation of native fishes, but this study may provide insight regarding its implications for stability and structure of a stream's fish assemblage, which in turn has consequences for riverine trophic ecology.

*Rachael Valeria**

Influence of increasing water temperature on the thermal tolerance of *Gonidea angulata* and its host fish, *Cottus spp.*

Globally, freshwater ecosystems have experienced temperature increases caused by climate change, water management, changes in riparian areas, and thermal pollution. Freshwater organisms are heavily influenced by thermal stress and can only tolerate increasing temperatures until they reach their individual thermal maximum. Increasing water temperatures are impacting freshwater mussels (Bivalvia: Unionoida), which are both ecologically and culturally important. Mussels support aquatic ecosystems much like corals by providing habitat and food, as well as filtering water. They are a First Food for Columbia Plateau Tribes like the Confederated Tribes of the Umatilla Indian Reservation (CTUIR). Mussel harvest remains a treaty right for these tribes, but it is not currently practiced because of the recent and widespread declines in

freshwater mussel abundance. Populations of the Western Ridged Mussel (Gonidea angulata) have disappeared from 43% of their historic range leading to a petition for listing as Endangered under the Endangered Species Act. Although many factors affecting this mussel species are not thoroughly understood, increasing water temperature may be a substantial stressor for both Gonidea angulata and its host fish, sculpins (Cottus spp.). The gills of Cottus spp. are colonized by mussel larvae for a period of their life history, during metamorphosis to the juvenile stage. This poster will present the research planned to investigate the thermal tolerance of Gonidea angulata and Cottus spp., which will provide important information for future mussel habitat management in the Columbia Basin.