42nd Annual

Salmonid Restoration Conference

Taking the Pulse: Measuring Restoration Success

April 29 - May 2, 2025 Santa Cruz, CA

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Taking the Pulse — Measuring Restoration Success

Salmonid Restoration Federation (SRF) produces the largest salmon restoration in California that convenes a diverse range of constituents in the watershed restoration field including non-profits, planners, engineers, biologists, policy makers, academics, students, Watershed Stewards Program members, consultants, academics, tribal members, on-the-ground practitioners, and landowners. It is this wide range of practitioners engaged in science, policy, and restoration that enlivens our annual conference and creates a dynamic venue for learning from "real life" experience and expertise.

SRF is excited to host the 42nd Annual Salmonid Restoration Conference in Santa Cruz, California which affords many opportunities to see and learn about lagoon restoration, post-fire recovery, dam removal, and coastal monitoring. The SRF Conference has grown tremendously and our small organization has navigated the growing pains of producing a high-caliber conference at larger venues in order to accommodate our swelling ranks. To keep the conference costs affordable, SRF will be using a few wonderful facilities this year so come prepared to walk, bike, and be adaptable.

Special Thanks

The Annual SRF Conference is a collaborative effort that brings in the expertise and enthusiasm of our many restoration partners. The SRF Conference could not happen without the dedicated support of SRF Co-sponsors; Session, workshop, and field tour coordinators; SRF Board of Directors and Staff; our many Conference Presenters; and all of the conference attendees who migrate from far and wide to participate in this conference.

Adaptation is the bedrock of evolution and also an underlying principle for people that work in the watershed restoration field. Most of us are used to adapting to policy changes and fluctuations in funding cycles. We are also becoming more adept at weathering landscape changes like drought and ocean conditions that impact salmonids as we seek to restore ecological processes and build resilience into our projects.

Despite the perseverance and persistence of watershed restoration practitioners, we are at a frightening precipice with the attempted wholesale dismantling of the federal workforce and the environmental safeguards that make our collective work possible. SRF values our state and federal colleagues and fisheries programs tremendously and it's painful to witness the impacts of federal layoffs and access to science.

The Annual SRF Conference has become the preeminent meeting of the many diverse sectors that comprise the watershed restoration field. When the framework that supports salmon restoration — the Endangered Species Act, funding, policies that govern science are threatened, the lifeblood of our work to preserve and restore salmon is also threatened.

In this time of disabling polarization, I hope the conference can be a place where we are reminded of our shared humanity and our shared goals of recovering wild salmon in California and beyond.

— Dana Stolzman, Executive Director and Agenda Coordinator

Table of Contents

WORKSHOPS AND FIELD TOURS - TUESDAY, APRIL 29, 2025

Table of Contents

WORKSHOPS AND FIELD TOURS - WEDNESDAY, APRIL 30, 2025

PLENARY SESSION - THURSDAY, MAY 1, 2025

Table of Contents

CONCURRENT SESSIONS - THURSDAY, MAY 1, 2025

CONCURRENT SESSIONS - FRIDAY, MAY 2, 2025 - MORNING

Table of Contents

Table of Contents

CONCURRENT SESSIONS - FRIDAY, MAY 2, 2025 - AFTERNOON

Table of Contents

Using Rapid Assessment Protocols to Gauge the Passability of Barriers to Anadromous Fish Passage, Including Hands-On Experience at Barriers Around Santa Cruz

Workshop Coordinators: **Holly Steindorf**, CA Fish Passage Forum; and **Ross Taylor**, Ross Taylor and Associates

This workshop aims to increase participants' familiarity with rapid barrier assessment techniques used to assess natural features or man-made structures for their ability to provide fish passage for anadromous fishes. The workshop will showcase assessment protocols outlined in Part 9 of the California Salmonid Stream Habitat Restoration Manual: Fish Passage Evaluation at Stream Crossings.

Rapid assessment of perched culvert in the Smith River watershed, 2021.
Photo: Ross Taylor

This workshop will include a classroom and field component. Participants will explore the use of standard techniques for barrier assessment and consider how passage assessment efforts inform both local restoration priorities and the wider body of knowledge on the state of aquatic connectivity across California. Additionally, participants will learn about how to utilize or contribute to records of passage barriers across their working watersheds and connect with resources to advance their fish passage projects as well as the general limitations of native California anadromous fishes to common barrier types.

During the field portion of the workshop and tour, participants will use the techniques introduced in the classroom portion to assess example barriers for passability.

Key Objectives:

- Familiarize participants with benefits and limitations of field assessment techniques.
- Practice assessing barriers via hands-on demonstration.
- Connect participants to existing and emerging data on assessment efforts in their working watersheds.

Integrated Model Development and Application to Game Changers for Salmon Recovery

Workshop Coordinators: **Darren Mierau**, Cal Trout; **Eric Palkovacs**, Department of Ecology and Evolutionary Biology, University of California Santa Cruz; and NMFS Southwest Fisheries Science Center; **David Boughton** and **Nate Mantua, Ph.D.**, NMFS Southwest Fisheries Science Center; and **Jacob Katz, Ph.D.**, Cal Trout

Our community of dedicated scientists, resource managers, and restoration practitioners has worked tirelessly to turn the corner toward the recovery of abundant, self-sustaining populations that are able to withstand climate extremes and produce a harvestable surplus. That said, salmon recovery success stories are unfortunately few and far between. Realistically, what will it take? How will we get there? Where success has been realized, how was it achieved? And while salmon recovery success stories are few, the huge investments made toward watershed restoration, reform of instream flow management, hatchery genetics management, and technical advances in population monitoring and modeling represent important and lasting progress.

But there's much more work ahead to achieve recovery goals. One important step forward is to replace the opportunistic and scatter-shot approach to restoration investment and implementation with watershed, basin-scale, or system-scale efforts that can identify feasible, prioritized, and integrated suites of recovery actions (considering all the H's) to increase the probability of measurable recovery outcomes. Acknowledging that a salmon-focused approach is not likely enough, how can we build broad coalitions based on a broader sense of co-benefits of improved river and wetland functioning?

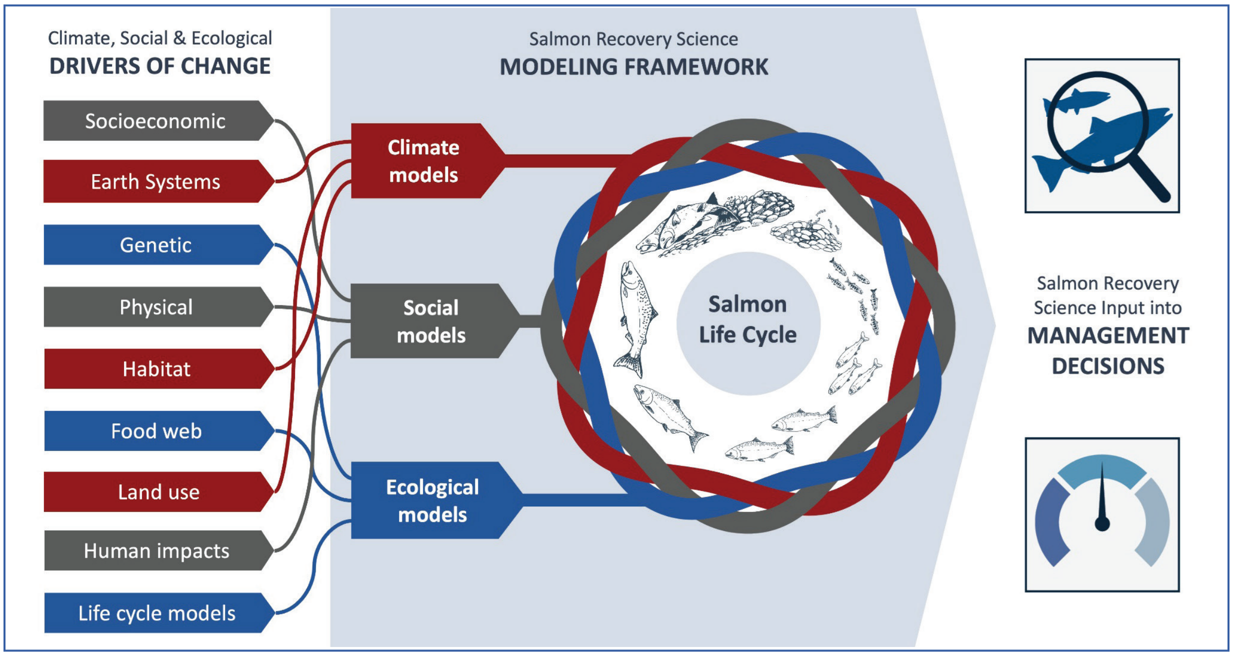
In this workshop, we will: (1) hear NOAA's vision for transformational salmon recovery science, integrated modeling, and restoration programs; (2) hear case studies of salmon recovery success stories that highlight ingredients and recipes for effective planning and action; and (3) explore a few case studies aimed at system-level recovery plans and actions at a range of developmental stages.

Speakers and panelists in parts (2) and (3) of our agenda will address these two questions:

- What are/were the elements of a feasible near-term scenario to improve your populations?
- What are/were the elements of a scenario of full recovery?

Product: A synthesis article describing the workshop elements, lessons-learned about recipes for successful salmon recovery at the watershed/systems-level, and ideas for better linking quantitative integrated models to salmon recovery scenarios and programs.

Integrated Model Development and Application to Game Changers for Salmon Recovery



◀ *Photo: NWFSC Salmon Recovery Science Strategy*

How Can Science Help Accelerate Recovery of Pacific Salmon?

Steve Lindley, Ph.D., NMFS Southwest Fisheries Science Center

Pacific salmon have been in decline throughout western North America for more than 170 years, reaching levels low enough in the 1990s for many populations to be listed as threatened or endangered under the US Endangered Species Act. A quarter century later, none have been removed from the list, and the status of most in California has declined further, in spite of significant investments in restoration and other conservation measures. While we have detailed recovery plans that list numerous actions that would contribute to recovery, it is not known how many of them are necessary, which offer the biggest return on investment, or how they should be combined and focused within recovery domains. An emerging consensus among NMFS scientists concerned with salmon recovery is that integrated models (models that include climate, habitat, and population dynamics across the salmon life cycle) will help identify pathways to recovery that are most cost effective, thereby better focusing management and investments on actions that are most likely to improve status. With support from the Inflation Reduction Act, the NMFS west coast science centers are investing in model development and focused studies that will supply critical information needed by the models. We are engaging resource managers, restoration practitioners, and other interested parties in the process of model development, identification of restoration strategies, and interpretation of results using lessons learned from the Reorienting to Recovery and the Collaboratory for Equity in Water Allocation (COEQWAL) projects. The workshop "Integrated Model Development and Application to Game Changers for Salmon Recovery" is an early effort in this direction. In this talk, I will review the NMFS SWFSC salmon recovery science strategy, 12 recently-funded research projects guided by this strategy, and highlight opportunities for collaboration.

Integrated Model Development and Application to Game Changers for Salmon Recovery

Salmon Recovery Success Stories from British Columbia - Context and Ingredients for Success

Jason Hwang, Pacific Salmon Foundation and **Karilyn Alex**, Okanagan Nation Alliance

In British Columbia, more than 70% of the salmon populations currently have returns that are worse than the long-term average. There are significant concerns about salmon in BC, and many entities are working to improve salmon outcomes. While the recent trends have largely been getting worse for salmon in B.C., there are reasons for hope, and the Okanagan sockeye salmon recovery is one that people in B.C. are turning to as a model for success. The Okanagan success has come in a context where many were skeptical that significant recovery could be possible, and the degree of recovery has been remarkable. This presentation will describe where the recovery work started, the key building blocks, the leadership that was provided, and the progressive plan that has been developed and implemented. We will discuss recent results, the next steps, and how we are using the Okanagan success to inform salmon recovery more broadly for other parts of B.C.

Integrated Model Development and Application to Game Changers for Salmon Recovery

The Elwha River Dam Removal: Over One Decade Later

George R. Pess, Ph.D., Supervisory Research Fishery Biologist and Program Manager, The Watershed Program, Fish Ecology Division, Northwest Fisheries Science Center, NOAA Fisheries

Two dams were removed on the Elwha River, Olympic Peninsula, Washington State September 2011 to April 2012, and were at the time the largest dam removal in the United States. The two main questions asked when describing this large-scale action to those not involved is, how did the fish respond and how was success defined and measured since then? Fish response has been positive for multiple species, and there are multiple "indicators" that point towards ecosystem recovery. Prior to dam removal multiple groups associated with the project including the Lower Elwha Klallam Tribe, Washington State Fish and Wildlife, the National Park Service, the United States Fish and Wildlife Service, the United State Geological Survey, the National Oceanic and Atmospheric Administration, the Bureau of Reclamation, as well as NGOS, worked to identify indicators and metrics to determine success. The work was identified as the Elwha Monitoring and Adaptive Management Guidelines (EMAM). The EMAM was a key ingredient in determining the success on the biophysical side. On the human side, the leadership of the Lower Elwha Klallam Tribe (LEKT) has been paramount to the overall success of the Elwha River dam removal. Multiple science and analytical tools helped before, during, and after dam removal, but those tools, without the leadership of both groups and individuals working together, resolving conflicts, and seeing where there were overall goals and objectives, would not have meant very much in terms of success. The talk will include examples of fish response, ecosystem response, biophysical and human ingredients for success, and what tools were helpful and why.

Oregon Coast Coho — Recovery in Progress

Tim Elder, Wild Salmon Center (Presenter) and Co-author: **Jess Helsley**, Wild Salmon Center

The Oregon Coast Coho Evolutionarily Significant Unit (ESU) was listed as a threatened species under the Endangered Species Act (ESA) in 1998. Prior to listing, the combined effects of high harvest rates, hatchery production, and habitat loss resulted in record-low adult abundances across the ESU. Immediately following ESA listing, harvest rates and hatchery production were dramatically reduced. The Federal Recovery Plan, completed in 2016, identified a lack of winter-rearing habitat as the primary factor limiting Oregon Coast (OC) Coho across their range. Wild Salmon Center (WSC), with state and federal partners, developed a Strategic Action Planning (SAP) process intended to increase the pace and scale of Coho recovery in coastal Oregon. The SAPs use the federal recovery plan as a starting point and convene a multi-stakeholder, population-specific planning process to identify strategic locations and actions where restoration investments will provide the greatest fish benefits. The SAPs utilize fine-resolution climate, fish, and habitat data and evaluate current and future habitat conditions at the sub-watershed scale, allowing for the prioritization of actions and locations to meet population-specific needs.

Since 2018, seven SAPs have been initiated in various OC Coho watersheds, leading to over 43 million dollars in secured funding and the implementation of 58 prioritized restoration projects (completed and in progress). A positive ESU-level response in adult returns has been observed since listing in 1998 and these prioritized restoration actions, combined with other opportunistic restoration actions, have likely provided a population uplift. However, disentangling the effects of reduced harvest and hatchery production from investments in habitat restoration remains challenging. An integrated approach of regulatory reform at the ESU scale (i.e., elimination of hatchery production and reduction in harvest), combined with strategic restoration actions at the watershed/population scale, is providing hope for OC Coho recovery and a potential framework to support other imperiled salmon stocks.

Integrated Model Development and Application to Game Changers for Salmon Recovery

Paving Way for Coho Recovery in the Ten Mile Watershed: A Discussion of Landscape Level Restoration Investments Over 20 Years

Peter Van de Burgt, North Coast Project Manager and **Jennifer Carah**, Senior Scientist, The Nature Conservancy; **Anna Halligan**, North Coast Coho Project Director, Trout Unlimited (Co-presenters) and Co-author: **Ellory Loughridge**, North Coast Stewardship Coordinator, The Nature Conservancy

In winter 2023/2024, the Coastal Mendocino County Salmonid Life Cycle and Regional Monitoring Project estimated that 5,574 adult coho salmon returned to spawn in the Ten Mile River watershed, exceeding the National Marine Fisheries Service (NMFS) Central California Coast (CCC) ESU recovery plan target of 3,700 fish for the first time. This cohort of coho has been the Ten Mile's strongest in recent years and has shown increases from 1,011 fish in 2017/2018 to 2,479 in 2020/2021, and now over 5,000. Between 2017 and 2022, the Ten Mile River watershed had the second-highest number of adult returns per NMFS IP mile of any watershed in the CCC or Southern Oregon Northern California Coast (SONCC) ESUs. These data indicate some success of watershed-based restoration investments and protection efforts. However, good escapement numbers are likely also related to other factors such as recent positive ocean conditions, as well as unique geographic properties of the watershed and favorable land ownership and water use patterns. While the positive trends and recovery target exceedance in the 2023/2024 cohort is a hopeful sign, the two other cohorts do not show consistent positive trends in adult numbers.

In this presentation, we will touch on key ingredients for effective restoration planning and action that we believe have contributed to the early stages of population recovery in the Ten Mile watershed. One key element is watershed-scale restoration investments made over the last 20 years by a wide range of partners including non-governmental organizations (NGOs), public agencies, and timber companies, targeting the highest priority actions identified in the NMFS recovery plan. These efforts include reach-level restoration of instream large wood across most of the mid-and upper- watershed to improve summer rearing conditions and large-scale restoration of coastal floodplain and flow refugia targeting winter rearing and outmigration. These investments address all three of the NMFS recovery plan Priority 1 Immediate Restoration Actions including promoting restoration projects designed to create or restore alcove, backchannel, ephemeral tributary, or seasonal pond habitats; promoting restoration projects designed to create or restore complex habitat features; and retaining, recruiting, and actively putting large wood into streams. While watershed-scale restoration targeting key limiting factors has likely paid early dividends, there is more work to do to support recovery including treating and re-treating mid- to upper-watershed streams to consistently reach or exceed large wood loading targets across the watershed and implementing additional large-scale floodplain and winter flow refugia restoration in the lower watershed. The presentation will conclude with a discussion of key steps to build on the current momentum with the hope of one day achieving resilient recovery for coho salmon in the Ten Mile watershed.

Integrated Model Development and Application to Game Changers for Salmon Recovery

Sharing Butte Creek

Jacob Katz, Ph.D., CalTrout

California's most dramatic example of a sustained population-level response to conservation action didn't come in one of the state's relatively unpopulated, "wild", north coast watersheds such as the Smith River. Instead, smack dab in the center of the Sacramento Valley, Butte Creek spring-run Chinook salmon dramatically rebounded in the midst of one of the largest and most intensively farmed valleys on Earth. And they did so while populations in neighboring tributaries continued to decline.

A couple of hundred spawners were all that returned to Butte Creek from the 60s through the mid-90s when a series of restoration actions removed small dams and screened agricultural diversions. Shortly thereafter the number of returning adults jumped and has averaged between 5,000 and 20,000 a year for the last couple of decades.

The dramatic response of Butte Creek salmon to this suite of impressive but by-no-means-unique conservation actions (similar work has been done in many other CA rivers) is a key piece of this story. For while Butte Creek, a tributary to the Sacramento, flows through hundreds of thousands of acres of farm fields, it also runs through both the Butte Sink and Sutter Bypass, which are the only two landscapes remaining in the Sacramento Valley where a fish-bearing stream is still consistently connected to its floodplain wetlands.

Butte Creek demonstrates the potential for explosive population-level response when a riverscape is able to provide all freshwater life stages with the sequences of biophysical conditions needed to graduate to the next, even amid an ecologically fragmented and highly managed landscape. This talk will also explore the apparent fragility of habitat conditions dependent on water management and aging water infrastructure through the story of the large 2022 and 2023 adult returns, which experienced very significant pre-spawn mortality while holding in canyon pools, fed in part by water carried from Feather River by aging flumes and penstocks.

The Butte Creek watershed has much to teach us about how riverscapes work, how fish use them; about warming water in a warming world, catastrophic fires, obsolete hydro infrastructure, inter-basin water transfers, and (more positively) the emergence of farm/water/fin/feather coalitions dedicated to landscape-scale change.

Watching Sharing Butte Creek, a half- hour PBS film prior to the workshop is recommended.

Integrated Model Development and Application to Game Changers for Salmon Recovery

On the Renewal of Carmel River and its Steelhead

David A. Boughton, Ph.D., NOAA Fisheries, Southwest Fisheries Science Center

In the early 1990s, the people of Carmel Valley made a definitive pivot away from rapid growth and development and toward restoring their local river system and recovering its steelhead. About a decade ago, I and various collaborators began working with local steelhead supporters to study the response of the steelhead population to these efforts. Here I review some of what the steelhead have revealed to us about aquifer regeneration, fish rescues, dam removal, dam retention, and the inherent demographic resilience of a mixed steelhead/rainbow-trout population in a semi-arid setting. In many ways, the renewal effort has been a success, but trying to characterize success is tricky and inevitably thought-provoking, in part due to the interplay of environmental variability and resilience.

Integrated Model Development and Application to Game Changers for Salmon Recovery

Klamath River – Understanding Where We Are Going, Sequencing Actions and Expectations

Tommy Williams, Ph.D., NOAA Fisheries, Southwest Fisheries Science Center

After decades of effort, four dams on the Klamath River have been removed and anadromous salmonids are returning to a landscape they had been excluded from for over a century. This happened as a result of committed efforts to form partnerships across communities including tribal, local, regional as well as federal, state, and local agencies, communities, and organizations. The tribal commitment and stewardship guided planners to take a long view of the River, the fish, and the Basin as a whole. This guidance encouraged those planning fish restoration in the Basin to take an approach that focused on understanding the historical conditions and river processes. As a result, the focus has been and continues to be on restoring ecological and physical processes that will lead to self-sustaining populations of salmon and the ecosystems where they were historically found. This required all partners to lock in and focus on those actions (or inactions) that would give the Basin the best chance, over time – many generations of fish – to restore a connected, dynamic, and resilient Basin for anadromous fish. With dams removed and fish finding their way upstream, restoration activities continue as does monitoring to assess where we are in terms of restoring those physical and ecological processes that will allow for reestablishing self-sustaining fish populations – how and when do we know when we get there?

Investment and Approach – NOAA Restoration Center's Role in Salmonid Recovery on the Pacific Coast

Ruth Goodfield, NOAA Restoration Center

NOAA has a long history of supporting our partners' habitat conservation efforts through funding sources and expert technical assistance. Recent funding has opened unprecedented opportunities to bring that expertise to transformational projects that make an impact on coastal communities and ecosystems. Through the Bipartisan Infrastructure Law (BIL) and the Inflation Reduction Act (IRA), the Restoration Center has been able to invest nearly 1.3 billion dollars into fish passage and transformational restoration projects throughout the coastal U.S. In addition, NOAA has awarded more than 9.2 million dollars in grants funded by IRA to academic partners that will help recover threatened and endangered Pacific salmon.

This presentation will offer insights into NOAA's vision for transformational and comprehensive salmon recovery science, integrated modeling, and restoration programs.

Integrated Model Development and Application to Game Changers for Salmon Recovery

Conducting Watershed-Scale Restoration and Evaluating Reintroduction Pathways in Effort to Return Steelhead to Jalama Creek

Matthew Mensinger, University of California, Santa Cruz (Presenter) and Co-authors: **Walter Heady, Jeanette Howard, Laura Riege**, and **Keith Miller**, The Nature Conservancy; **Ian Budesa**, and **Eric Palkovacs**, University of California, Santa Cruz; **John Carlos Garza, Ph.D.**, NOAA Southwest Fisheries Science Center; and **David Herbst**, Sierra Nevada Aquatic Research Laboratory

Historically, coastal rivers and streams in Southern California supported anadromous *Oncorhynchus mykiss* life histories (i.e., "steelhead"). Human actions have since led to precipitous declines in steelhead populations throughout the region, resulting in this Distinct Population Segment being federally listed as Endangered in 1997. In 2017, The Nature Conservancy acquired the Dangermond Preserve in Santa Barbara County, which includes 94% of the Jalama Creek watershed. While this basin is designated as a critical habitat for Southern California Steelhead, they have not been observed in Jalama Creek in over 25 years. In partnership with the National Marine Fisheries Service (NMFS) and California Department of Fish and Wildlife (CDFW), we report here on an ambitious project to return steelhead to the watershed and position Jalama Creek as a regional stronghold. Since Fall 2023, two fish passage barriers have been removed, opening access to over 15 km of potential steelhead habitat. Now, we are evaluating options to exclude cattle from the creek which has been used as the principal water source to support ranching operations for the last 200 years. As restoration continues, we ask these key questions: 1) When will Jalama Creek be ready for reintroduction?, 2) How will we move fish into the watershed?, 3) Where will these fish come from?, and 4) How should we monitor them post-reintroduction? Overall, this project has the potential to be a "game changer" in salmonid conservation because it combines a protected watershed with a strong foundation of partnerships and the opportunity to pioneer innovative approaches to restoration and reintroduction.

Landowner Willingness as a Critical Variable in Integrated Modeling for Tuolumne River Salmon Recovery

Willam Eisenstein, Ph.D., River Partners

Between various public and private entities, including River Partners, Tuolumne River Trust, Tuolumne River Conservancy, Turlock Irrigation District (TID), Modesto Irrigation District (MID), and San Francisco Public Utilities Commission (SFPUC), approximately 8 contiguous miles of the Tuolumne River near La Grange will be restored in the next few years. Lessons learned from this case study of a system-level habitat program so far include the benefits of landowner support, collaboration between restoration organizations, benefits and improvements that could be made to Cutting the Green Tape permits, and the importance of material procurement. The Lower Tuolumne River Habitat Restoration Plan, developed in 2000, identifies restoration actions along the entire river. Most of these have not been implemented, due to a lack of willing landowners and/or funding. The primary factor currently affecting restoration site selection is landowner willingness. However, River Partners has successfully implemented a landowner outreach program in the past year on the Tuolumne and identified over a dozen willing sellers. Life-cycle modeling, if developed over the next few years, could help inform investments in the next suite of restoration actions on the Tuolumne. The presentation will focus on the need for adaptability in modeling and plan implementation to reflect the discrepancy between model-based system optimization and landowner willingness, and the socio-economic feasibility of project implementation.

Integrated Model Development and Application to Game Changers for Salmon Recovery

Reorienting to Recovery in the Central Valley: Adapting Decision Support Models to Advance Values Informed, Landscape Scale, and Equitable Decision-Making

Liz Stebbins, FlowWest; **Alison Collins**, The Metropolitan Water District of Southern California (Co-presenters) and Co-authors: **Mark Tompkins** and **Erin Cain**, FlowWest; **Rene Henery, Ph.D.**, and **Natalie Stauffer-Olsen, Ph.D.**; Trout Unlimited; **Brian Crawford, Ph.D.**, Compass Resource Management; **Rafael Silberblatt**, Kearns and West; and **Darcy Austin**, State Water Contractors

The Reorienting to Recovery (R2R) effort seeks to create a transparent, equitable, and inclusive pathway to salmon recovery in California's Central Valley and Bay Delta by bringing together diverse parties and interests, including State and Federal Agencies, Tribes, conservation NGOs, water managers, commercial and recreational fishing, agriculture, and other interest groups to 1) develop a shared, scientific definition of salmon recovery outside the confines of existing regulatory processes, 2) identify the diverse range of participants' other related values via storytelling, dialogue, and mirroring, and 3) apply structured decision making (SDM) to identify preferred suites of actions that recover Central Valley Chinook Salmon populations while equitably balancing benefits and impacts across the range of participant values. Despite significant investments in salmonid modeling through prior adaptive management efforts, existing models are often restricted to targeted areas rather than addressing a comprehensive suite of management actions, which does not allow for inclusive collaborative processes and hampers widespread recovery. R2R addresses this limitation by adapting existing decision support models to integrate actions across habitat, hatcheries, harvest, and hydrology (the four H's) into a comprehensive model. The R2R technical team adapted the Central Valley Project Improvement Act Science Integration Team (SIT) Decision Support Models (DSMs), existing life cycle models that leverage the best available research to predict annual Chinook salmon population metrics across the Sacramento and San Joaquin watersheds. The updated R2R life cycle models integrate data on habitat, hydrology, hatcheries, and harvest to provide a holistic view of potential outcomes for salmon populations. The expanded life cycle models predict that biological recovery of fall-run Chinook salmon can be achieved through a combination of actions addressing these four H's. Our findings show that salmonid recovery is possible in our system and outline the combinations and scale of management actions necessary to get there. The R2R portfolio of actions and models provides a roadmap for salmonid recovery in the Central Valley. R2R's continued commitment to transparency and accessibility of the tools we develop will ensure that these models and our chosen suite of management actions to achieve salmonid recovery equitably can be utilized widely beyond our project, supporting sustained and collaborative conservation efforts.

Integrated Model Development and Application to Game Changers for Salmon Recovery

Floodplain Forward: Aligning Ecological and Economic Outcomes

Jacob Katz, Ph.D., CalTrout

With the Sacramento River's native fish balanced on the very edge of extinction, recovery of endangered Sacramento River salmon populations requires transformational change now. Like most major rivers in the developed world, the Sacramento River Valley has been extensively leveed and channelized, leaving only a scattered remnant of hydrologically-activated floodplains.

Restoring or replicating ecological function at a watershed/landscape scale requires an understanding of the social and economic structures that have altered these functions over time. We inherit not only the built environment – dams, diversions, levees, roads, and farm fields – from previous generations, but also the ways of thinking – ecology, economics, the legal framework – that justified these investments. Existing infrastructure is the physical embodiment of a worldview that nature could be controlled without costs that exceed the benefits. Our understanding of the costs and consequences of interrupting nature is evolving as we bear witness to diminished water resources, increased catastrophic wildfires, rising sea levels, species loss, etc.

Environmental crises are born from human land and water uses that interrupt the natural processes that create and sustain the patterns of landscape-scale biophysical conditions to which native biota is adapted. Resource management and the landscape modifications and infrastructure undertaken to achieve it have altered the flow of energy and material through the landscape: these include the patterns of fire through forests, grazers through grasslands, sediment through rivers to estuaries and beaches, and water through landscapes.

Enter The Floodplain Forward Coalition consisting of over 27 organizations of landowners, irrigation districts, university researchers, fishermen, and fish and bird conservation NGOs in the Sacramento River Basin, dedicated to reactivating the Sacramento Valley floodplain to benefit fish, wildlife, and people. The coalition, motivated by the belief that "only with landscape-scale restoration can we expect a population-level response," has collectively developed a portfolio of ridge top to river mouth projects, including in-river salmon restoration actions and stages of the salmon life cycle with the ultimate goal of population recovery in the Sacramento River Valley. These multi-benefit projects provide nature-based solutions that not only improve ecosystem conditions for salmon and other wildlife, but also replenish groundwater supplies and enhance floodplain resilience for the benefit of local communities.

Integrated Model Development and Application to Game Changers for Salmon Recovery

Restoration in Reconciled Aquatic Ecosystems in the Wildland Urban Interface: Mill Creek, Lower Russian River Watershed, Sonoma County, California

Matt O'Connor, Ph.D., CEG, Coast Range Watershed Institute (Presenter) and Co-authors: **Jeremy Kobor, M.S.**, PG and **Michael Sherwood, B.S.**, PG, O'Connor Environmental, Inc.

The term "reconciled" describes aquatic ecosystems that are irreparably altered from "natural" conditions yet retain habitat worth managing. California river systems are reconciled to varying degrees by reduced streamflow. Restoration in reconciled ecosystems may require unique assessment criteria, restoration objectives and implementation methods. Mill Creek's reconciliation factors include hydrogeomorphic change and the "wildland-urban interface" (WUI) prevalent in the watershed. Identifying strategies for watershed-scale restoration requires resource inventory, analysis of ecosystem processes, planning, and long-term local and institutional investment of resources. Mill Creek in the lower Russian River provides a case study for habitat restoration targeting recovery of the federally listed Central California Coast Coho Salmon evolutionarily significant unit.

Coho salmon habitat restoration to-date in Mill Creek owes to its status as a "Core Area" in the federal species recovery plan and has benefitted from extraordinary investments. These include the Russian River Captive Broodstock Program (CDFW, Army Corps of Engineers, California Sea Grant), the NFWF Coho Partnership (2010-2020), development of datasets describing fish use and habitat (CDFW, California Sea Grant, Sonoma Water), hydrologic data from gauge sites in the watershed (Trout Unlimited), outreach to landowners and implementation of restoration actions (Sonoma Resource Conservation District, Trout Unlimited), and hydrologic and ecohydraulic modeling (CRWI and OEI). CDFW's North Coast Salmon Project also assessed Mill Creek conditions and restoration priorities (2024). These efforts provide an excellent basis for restoration planning.

Limiting factors affecting coho salmon in Mill Creek are streamflow and in-stream habitat; intermittent and perennial reaches are vulnerable to drought and changes in streamflow induced by climate change. Summer habitat is limited by streamflow in the upper watershed. Spring outmigration of coho smolts is limited by loss of streamflow to groundwater. In-stream habitat is affected by historic logging in redwood/ Douglas-fir forest, development of rural homesteads, and stream-side roadways have reduced in-stream large woody material (LWM) reducing summer and winter rearing habitat. Spawning habitat in the confined channel system is limited in the absence of abundant LWM.

Restoration planning needs to focus on enhancing streamflow and in-stream habitat. Near-term streamflow enhancement could be achieved using small reservoirs for flow releases in critical periods. Long-term streamflow enhancement could potentially be achieved by forest management to simultaneously reduce fuel load and modify forest stands to reduce evapotranspiration and increase streamflow in spring and summer. In-stream habitat enhancement is being pursued at present through engineered LWM loading in a one-mile reach of critical summer habitat in the upper watershed. Spawning and winter rearing habitat would improve owing to LWM structures that will accumulate spawning gravel and provide improved winter velocity shelter.

Integrated Model Development and Application to Game Changers for Salmon Recovery

The Eel River on the Threshold of Transformative Change for Basinwide Salmonid Recovery

Darren Mierau, CalTrout, and **Suzanne Rhoades**, Applied River Sciences, (Co-Presenters); and Co-authors: **Chistine Davis**, Cal Trout; **Scott McBain**, and **Tim Caldwell**, Applied River Sciences; and **Dirk Pedersen, Jay Stallman**, and **Abel Brumo**, Stillwater Sciences

Once known as The River of Abundance, the Eel River historically supported the third largest runs of salmon and steelhead in California, exceeded only by the Sacramento-San Joaquin and the Klamath rivers, with adult salmonids estimated to exceed a million fish in good years. These salmonid populations, other native fish and wildlife species, and the Eel River's ecosystem have been in severe decline since European-American settlement began in the region around 1850. Since then, the Eel River has been transformed from one of the most productive river ecosystems along the Pacific Coast to a degraded river with severely impaired salmonid populations. Current population abundance in the Eel River is now hovering in the 2.5% to 5% range of historical abundance (14,000–18,000 Chinook Salmon, 500–5,000 Coho Salmon).

To reverse these conditions, Eel River restoration proponents (fisheries agencies, tribes, NGOs) have begun developing a basinwide restoration and conservation plan that seeks to restore ecological function and resilient habitats that will in turn support the return of diverse and abundant salmonid populations. The recently completed Phase 1 Eel River Restoration and Conservation Plan proposed a range of feasible actions and a framework for prioritization, a new Eel River management entity to oversee implementation, and a robust monitoring program to assess restoration outcomes. Phase 1 recognized the importance of restoring life history diversity within salmonid species, and the habitats that allow diversity to thrive, as a mechanism for increasing population abundance and resilience. Phase 2 will prioritize recommended actions.

We will present a suite of meaningful ecological restoration and conservation actions that, once implemented, will promote recovery of salmonid population life history diversity and spatial structure, as well as abundance. Recommended actions include (1) removal of Scott Dam and Cape Horn dam to restore migratory access to hundreds of miles of high quality salmonid habitat; (2) establishment of basin-wide instream flow requirements that will protect streamflows during low-flow seasons and droughts; (3) active suppression and long-term management of non-native piscivorous pikeminnow to reduce predation and habitat displacement; (4) targeted and prioritized habitat restoration in tributaries and mainstems to maintain and increase habitat capacity and productivity in key seasons and locations; and (5) large-scale restoration of the stream-estuary ecotone from the Van Duzen River confluence to the Eel River mouth, to restore highly productive estuarine habitat and adult holding habitat. Beyond these initial actions, we seek to prioritize basin-wide actions in a multi-criteria scoring approach that considers the recovery of life history diversity as an essential component of population-level recovery. In future phases, we seek to develop life-cycle models to aid in prioritization, analysis, and refinement of recommended actions. Success will be defined at both the project and program level, with a monitoring and assessment program that seeks to refine hypotheses about the cause-and-effect relationships of restoration actions, short-term ecological and physical responses, and population response metrics.

Integrated Model Development and Application to Game Changers for Salmon Recovery

Upper Shasta River Recovery Actions

Ada Fowler, Ph. D., CalTrout

The Shasta River has exceptional potential to restore coho salmon, Chinook salmon, steelhead and other native aquatic species. Unique among salmon-bearing streams along the Pacific Coast, the hydrology in the Shasta River is driven predominately by springs originating from the slopes of Mount Shasta, a 14,000-foot volcano in the Cascades of Northern California. Due to the springs' cold temperatures, high nutrient content, and consistent year-round flows, the Shasta was once the largest salmon-producing tributary of the Klamath. More than a century of aquatic and riparian habitat degradation along the river has resulted in dramatic declines in its fish populations. The Upper Shasta River and its main tributary, Parks Creek, are of paramount importance to the recovery of anadromous species; and this area of the watershed is widely recognized as the core area for the federally listed evolutionary significant unit of the Oregon/Northern California Coast (SONCC) coho salmon.

This core area in the Upper Shasta Watershed is more than 80% privately owned and primarily used for cattle ranching. For over a decade, water users in the Upper Shasta Watershed have worked with state and federal partners on a voluntary agreement that identified land and water management actions that, if implemented, could help change the trajectory of current salmon population trends in the Shasta River. This area includes 14 individuals, corporations, or entities that collectively own over 30,000 acres and 37 miles of river. Currently, the voluntary agreement is on hold, but there is still a desire by most participants to continue the process of implementing restoration and flow enhancement projects.

Herein, I present an overview of recovery actions that could protect and enhance aquatic and riparian habitats and increase the abundance and distribution of coho salmon. What is needed in the complex social environment of the Shasta Valley are tools to help characterize and prioritize the benefits of restoration actions and focus limited effort on the most important actions for fish recovery.

Systems-level case studies underway: We will hear from those currently involved in building systems-level recovery plans and actions. Each will respond to the following questions:

- What actions are being proposed?
- Why do you expect to get a population level response from these actions?
- What kind of analytical tools helped in planning, or could help?
- How would you describe your baseline scenario?
- How would you prioritize actions, what tools would be most useful for prioritizing?
- How will you define success?

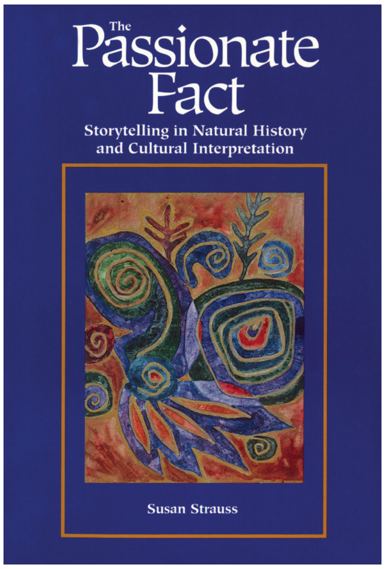
The Passionate Fact: Telling Restoration As Story

Workshop Coordinator: Susan Strauss, Storyteller and Author of *The Passionate Fact*

A biologist's life experience holds a wealth of story material. Personal experience or anecdote is the most accessible story form and can be very effective when communicating with the public about restoration.   In this workshop, participants will refine a personal anecdote and a restoration experience for use in public presentations, while at the same time, develop an understanding of the "storytelling way of giving information" - or how to translate experience into story. Participants will leave the workshop confident with their working understanding of new found storytelling skills.

Focusing on personal anecdotes in the morning, participants engage in a series of fun activities that reveal specific attributes of story narrative and storytelling skill. These group and partnered activities provide participants with an experience of how story does its work and provides knowledge of the essential elements for creating compelling communications. These include:

- Transforming information into imagery.
- Developing a sense of the "hook phrase" and ending.
- Exploring compelling story structures.
- Use of repetition.
- Building the element of mystery and climax.
- Development of sensory experience.
- Use of metaphoric language.
- Use of voice: character dialogue, sound effects, and the picture-making capacity of language.



Through the progression of these activities, participants' personal anecdotes are refined and prepared for effective public telling. The tools that are presented and practiced throughout the morning will be applied to the afternoon work on restoration stories.

Focusing on a particular restoration experience in the afternoon, participants will develop a story out of this. Activities for guiding this work will be collaborative and give practice telling shorter and longer versions of the same story — preparing participants for sharing their restoration story in multiple public settings, formal and informal.

Pre-workshop guidance will be sent to participants so they can give thought to stories for sharing in the workshop — both, personal childhood experiences in nature and an experience from their professional life in restoration work. Think and ruminate about these stories, don't write them out as text.

The target audience for this workshop includes: permitting Natural Resource managers, students, tribal partners, agency personnel, consultants, scientists, technical experts, and NGO staff.

Rancho Cañada Floodplain Restoration Project

Tour Coordinators: **Katrina Harrison**, Applied River Sciences, and **Jim Robins**, Alnus Ecological

The Rancho Cañada Floodplain Restoration Project provides an example of how to implement a large process-based restoration project in a constrained system. A Stage 0 design is not an option due to the upstream housing development. However, the channel evolution state that provides the second highest level of ecological benefits according to Cluer and Thorne (2013), Stage 8, is possible here. Therefore, the designs include excavating over 600,000 cubic yards of sediment to recreate a wide floodplain inset within the former golf course.

Carmel River at the Rancho Cañada Floodplain Restoration site
Photo: Ben Snyder

This walking tour of the Rancho Cañada Unit of the Palo Corona Regional Park will include speakers from the National Marine Fisheries Service (NMFS), Monterey Peninsula Regional Park District (MPRPD), Trout Unlimited, California Coastal Conservancy, Applied River Sciences, and others who will provide an overview of the project and tour of the restoration site. On site presentations will include inspiration, lessons learned, and challenges overcome with focus on restoration of stream channel and active floodplain including:

- Stream Evolution Model and Stage 8 - Brian Cluer, NMFS
- Building coalitions for restoration
- Carmel River streamflow - Tim Frahm, Trout Unlimited
- Funding restoration
- Streamlined permitting pathways - Jim Robins, Alnus Ecological
- Restoration near the urban interface
- Managing multiple benefits on public lands - Rafael Payan, MPRPD
- Educational opportunities for a range of constituents
- Consideration of basin-wide conditions and the role of lower floodplain restoration

Monterey Peninsula Sleepy Hollow Steelhead Rearing Facility Tour

Field Tour Coordinators: **Brian LeNeve**, Carmel River Steelhead Association; **Cory Hamilton**, Monterey Peninsula Water Management District; Doug Smith, California State University Monterey Bay (CSUMB); and **Julio A Gonzalez**, California American Water

One of the functions of the Monterey Peninsula Water Management District's (MPWMD) environmental resources program is to rescue and rear naturally-born juvenile steelhead with the objective of assisting the restoration, conservation, and maintenance of the steelhead population at viable levels in the Carmel River Basin as mitigation for environmental impacts caused by diversion of surface and subsurface streamflow in the lower twenty-four miles of the mainstem Carmel River and subunits of the Carmel Valley Alluvial Aquifer. The program began before the listing of steelhead as a threatened species under the Endangered Species Act (ESA) in 1997. In fact, seven years earlier, the program was initiated as a mitigation requirement from the District's 1990 Environmental Impact Report (EIR) for its Water Allocation Program (Mintier et al., 1990), developed to comply with the California Environmental Quality Act (CEQA).

Remnants of San Clemente dam after dam removal.
Photo: Brian LeNeve

Steelhead rescues on the Carmel River were started in the late 1970s by the Carmel River Steelhead Association (CRSA). Once the MPWMD program started, the two programs were mostly combined to where now cooperation between agencies and non-governmental organizations (NGOs) have developed a unique program to try and save what is left of a once thriving run of steelhead that numbered over 10,000.

We will tour the MPWMD's Sleepy Hollow Steelhead Rearing Facility, where up to 40,000 steelhead rescued from drying sections of the Carmel River can be reared until it rains and the Carmel River runs again. While you will not see any fish in the facility at this time, you will see the complete rearing facility including the 800 ft long artificial rearing channel, tanks, filtration methods, water conditioning methods, pumps and screens. We will also talk about rearing methods and adaptive techniques utilized over the many years.

MPWMD and CRSA will discuss steelhead rescue methodology, how they are done, where they are done and what we are accomplishing and have learned over the years. As a bonus we will drive less than four miles to see what a dam removal looks like after almost 10 years. Representatives of the old dam as well as academics from CSUMB will discuss what was done to help the river recover and how the river has actually recovered.

Process-Based Restoration on Paicines Ranch Tour

Field Tour Coordinator: **Kevin Swift**, Swiftwater Design

This full-day field tour will highlight process-based restoration (PBR) efforts taking place at the 7,500-acre Paicines Ranch in San Benito County. Since 2001, Paicines Ranch has been working with natural systems to regenerate the ranch ecosystem while producing food, fuel, and fiber, much of which is sold locally, helping to create a resilient local food system.

For more than a decade, Paicines Ranch owner Sallie Calhoun and partners have been laying the groundwork to restore the upper reach of this imperiled river that once supported steelhead trout. Key strategies include holistic livestock management and focusing on restoring natural river processes.

Process-based Restoration on Paicines Ranch structure
Photo: Kevin Swift

The San Benito River runs approximately 7 miles southwest to northeast down the middle of the ranch. The river is dammed approximately 60 miles upstream at Hernandez Dam, built in the 1930s to provide flood protection. The river is silt-laden and despite the dam, can experience large spring flows.

In 2024 Paicines Ranch hired Swift Water Design to install a 30-structure PBR build to provide significant water quality and hydrologic benefits to the river system and ranch ecosystem.

A couple miles upstream of the build there was a sudden geomorphic change in the 2022/2023 winter. In three days, a 12-foot deep, 2-acre section of pasture mobilized, cutting through an oxbow and dewatering a mile of stream. This dramatic change provides an opportunity to consider various restoration techniques, including taking no action, and their likely effects on the evolution of the channel and surrounding vegetation.

In this tour we will get an introduction to the principles of PBR and how using local materials and hand tools can effect geomorphic and biologic changes within the riverscape. We will learn about the potential for integrating PBR into a working ranch, Paicines' grazing practices, and the changes in land-use and vegetation over time.

Potential discussions include: what it took for a novice to permit the project, how to rapidly respond to drastic site condition change between design and implementation, the potential for using road crossings as restoration measures, beaver reintroduction site selection, statewide beaver restoration updates, build challenges of sand bed systems (significant), water quality issues, navigating complex neighbor relations, and more.

California Estuarine Marine Protected Act (EMPA) Monitoring Program

Workshop Coordinators: Kevin O'Connor, Central Coast Wetlands Group;
Jan Walker, Southern California Coastal Water Research Project; and
Christina Toms, San Francisco Bay Regional Water Quality Control Board

The California Estuarine Marine Protected Area (EMPA) Monitoring Program is an ongoing Ocean Protection Council-funded effort to assess the quality and condition of estuaries statewide, including but not limited to estuarine Marine Protected Areas (MPAs).

The workshop will include presentations on the EMPA Monitoring Framework including the development process, standard monitoring protocols and data structures, where the framework is being implemented, and how to incorporate it into new and existing monitoring programs. Following the presentations there will be a field demonstration of several of the monitoring protocols in the San Lorenzo River Lagoon. This workshop and field trip is a great opportunity for conference attendees and other interested parties to be trained on eMPA protocols, and help build a more comprehensive picture of estuarine health in California.

Central Coast EMPA field team conducting beach seines in the Pajaro River Estuary
Photo: Kevin O'Connor

Fish & Fire 2025: Where There are Fish, There is Fire

Workshop Coordinators: **Lenya Quinn-Davidson**, University of California Agriculture and Natural Resource and **Josh Smith**, Watershed Research and Training Center

Smith River Complex
Photo: Lenya Quinn-Davidson

2024 brought another major fire season to California, and more reminders of the interconnectedness across fire, water, and fish. Like so many fires before it, the Park Fire has daylighted several interesting intersections: the potential for high-severity fire in critical watersheds like Mill Creek (one of the last Central Valley strongholds for wild spring-run Chinook), the need for suppression activities and retardant drops to carefully consider fish habitat and infrastructure (like the fish hatchery in lower Battle Creek), and the reality that the same fire can be both damaging and restorative across the larger landscape, especially in a place that evolved with frequent fire. This workshop will continue the Fish & Fire conversation started over the last two years of SRF conferences, highlighting recent examples like the Park Fire and digging further into the ecology of fish and fire, the impacts of fire exclusion and fire suppression on aquatic habitats, and the potential for restoration practitioners to more meaningfully bring fire into the way they envision and implement their work. The first part of the workshop will focus on relevant research and management examples, and part two will be more hands-on, including dialogue and training on the use of beneficial fire. By the end of the day, participants will have a better understanding of the many connections between fish and fire, more contacts and networks to bridge the two disciplines, and new skills and inspiration that they can bring to their restoration work.

Fish & Fire 2025: Where There are Fish, There is Fire

Fire: From the Headwaters to the Estuary

Don L. Hankins, Ph.D., California State University, Chico

The decline of native fisheries across western North America stems from multiple causes including land use change, degraded ecosystems, altered natural processes, virtually all of which contribute to the climate crisis. While hydrologic processes are fundamental to fisheries, fire is similarly fundamental. However, not all fires provide negative feedback that enhances the native fisheries. While fish and fire have coexisted throughout the evolutionary history of fishes, some types of fire have been more conducive to supporting robust fisheries. Indigenous fire stewardship has been integral to maintaining ecological benefits and climate resilience across catchment systems. The influence of Indigenous fire stewardship is deeply connected to fisheries benefits as ecocultural outcomes across terrestrial and aquatic systems from mountain peaks to the tidal zone and beyond. The practices and lessons of stewardship are essential to addressing fisheries recovery.

Fish & Fire 2025: Where There are Fish, There is Fire

Fire, Fish, and Flows: Community-led Climate Modeling for the Karuk Ancestral Territory

Cleo Woelfle-Hazard, Ph.D. (Presenter), Fire Advisor, Humboldt & Del Norte Counties; **Leaf Hillman**, Ceremonial Leader and Cultural Practitioner; **Andrew Newman, Ph.D.**, Research Applications Lab, National Center for Atmospheric Research (NCAR); **Daniel Sarna-Wojcicki, Ph.D.**, Independent Scholar; **Yifan Cheng, Ph.D.**, Assistant Professor, University at Buffalo; **Naoki Mizukami, PhD.**, NCAR; **Danielle Touma, Ph.D.**, Research Scientist, University of Texas, Austin; **Danica Lombardozzi**, Assistant Professor, Colorado State University

Indigenous and place-based communities increasingly rely on climate change projections to guide management activities. Karuk Tribe managers and their partners are looking to a variety of watershed restoration interventions to buffer the effects of flooding and drought. Upland forest management using prescribed or cultural fire can potentially reduce evapotranspiration and increase infiltration. While Tribes like the Karuk and Yurok have long used cultural fire to manage streamflow and moderate late-summer stream temperature, few climate model experiments have explicitly evaluated the effects of restoring Indigenous fire management practices at the landscape scale. In forests where fire suppression and timber industry practices have increased forest density, re-introducing intentional fire is increasingly recognized as critical for reducing catastrophic wildfire and also reducing evapotranspiration, potentially increasing dry-season streamflow and benefitting salmonids by sustaining summer cold water refugia. Beginning in 2019, academic and Karuk partners worked with National Center for Atmospheric Research (NCAR) climate modelers to explore relations among fire, land cover, evapotranspiration, and streamflow in current and future climate scenarios. We used the Community Terrestrial Systems Model (CTSM) developed at NCAR, a land-surface model that includes complex snow, soil, and vegetation processes. Our team, co-led by Karuk cultural practitioner Leaf Hillman, set out to create a "counter model" using historical and future cultural fire scenarios as inputs to the CTSM, within a cultural context group made up of Native and natural resource managers. Ensemble climates were developed using the Community Earth System Model version 2 large ensemble (CESM2-LE) for 30-year historical, mid, and end of the 21st century time slices under SSP3-70.

We analyze the process of developing a fire-vegetation-water-fish model for the Karuk Ancestral Territory, along the Klamath River, as a world-making practice, exploring what shared questions and understandings emerged, and where water and fire worlds fundamentally diverged. We critically evaluate how models are constructed, by and for whom and the resulting distributions of benefits and harms of different modeling processes, outputs and outcomes.

After generating hydrological outputs based on these land cover layers, community partners evaluated (1) whether the model produced plausible outputs, as judged by local knowledge, and (2) how useful these outputs were for local managers seeking to plan fire and watershed restoration projects. Iterating between community knowledge and model development can generate a more robust model configuration that is more representative of local landscape ecological processes and is built to reflect the concerns and priorities of Indigenous land managers. We present principles to guide future collaborations between modelers and place-based communities around the issues of fire and streamflow modeling.

Fish & Fire 2025: Where There are Fish, There is Fire

Food Webs of 10 Lakes Before and After a Mega-Wildfire

Christine A. Parisek, Ph.D., University of California, Davis, Department of Wildlife, Fish, & Conservation Biology, and Center for Watershed Sciences (Presenter) and Co-authors: **Steve Sadro**, University of California, Davis, Department of Environmental Science & Policy, and **Andrew L. Rypel, Ph.D.**, University of California, Davis, Department of Wildlife, Fish, & Conservation Biology and Center for Watershed Sciences

Understanding the ecological effects of climate-driven wildfires is of increasing importance. For example, the seven largest wildfires in state history all occurred within the last four years, but little is known about direct fire effects on fishes, food webs, and freshwater ecosystems. During summer 2021, the Dixie fire burned approximately one million acres in Northern California. This massive fire engulfed the entire watersheds of ten lakes along an ecosystem size gradient that our team sampled extensively pre-fire during the summer of 2020 in the Lassen National Forest, Caribou Wilderness, CA. These sampling efforts included studies of fish populations and food webs of all burned lakes. We subsequently resampled these same ecosystems post-fire (summer 2022, 2023, and 2024) to understand how the severity of fire impacted lake ecology. Preliminary results suggest a shift in primary consumers (zooplankton) as a function of burn severity and lake volume. We observed declines in the abundance of fishes in almost all lakes, and in some cases, the decline was substantial (Catch Per Unit Effort [CPUE] declined 19-100%; mean 68%). Yet burn severity alone was not a significant predictor of pre- and post-fire CPUE difference. The mean condition of trout increased in four lakes post-fire and decreased or remained constant in two lakes post-fire. Future research is examining how the fire-driven loss of fishes reverberates through food webs to affect the lake ecology more generally. We seek collaborative opportunities to continue this work and hope these data aid decision-makers in managing these resources moving forward.

Fish & Fire 2025: Where There are Fish, There is Fire

Linking Fire and Fish: The Importance of a Whole-Ecosystem Perspective

David Roon, Oregon State University (Presenter); and Co-authors: **Kevin Bladon**, Oregon State University; **François-Nicolas Robinne**, Pacific Salmon Foundation; **Becky Flitcroft**, United States Department of Agriculture Forest Service; **Jana Compton**, **Joe Ebersole**, Environmental Protection Agency; **Ryan Bellmore, Ph.D.**, United States Department of Agriculture Forest Service; **Joe Benjamin, Jason Dunham**, US Geological Survey; and **Dana Warren**, Oregon State University

Wildfires can have complex and varying effects on aquatic ecosystems depending on fire characteristics and the ecological context of watersheds. This variability creates challenges for predicting fire effects on species of social and conservation interest, like salmonid fishes (*Oncorhynchus spp*.). As fire regimes shift, resource managers need to identify where wildfires pose risks to aquatic habitats and fish. To predict these vulnerabilities effectively, a deeper understanding of how and why fires influence aquatic ecosystems can be informative. For example, light availability and temperature in streams often increase after fires, accompanied by increases in sediment, carbon, and nutrient transport, but the nature of these changes and how they interact depends on context and can have varied effects on aquatic biota. Whole-ecosystem perspectives are essential to synthesizing aquatic responses to fire and identifying the mechanisms driving those responses. In our presentation, we will describe two approaches using whole-ecosystem perspectives to better understand wildfire effects on aquatic systems and species in the Pacific Northwest. First, we applied food- web simulation models to explore how wildfires influence aquatic ecosystems across multiple trophic levels. Our model simulations enabled us to explore how variation in fire severity can influence aquatic ecosystem responses in forested headwater streams of the Pacific Northwest, highlighting the pathways driving those responses. Preliminary results from model simulations revealed the importance of stream temperature as a major driver and indicated that wildfires can have diverse effects on aquatic ecosystems, varying extensively over time, with fire severity, and across trophic levels. Second, we conducted a post-fire, watershed-scale field study in the Hinkle Creek watershed in western Oregon—an area intensively monitored in the early 2000s that burned at high severity as part of the Archie Creek Fire in 2020. Preliminary data from this unique pre- and post-fire comparison have revealed some surprising responses. For example, post-fire reductions in riparian canopy cover by 48-63% are associated with increases in post-fire summer stream temperatures by 6°C, yet salmonid populations have shown resilience, not only surviving but increasing in abundance by 1.5-2 times relative to pre-fire levels. Additional post-fire data suggest potential mechanisms driving these fish responses, including spatial variation in stream temperatures and post-fire increases in aquatic productivity. Collectively, these studies highlight the value of whole-system approaches, such as food web modeling and post-fire watershed-scale studies, to better understand the mechanisms linking fire and fish.

Fish & Fire 2025: Where There are Fish, There is Fire

Lethal and Sublethal Effects of Fire Retardants on Salmonid Early Life Stages: Establishing Toxicity Thresholds for Aquatic Health

Louise Cominassi, University of California, Davis, Department of Anatomy, Physiology, and Cell Biology, and School of Veterinary Medicine (Presenter) and Co-authors: **Emerson Feddor, Dylan Lin**, and **Amelie Segarra**, University of California, Davis, Department of Anatomy, Physiology, and Cell Biology, and School of Veterinary Medicine; **Patrick Reece**, **Rukmini Raman, S. Blechschmidt**, and **Susanne Brander**, Oregon State University, Department of Fisheries, Wildlife, Conservation Sciences Coastal Oregon Marine Experiment Station

Increased wildfire activity across the western United States has driven extensive use of fire retardants, which often contaminate nearby waterways through runoff and spray drift, impacting aquatic ecosystems. However, data are sparse, particularly for the effects of fire retardants on early life stages of Chinook salmon (*Oncorhynchus tshawytscha*) and rainbow trout (*Oncorhynchus mykiss*). Chinook are particularly vulnerable during out-migration, and trout are a useful surrogate species that is available year-round for testing. Building on previous research on rainbow and brown trout, we are investigating both lethal and sublethal impacts of weathered and non-weathered formulations of the commonly used Phos-Chek retardant and a more environmentally-friendly formulation, Pyrocool, on two early life stages of both salmonids. Embryos and alevins were exposed to a range of concentrations over 96 hours simulating first-flush events following retardant applications. Preliminary data in rainbow trout suggests that LC50s are in line with those previously published and that older alevin may be more sensitive than those still retaining their yolk sacs. Ultra violet (UV)-weathered retardants were also included to represent realistic environmental conditions. Measured outcomes included mortality (LC50), hatching success, and morphological and behavioral changes. We hypothesize that the LC50 of Chinook salmon embryos and alevins will be similar to that observed in trout. We expect to observe reduced hatching success and altered behavior in individuals exposed to sublethal levels of fire retardants compared to control fish, with weathered formulations exhibiting greater toxicity than non-weathered counterparts due to increased potency following UV exposure. Overall, the goal of this study is to underscore the compounded risks posed by fire retardants in salmon habitats already stressed by climate change and pesticide residues. Results will provide critical thresholds for fire retardant concentrations in sensitive habitats, underscoring the need for fire management practices that minimize runoff into salmon-bearing waterways.

Fish & Fire 2025: Where There are Fish, There is Fire

The Klamath Dams Fell, So Let's Get to Work Restoring Fire for the Fish!

Will Harling, Restoration Director, Mid Klamath Watershed Council (Presenter) and Co-authors: **Toz Soto**, Senior Fisheries Biologist, Karuk Tribe Department of Natural Resources; **Charles Wickman**, Fisheries Program Director; **Mitzi Wickman**, Fisheries Project Coordinator; **James Peterson**, Fisheries Project Coordinator; **Rachel Krasner**, Fisheries Project Coordinator; **Bryan Souza**, Fisheries Project Coordinator; and **Eric Darragh**, Fire and Forestry Program Director, Mid Klamath Watershed Council

With the monumental achievement of Klamath dam removal accomplished through unprecedented coordination between Tribes, federal and state governments, and a diverse coalition of non-governmental partners over several decades, there is an opportunity to focus the energy of these and related partnerships on restoring the fire process throughout the Klamath Basin to enhance salmon recovery efforts that can improve instream flows, and the stable inputs of sediment, wood, and nutrients to rapidly recover impacted salmon streams at the watershed scale. While there have been several critical advances in restoring beneficial fire at larger scales through managed wildfires, increased prescribed and cultural fire, and strategic fuels treatments over the past decade, we have seen a resurgence of state and federal fire managers prioritizing regressive fire suppression actions over proactive fire management in 2024.

The management of the 2024 Boise Fire, which burned directly adjacent to the proactively managed 2023 Six Rivers Forest Lightning Complex in the Western Klamath Mountains, highlights how governmental fire suppression agencies are actively resisting the lessons learned from recent successes and seeking to return to full-fire suppression policies that have only deferred risk to future fire seasons and increased the potential for catastrophic wildfires across vast swaths of California and the West. This presentation will help restorationists working in instream and upslope habitats understand how to advocate for beneficial fire management on their landscapes and prepare for the interaction of fire with instream salmon habitat restoration. It will highlight recent instream restoration projects from the Klamath River that incorporate a nuanced understanding of how fire has and will interact with these streams and the project reaches to maximize benefits to salmon while minimizing the need for extensive engineering, permitting, and funding.

Fish & Fire 2025: Where There are Fish, There is Fire

Rapid and Scaled Low-Tech Instream Restoration Can Capture Post-Wildfire Sediment in Historically Depositional Reaches Instead of Important Fish Reaches

Karen Pope, Ph.D., United States Department of Agriculture Forest Service, Pacific Southwest Research Station (Presenter) and Co-authors: **Adam Cummings, M.S.**, **David Dralle, Ph.D.** and **Joe Wagenbrenner, Ph.D.**, United States Department of Agriculture Forest Service, Pacific Southwest Research Station

Headwater stream channels have been modified and simplified, often resulting in an increase in the conveyance of water and sediment through headwater catchments. Severely burned watersheds exacerbate this trend when bare soils enhance the transportation of water and sediment from hillslopes into the simplified stream channels. This post-fire stream sedimentation process can be highly detrimental to fish and other aquatic organisms. Yet, in most cases, very little is done to prevent it. We propose that targeted low-tech process-based restoration actions in low-gradient, historically depositional stream reaches in burned catchments can capture some of the expected sediment by slowing water and trapping sediment. Extensive past erosion and incision in these reaches provide an opportunity to capture large volumes of sediment while also increasing local floodplain recovery. We conducted an experiment where we applied low-tech process-based restoration in burned and unburned headwaters and quantified sediment capture and retention. We also describe a project in which 20 riparian meadows including ~ 14 km of stream were treated in summer 2024 by one crew within the Dixie Fire footprint. The evidence thus far suggests that rapid and scaled low-tech instream restoration treatments capture and store sediment, likely protecting important downstream fisheries.

Remote Sensing Tools for Restoration Planning and Assessment Workshop

Workshop Coordinators: **Emily Fairfax, Ph. D.**, University of Minnesota; **Eli Asarian**, Riverbend Sciences; **David Dralle, Ph.D.**, U.S. Forest Service Pacific Southwest Research Station; and **Mitzi Wickman**, Mid Klamath Watershed Council

Do you want to travel through time, see patterns and colors not visible to the naked eye, and soar thousands of feet in the sky over your field sites? You can - with remote sensing! This full-day workshop provides a hands-on introduction to get you started using remotely sensed datasets and tools for restoration planning and assessment. Thanks to recent technological advances and ever-expanding availability and quality of data, what was once only possible in science fiction is now readily doable from the comfort of your home or office. And this workshop will show you how. We demystify remote sensing by introducing attendees to easy-to-use "no-code" and "low-code" tools, ranging from just your web browser to GIS softwares to simple snippets of R and Earth Engine code.

In the morning, instructor presentations will cover topics including:

- Remote sensing introduction
- Available data types (e.g., imagery, vegetation, topography, land cover, land use, and climate) and what they are useful for
- How to efficiently access and analyze these data to better understand landscape conditions and subsequent response to disturbances and/or restoration work
- A preview of the afternoon activities

In the afternoon, participants who bring laptops* will have a hands-on opportunity to explore data, test-drive tools, and work on projects with instructors available for guidance and troubleshooting. Participants can choose from:

- Working through a step-by-step instructor-led example project moving through the steps together as a group in one room, but on your own laptop
- Doing several different short step-by-step tasks that match your interests, selecting from a menu of ≥14 tutorials listed in handouts
- If you have a particular location and/or question in mind, you can work on your own mini-project with personalized light guidance from instructors

Examples of practical topics includes in this workshop are: 1) where to find and browse historical and current satellite imagery, aerial photographs, and other remote-sensed data products; 2) how to delineate watersheds upstream of a point; 3) how to generate summarized time series of vegetation, land cover, and climate for areas of interest to assess effects of management, beaver activity, fires, floods, and landscape changes; and 4) tools for analyzing topography. Participants will be given handouts with a list of tools and applications.

San Lorenzo River Restoration, Resilience and Recovery Tour

Field Tour Coordinator: Chris Berry, City of Santa Cruz

The San Lorenzo River historically had one of the most productive anadromous salmonid fisheries south of San Francisco. However, this river is very much a "working river" and has served many other beneficial uses for generations as well. Reconciling past land use, increased climatic variability, growing population and related pressures with recovery needs of Central California coast Coho and steelhead is a major challenge for local natural resource managers.

Newell watershed looking southwest.
Photo: Chris Berry, City of SC photos

However, recent and upcoming restoration efforts by local government and NGO stakeholders are beginning to make significant improvements in the San Lorenzo River watershed that will support recovery, as well as enable more sustainable management of local water resources that is critical for the overall resilience of the river. The tour will visit numerous locations around the watershed, beginning at the urbanized mouth where the river meets Monterey Bay National Marine Sanctuary, and ending up in the redwood forests of the headwaters. Topics discussed will include, but may not be limited to, emergency stream bank stabilization, homelessness response, stream wood management, fish passage improvements, instream flow improvements, water rights, levee management, stream wood augmentation, and CZU fire recovery.

While this tour may be similar to the 2022 and 2009 SRF conferences San Lorenzo River - related tours, recent significant changes in local water resource management, progress on high priority restoration projects, regulatory changes, recent extreme weather events, and catastrophic wildfire will provide a rich tapestry of new subject matter to be presented during the 2025 tour.

The Gold Standard vs. Pragmatism: Threading the Needle to Accomplish Restoration at Scale

Field Tour Coordinator: **Jarrad Fisher**, San Mateo Resource Conservation District

Field tour participants will see examples of a range of restoration projects in the lower Pescadero watershed, including floodplain restoration, off-stream farm water storage, instream riparian habitat enhancement, and a dredge project that restored a stream channel and fish passage. We will visit a relatively unconstrained site owned by a conservation landowner as well as a highly-constrained site spanning dozens of private landowners. We will discuss how we navigate trade-offs, balance permit and funding requirements, reconcile diverse partner and landowner needs and concerns, and the role of engineering, risk management... and reality.

The Butano Creek Backfield Floodplain and Streamflow Enhancement Project, completed in 2024, restored floodplain and riparian habitat, increased instream complexity, and supported farming by elevating the farm field and expanding a historical pond. See the pond in the background, the farm field in the middle, and the floodplain in the foreground.

Photo: San Mateo RCD

Fish Passage Partnerships in Alameda Creek Watershed Tour

Tour Coordinators: **Leonard Ash**, Alameda County Water District; **Joe Merz, Ph.D.**, Cramer Fish Sciences; **Scott Chenue** and **Randall Renn**, San Francisco Public Utilities Commission; **Claire Buchanan**, California Trout; **Joe Sullivan**, East Bay Regional Park District; and **Jeff Miller**, Alameda Creek Alliance

The Alameda County Water District (ACWD), San Francisco Public Utilities Commission (SFPUC) and California Trout (CalTrout) are collaborating to propose a tour of Alameda Creek to highlight fish passage improvements and fish monitoring in the watershed. Moving upstream, Alameda Creek gives way from a flood control channel in a dense urban and suburban setting to a natural stream with an intact riparian canopy and diverse substrate. Alameda supports a self-sustaining population of wild resident steelhead (*Oncorhynchus Mykiss*) and provides habitat for Chinook salmon (*O. tshawytscha*) near the southern extent of their range as well as multiple species of lamprey.

PG&E pipeline crossing Sunol Valley

ACWD will host the first stop at their downstream fish ladder at their rubber bladder dams in Fremont. After completion of the ladder in December 2022, anadromous fish had access to Alameda Creek for the first time in 50 years. ACWD will talk about the history of fish passage efforts in the lower watershed by myriad partners through challenging infrastructure, how they coordinated their effort with Alameda County Flood Control and Water Conservation District, and how Cramer Fish Sciences has assisted with monitoring fish movement past the ladder.

Moving upstream, the next stop will be at the Sunol Valley Fish Passage project site where the last major barrier to anadromous fish, a PG&E gas pipeline, remains on the mainstem Alameda Creek. CalTrout, the project lead, will bring tour participants to the barrier location within an active working quarry and discuss implementation plans, which will begin in June 2025, as well as their post-project fish monitoring strategy.

The last stop on the tour will be in the upper watershed at the Sunol Regional Wilderness where SFPUC will provide some history of their fish passage improvement and related infrastructure projects as well as their longstanding and extensive fisheries monitoring program that incorporates electrofishing, fish trapping, PIT tagging, spawning, and benthic macroinvertebrate and snorkel surveys. There will be time before departing back to Santa Cruz for tour participants to explore the wilderness preserve as it is a truly unique wild area in the Bay Area. Additional collaborators on the tour include East Bay Regional Park District and Alameda Creek Alliance.

Restoring Balance: The Klamath Dam Removal and its Significance for Reconnecting Humanity to the Environment

Frankie Myers, Yurok tribal representative

Frankie and Molly Myers celebrating Klamath Dam Removal that they advocated for their entire adult lives.
Photo: Frankie Myers

As we explore the Klamath Dam Removal Project, this presentation will highlight how Traditional Ecological Knowledge (TEK) serves as a foundational principle guiding our understanding of river restoration and ecological balance. Drawing on insights from the Klamath Basin Tribal Communities and their deep-rooted relationship with the Klamath River, we will discuss how TEK emphasizes a holistic view of nature that integrates cultural, spiritual, and scientific processes.

The Klamath Dam removal is not merely a transformative engineering endeavor; it is an opportunity to reclaim the river's natural connections and restore resiliency to the ecosystem. TEK offers a framework for understanding the interconnectedness of the world around us and demonstrates how collaborative stewardship aligns with the natural processes of the environment.

Furthermore, we will reflect on the critical understanding that humans are an integral part of nature, emphasizing our responsibility to foster restoration and maintain balance, as tribal communities have done for thousands of years. This work is essential not only for the health of the Klamath River but also for the broader landscape that sustains us all.

In conclusion, we will delve into the profound truth that the complex ecosystems present in America prior to contact were shaped and maintained by Indigenous practitioners. By learning from these traditional methods and embracing those systems in our restoration efforts today, we hold the keys to addressing the climate crisis. The Klamath River restoration serves as a lighthouse for a renewed commitment to ecological reciprocity, urging us to take actionable steps toward recreating functioning ecosystems for future generations.

How Redband Trout Navigate The Challenges And Opportunities of The Upper Klamath Basin: Implications For Salmon Recovery

Jonny Armstrong, Ph.D., Department of Fisheries, Wildlife, and Conservation, Oregon State University (Presenter), and Co-author: **Jordan Ortega**, The Klamath Tribes Ambodat Department

The removal of the mainstem Klamath River dams will reopen migratory corridors for anadromous salmon and lamprey, providing access to the Upper Klamath Basin. Predicting biological responses to large-scale restoration efforts is inherently challenging, especially in this region, given its unique hydrology and biogeography. To better anticipate how future runs of anadromous salmonids might thrive in this complex and variable watershed, we can look to a locally adapted analog: the Klamath redband trout. Like Pacific salmon and steelhead, redband trout spawn and rear in tributaries but grow large in downstream water bodies. While salmon grow large eating herring and anchovy in the Pacific Ocean, redband trout grow to similar sizes eating chub and sculpin in Upper Klamath Lake and exhibit ontogenetic shifts analogous to smolts entering estuaries. In collaboration with ODFW, the Klamath Tribes, and other partners, our research explores the full life cycle of these migratory trout to understand how they navigate the challenges of this basin. In this talk, I will explore the unique threats and opportunities the Upper Klamath Basin presents to salmonids and share findings from our research on how redband trout overcome these challenges. I hope to highlight valuable insights that can inform the future of salmon and steelhead restoration in the region.

Redband trout in the Upper Klamath give us an indication of how salmonids will repopulate the Klamath. *Photo: Jonny Armstrong*

Water Quality and Primary Production Responses in the Klamath River During Drawdown and Dam Removal

Desiree Tullos, Ph.D., Department of Biological and Ecological Engineering, Oregon State University

Despite decades of decommissioning and removing dams from rivers, the Klamath dam removals presented the regulatory and scientific community with some uncertainties regarding how water quality and the plants and algae in the river would respond and recover. Computer simulations were developed to anticipate changes but often were based on limiting assumptions. For example, would dissolved oxygen models developed for wastewater accurately predict the complex interactions in a river? How would the really wet fine sediment in the reservoirs mobilize, and would that sediment deposit primarily along the margins proximal to the dams, as predicted by 1D and 2D models? Would our conceptual models of how light drives primary production be adequate to explain the biomass of plants and algae when the water looked like chocolate milk? The Klamath dam removals gave scientists an unprecedented opportunity to examine some of our most basic conceptual and numerical models of how rivers work. In this talk, I will summarize some of the key hypotheses we had regarding water quality and primary production in the river, where the data support those ideas, and where they don't. Not every dam removal will push scientific boundaries, but some, like the Klamath, have the potential to transform our thinking about rivers well beyond the context of dam removal.

The Humanity of Fisheries Restoration

Kellyx Nelson, Executive Director, San Mateo Resource Conservation District

We care deeply about our mission to prevent species extinction and recover salmonid populations. In this work we encounter and overcome countless obstacles, but are we acknowledging the obstacles within ourselves? Our success depends in no small part on how we experience risk, fear failure, navigate uncertainty, and develop trusting partnerships that can weather the good times and the bad while sharing credit, blame and resources. Sharing our "epic fails," embracing some risk, investing in our relationships, and practicing empathy may be essential ingredients for the survival of salmonids.

Knowing What We Want – A Conceptual Framework For Restoring Klamath River Salmon Populations

Tommy Williams, Ph.D., NOAA Fisheries, Southwest Fisheries Science Center

After decades of effort, four dams on the Klamath River have been removed and anadromous salmonids are returning to a landscape they had been excluded from for over a century. A conceptual framework was needed to inform the plans to reintroduce native fish species and restore hundreds of miles of historical habitat. Those working on this effort wanted to develop a framework to provide consistent guidance and to allow for productive conversations and planning within and among partners throughout the Basin. Based on other large-scale restoration actions and recovery plans, a generally agreed upon desired future condition or goal was required – the re-establishment of viable and self-sustaining fish populations. The reintroduction and monitoring plans developed by California and Oregon focus on this outcome. In addition, plans developed for other dam removals, such as the Elwha River, provided an example framework and provided information as the Elwha River and its fish populations responded to the dam removals. For my part, having a clear target or desired future condition was a necessity to consider various plans and actions, some requiring either short response times or working through differences in opinion among the partners. I will present a quick overview of the background information and experiences I used to develop and inform my contributions to the planning and implementation of monitoring and reintroductions. Like other restoration and recovery actions, the focus has been and continues to be on restoring ecological and physical processes. To restore a connected, dynamic, and resilient Basin for anadromous fish.

Klamath Dam Removal - Lessons Learned as a River is Reborn

Session Coordinators:
Bob Pagliuco, Marine Habitat Resource Specialist, NOAA Fisheries Restoration Center and **Mike Belchik**, Senior Water Policy Analyst, Yurok Tribe

This session will highlight the current state of post-dam-removal restoration, dam-removal lessons learned, science and monitoring, and what the future holds following implementation of the largest river restoration project in the world.

Free flowing Klamath River post-dam removal.
Photo: Swiftwater Films

Klamath Dam Removal - Lessons Learned as a River is Reborn

Planning, Implementation, and Lessons Learned for the Removal of the Four-Dam Complex of the Lower Klamath Project

Morton D. McMillen, Executive Vice-President, Owner's Representative, McMillen Inc.

The Lower Klamath Project consists of four hydroelectric developments on the Klamath River located in the Western United States. The restoration of the Klamath watershed, spanning over 15,000 square miles of California and Oregon, is the largest dam-removal project in history, opening more than 400 miles of habitat. In September of 2016, the Klamath River Renewal Corporation (Renewal Corporation) filed an Application for Surrender of License for Major Project and Removal of Project Works (License Surrender) with the Federal Energy Regulatory Commission (FERC). The Renewal Corporation filed the License Surrender Application as the dam removal entity for the purpose of implementation of the Amended Klamath Hydroelectric Settlement Agreement (AKHSA). In November 2020, the Renewal Corporation filed its Definite Decommissioning Plan (DDP) which is a comprehensive plan to physically remove the Lower Klamath Project and achieve a free-flowing condition and volitional fish passage, site remediation and restoration, and avoidance of downstream impacts. Renewal Corporation received the Licensure Surrender Order in November 2022, approving facility removal and habitat restoration. The proposed action consisted of the deconstruction of the J.C. Boyle Dam/ Powerhouse located in Oregon, and Copco No. 1 Dam/ Powerhouse, Copco No. 2 Dam/ Powerhouse, and Iron Gate Dam/ Powerhouse located in northern California. Dam removal and volitional-fish passage were established in October 2024. This presentation discusses the planning effort and strategy developed and implemented to execute the project, with a focus on the construction- and restoration-work phase. It includes a discussion of the organizational structure of the Renewal Corporation designed to efficiently execute a multi-discipline engineering and construction project, challenges, and execution of a progressive-design-build contract to meet set project budgets and schedules. Lessons learned specifically to the design and construction aspects of the project will be presented.

Klamath Dam Removal - Lessons Learned as a River is Reborn

From Reservoirs to Rivers: A Look at the Past Year of the Klamath River Renewal Project Restoration Journey

Dan Chase, Director, Fisheries, Aquatics & Design – Western Region, Resource Environmental Solutions (RES)

Removal of four hydropower dams (Iron Gate, Copco 1, Copco 2, and J.C. Boyle) on the Klamath River in northern California and southern Oregon represents the largest dam- removal and river-restoration project in the country. In the Fall of 2024, the project restored free-flowing conditions and volitional fish passage to hundreds of miles of the Klamath River, once the third-largest producer of salmon on the West Coast and is leading to landscape-level change seldom seen in a single project. RES was selected by the Klamath River Renewal Corporation to lead restoration for this ambitious effort, as well as accept liability associated with ensuring restoration meets ecological- and biological-performance standards and long-term goals/ objectives. RES is leading design and implementation efforts for the restoration of nearly four miles of priority-tributary streams and associated fish habitat, as well as vegetation restoration for approximately 2,200 acres of previously-inundated lands. This presentation provides a look back at the year of dam removal and restoration actions accomplished, along with lessons learned during the restoration implementation and how RES has positioned our work for the years ahead. Additional discussion will include the tributary restoration and revegetation work occurring in 2025.

Klamath Dam Removal - Lessons Learned as a River is Reborn

Water Quality Conditions During Klamath Dam Removal Drawdown

John R. Oberholzer Dent, Biologist, Karuk Tribe Department of Natural Resources

Year one of Klamath dam removal exported large quantities of sediment from the footprints of J.C. Boyle, Copco, and Iron Gate reservoirs. Evacuation of reservoir sediment was anticipated to impair water quality and was timed to minimize ecological impacts to the Klamath River below the dams. While the impact on water quality during the sediment evacuation phase was generally anticipated, specifics about the timing, magnitude, and duration of how water quality would be affected by drawdown are yet to be assessed. Using monitoring data collected by the Karuk Tribe, Yurok Tribe, and other partners, we analyzed water-quality parameters to examine the timing and extent to which water quality deviated from "dams in" baseline conditions during the reservoir drawdown process. We analyzed data from six continuous-monitoring stations and nine grab-sampling locations between Keno, OR (above the dams) and Turwar, CA (near the mouth, 227 miles downriver). We explored changes to turbidity, dissolved oxygen, temperature, nutrients, suspended sediment concentration, microcystin, heavy metals, and other analytes. Results demonstrate the anticipated short-term water-quality impairments associated with heavy sediment loads, but also the resilience of the river to disturbance, as shown by the recovery of dissolved oxygen and successful fish migration. In addition, some benefits of dam removal to water quality, including temperature and microcystin levels, have already been realized in the first year after dam removal. Tribal monitoring of baseline conditions, impairment during drawdown, and long-term water-quality improvements into the future will support the management of the Klamath River and also inform dam removals more broadly.

Klamath Dam Removal - Lessons Learned as a River is Reborn

Mapping a New River – First Aerial Surveys of the Klamath River After a Century of Dams

DJ Bandrowski, P.E., Senior Civil Engineer/ Program Manager, Yurok Tribe (Presenter) and Co-Authors: **Cort Pryor,** Survey Manager, Yurok Tribe and **Ben Hocker**, Professional Land Surveyor; PLS, CH, Yurok Tribe

During the removal of four hydroelectric dams on the Klamath River, the Yurok Tribe performed the first aerial surveys after the reservoir drawdown, uncovering a newly-formed river that was locked away underwater for over a century. The surveys were completed using tribal-owned aircraft made possible with the formation of Condor Aviation, Yurok Tribe Enterprise, integrating tribal workforce and indigenous knowledge with the latest cutting-edge-geospatial technology. High-resolution 4-band imagery combined with LiDAR topography and other remote-sensing tools are being used to monitor the "change over time dynamics" and evolution trajectory of this newly-formed river system.

In 2018 the Yurok Tribe, in partnership with various federal agencies and basin patterns, developed a 260-mile Digital Terrain Model (DTM) and associated numerical hydraulic model of the entire Klamath River from Iron Gate Dam to the Pacific Ocean. This baseline DTM was developed from topographic surveys of the river's bathymetry and terrestrial topography using LiDAR technology and multi-beam sonar data. The 2018 baseline data is being compared with the new 2024 surveys during dam removal to help restoration practitioners, research scientists, managers, and other technical professionals better understand physical processes and habitat conditions related to sediment transport. The integration of the terrestrial DTM's and numerical-hydraulic models before- and after- dam removal will allow us to better understand the physical parameters (water depth, velocity, sheer stress, etc.) of the geomorphology and habitat characteristics. With evolving conditions on the Klamath River due to dam removal, there is a need to have a new updated DTM and hydraulic model to evaluate and document sediment transport, geomorphic evolution, and changes in habitat conditions.

The new conditions on the Klamath River and updated models will be used to evaluate the trajectory of change with quantitative data from these geospatial surveys. New hydro-dynamic models will be updated with both terrestrial topography from LiDAR and bathymetry from boat-based-sonar surveys. Models will be enhanced extending the surveys through the hydro-electric reach post-dam removal along with key tributaries that were once underwater from the reservoirs. These surveys and the development of new models are currently underway and will help the restoration community better plan, analyze, and design future dam removals and help inform the science and engineering for large-scale-restoration projects in a new era of a free-flowing Klamath River.

Klamath Dam Removal - Lessons Learned as a River is Reborn

Factors Limiting Filamentous Algae and Rooted Macrophyte Growth During Dam Removal in the Klamath River

Isabelle Tang, M.S. Student, Oregon State University (Presenter) and Co-authors:
Desirée Tullos, Ph.D., Oregon State University and **Laurel Genzoli, Ph.D.**, University of Nevada, Reno

Filamentous algae (FA) and rooted-aquatic plants (macrophytes) are essential primary producers in river systems, providing habitat and basal-food resources, but the accumulation of high-biomass taxa causes problems. The Klamath River in Southern Oregon and Northern California has high rates of primary production. When conditions promote excess growth in the summer, the river accumulates FA and macrophyte biomass which can clog fishing nets and other infrastructure, reduce dissolved oxygen levels, and decrease the perceived aesthetics of the river. The world's largest dam removal on the Klamath River in 2024 provided an opportunity to study the conditions that suppress and promote FA and macrophytes, including the impacts of a large sediment pulse and variability in spring peak flows. We hypothesized high turbidity caused by the sediment pulse would inhibit growth compared to pre-dam-removal conditions by limiting light penetration to algae and macrophytes on the riverbed. With this study we aim to: 1) document biomass and growth timing of FA and macrophytes compared to pre-dam-removal spring- and summer- light availability and discharge conditions, and 2) understand the environmental mechanisms and limiting factors that resulted in the observed biomass growth. To address these goals, we collected field data before and during dam removal and will apply two different modeling frameworks, a mechanistic model and a random forest analysis, to identify the limiting factors of FA and macrophyte growth. We collected bi-weekly FA and macrophyte biomass, % cover, and water quality data (velocity, temperature, depth, light availability, turbidity) at two sites downstream of the dam removals in the summers of 2023 (pre-removal) and 2024 (during removal). Data from both years will be used to parameterize and calibrate the mechanistic and statistical models that we will use to evaluate which environmental drivers limit FA and macrophyte growth. Preliminary 2024 data show persistent growth of both FA and macrophytes despite high levels of turbidity. Additionally, a large wildfire and subsequent debris flow upstream in 2023 caused exceptionally turbid conditions compared to a "typical" year, complicating cross-year comparisons. Dam removal did not seem to delay the growth timing of FA and macrophytes and the relatively-high biomass in very turbid conditions suggests that other actions will need to be taken to reduce high biomass accumulation in the Klamath River moving forward.

Klamath Dam Removal - Lessons Learned as a River is Reborn

Quantifying Benthic Macroinvertebrate Responses to Klamath Dam Removal During Juvenile Salmonid Outmigration Season

Rosa Cox, M.S. Student, Cal Poly Humboldt (Presenter) and Co-authors: **Alison O'Dowd, Ph. D.**, Cal Poly Humboldt; **Nicholas A. Som**, Unit Leader - U.S. Geological Survey California Cooperative Fish and Wildlife Research Unit; and **Toz Soto**, Karuk Tribe Fisheries Program Manager

The removal of four hydroelectric dams on the Klamath River will likely restore hydrologic and ecosystem processes within the basin that have been disrupted for over a century. However, sediment fluxes associated with dam removal can impact benthic habitat and water quality downstream of former dam sites. The release of reservoir sediments from reservoir drawdown and dam deconstruction on the Klamath not only increased turbidity and sediment deposition downstream, but also caused temporary declines in dissolved oxygen. This study investigates food web responses to Klamath dam removal downstream of Iron Gate Dam during a critical period of juvenile salmonid growth and outmigration in the late spring. Benthic invertebrate communities were characterized using kick net samples and salmonid prey availability was assessed using drift and non-lethal gastric lavage sampling of juvenile fish in paired tributary and mainstem sites before (2022, 2023) and during dam removal (2024). Preliminary results suggest that benthic macroinvertebrate abundance and biomass in the mainstem sites were not severely impacted by winter/ spring sediment fluxes and that prey resource availability to juvenile salmonids was similar across all study years. These results may be confounded by the impacts of the McKinney fire, which introduced substantial sediment loads into the river in our study reach between the 2022 and 2023 sampling periods. Results from this study can hopefully inform future dam removals which may impact sensitive life stages of anadromous fish.

Klamath Dam Removal - Lessons Learned as a River is Reborn

Evaluating the Effectiveness of Dam Removal on the Klamath River Using SONAR and Radio Telemetry

James Whelan, California Trout, and **Alex Corum**, Karuk Tribe (Co-presenters); and Co-authors: **Damon Goodman**, California Trout; **Bob Pagliuco**, NOAA Fisheries; **Toz Soto**, Karuk Tribe; **Oshun O'Rourke**, Yurok Tribe; **Rosemary Romero** and **Crystal Robinson**, California Department of Fish and Wildlife; **Mark Hereford**, Oregon Department of Fish and Wildlife; **Keith Denton**, Keith Denton and Associates; **Nicholas A. Som**; **Cyril Michel,** UC Santa Cruz, NOAA Fisheries; **Stephanie Quinn-Davidson**, Ridges to Riffles; **Thomas Williams**, **Ph.D.**, NOAA Fisheries

The removal of four dams on the Klamath River has restored hydrologic connectivity to the Upper Klamath River Basin. For anadromous fish, habitat and ecological processes not available for over 100 years are now accessible. Traditional ecological knowledge, as well as historical accounts, provides us with some general understanding of the historical-movement patterns and distribution of anadromous fish, although greater understanding is required to inform future restoration and fish-management actions. For this reason, monitoring plans focused on evaluating the reestablishment of salmon populations as they return to their historical range in the Klamath Basin are critical. Of particular interest is how many salmon and steelhead disperse into the reconnected watershed and the timing of that dispersal. The questions of interest include what are the species and life-history-specific timing of fish movement into the restoration reach (i.e., location of Iron Gate Dam and upstream throughout the upper Klamath Basin) and habitat used by fish as they move through the restoration site.

This project will result in abundance estimates of salmon and steelhead entering the reach previously blocked by the dams and follow their migrations to spawning grounds. Understanding the time of movement and habitat use of adult fish moving upstream to historical habitat will inform current- and future- restoration actions to effectively use available funds in the most impactful manner, guiding future restoration efforts in the newly-accessible habitats. In addition, these data will provide a foundation for assessing key ESA viability criteria such as diversity, spatial structure, and abundance. Our study combines a SONAR fish-counting station, species composition sampling, and radio telemetry with study designs adapted from the Elwha River and other large-scale dam removals. This effort is being guided by the expertise of Tribal members, NGO staff, and federal and state agency staff that have implemented monitoring in the Klamath Basin, on the Elwha River, or other coastal rivers throughout the western United States. The project will provide a toolset to support information to inform the sequencing and prioritization of future restoration and monitoring in the Klamath River as well as other dam removals around the world.

The Gold Standard vs. Pragmatism: Threading the Needle to Accomplish Restoration at Scale with a combination of multibeam-imaging SONAR and radio telemetry. SONAR imagery provides imagery of passing fish on a continuous basis, while weekly-instream-tangle net sampling in the vicinity of the SONAR site provides field-based data to transform imagery into species-specific passage estimates. The tangle net sampling provides fish for radio-telemetry tagging. Monitoring of radio-tagged fish with fixed sites and mobile tracking provides detailed information on movement and habitat use as adult salmon and steelhead migrate and spawn in the newly-accessible habitat and the environmental variables that affect their migration.

Salmon and Climate Change: Advancing a Climate-resilient Recovery Approach for Pacific Salmon

Session Coordinators: **Shaara Ainsley**, Long Live the Kings, and **Sherri Norris**, California Indian Environmental Alliance (CIEA)

Robust and resilient Pacific salmon populations that support thriving ecosystems, Indigenous rights and cultures, local economies, and recreation require effective and ongoing stewardship. However, rapid climate change is making this salmon recovery goal more difficult to achieve and calls into question the viability of salmon runs and fisheries along the coast and watersheds of western North America. Climate change is adding to existing stressors, causing complex, interacting processes that drive mass mortality events and changes in phenology, range shifts, and extirpations. A future in which resilient salmon can flourish and salmon populations can support harvest in the face of climate change depends on a recognition of social – ecological systems and diverse knowledge sources, innovative science and policy, dramatically increased funding, well-informed climate resiliency planning, and significantly greater information-sharing across a wide geographic range. Salmon-reliant communities are working hard, but we need new approaches to achieve recovery and support salmon resiliency. This requires a rapid paradigm shift with an unprecedented expansion of collaborative engagement and a braiding together of Indigenous and Western knowledge systems. To advance this paradigm shift, presenters in this session will share innovative and collaborative approaches to supporting tribal climate resilience planning and climate resilience of Pacific salmon populations.

Salmon and Climate Change: Advancing a Climate-resilient Recovery Approach for Pacific Salmon

Developing Collaborative Solutions to Address and Plan for Climate Impacts on Pacific Salmon

Shaara Ainsley, Long Live the Kings and **Sherri Norris**, California Indian Environmental Alliance (Co-presenters)

Salmon are crucial to the environmental, cultural, and economic health of Western North America. However, many salmon populations, fisheries and salmon-reliant communities are in crisis. We are working hard toward salmon recovery but addressing the added challenges of climate change requires dramatically more funding, an increase in strategic actions, and unprecedented collaboration. For example, climate planning has to date included siloed approaches that are not aligned with the resiliency plans of neighboring Tribes, which are focused on the interconnected health of all species of shared landscapes, and do not apply Traditional Knowledge. As a result, climate adaptation and resiliency plans are missing vital information needed to successfully protect Tribal resources, like salmon, and vulnerable communities. We will describe two efforts to take collaborative action to address climate impacts on salmon and salmon-reliant communities.

Long Live the Kings (LLTK), Pacific Salmon Foundation, Salmon Defense, and partners are developing a collaborative Salmon and Climate Initiative (SCI) that will bring together Indigenous and non-Indigenous knowledge holders, resource managers, and policy makers from across Western North America to work together to eliminate barriers and to accelerate solutions related to salmon recovery in the face of climate change. Salmon cross many jurisdictions and ecosystems, and collaboration and investment must go beyond isolated geographies. The SCI will provide a space to collectively examine what is occurring from California to Alaska, collaborate across boundaries, consider which solutions are working and where more effort is needed, and identify strategies to accelerate salmon resilience action. This initiative is not intended to replace important watershed-level actions, but will allow us to articulate a broader vision for salmon in the face of climate change, and leverage the on-the-ground groups and elevate their work through collective action. We will seek feedback on the draft Strategic Plan, and opportunities for regional collaboration to support salmon recovery efforts.

The Northern California Tribal Climate Collaborative (NCTCC) conducted an extensive literature and tools review to support community participatory planning. NCTCC created 1) a Climate Action Resiliency Plan Framework which integrates sources into a step-by-step process to support Tribal Vulnerability Assessment and actionable Climate Resiliency Plans, 2) A Climate Resource Library with over 200 sortable open source resources to help planners navigate and choose from climate resources, templates, modeling and mapping links, 3) Community Participatory Surveys targeting Tribal staff, leadership and community members which lead to community planning meetings and prioritization of actions. The NCTCC is holding meetings of California Tribes to prepare for wider collaborations, discuss climate challenges, build shared strategies, and discuss alignment of actions to protect communities, Tribal resources and the species that reciprocally rely on our continued stewardship. A wider inter-regional planning conference is in development with smaller strategic planning meetings. This talk will introduce and seek feedback on the Northern California Tribal Climate Portal, and the approach to plan for human resiliency by ensuring that planning increases the resiliency of species that Tribal communities rely on for continuance in the face of climate change.

Salmon and Climate Change: Advancing a Climate-resilient Recovery Approach for Pacific Salmon

Reorienting to Recovery: Stretching into the Whole

Natalie Stauffer-Olsen, Ph.D., Trout Unlimited (Presenter) and Co-authors: **Darcy Austin**, State Water Contractors; **Erin Cain**, **Liz Stebbins**, and **Mark Tompkins**, FlowWest; **Alison Collins**, The Metropolitan Water District of Southern California; **Brian Crawford**, Compass Resource Management; **Dr. Rene Henery**, Trout Unlimited, and University of Nevada; **Sherri Norris** and **Michelle Rivera**, California Indian Environmental Alliance; and **Rafael Silberblatt**, Kearns and West

In order to address the complex obstacles facing salmonid recovery in California's Central Valley (CV) and Bay-Delta (Delta), the Reorienting to Recovery (R2R) effort has sought to create a values-driven, scientifically robust, inclusive, and achievable pathway into the unknown future towards salmonid recovery. The R2R process is generally rooted in: 1) trust in and respect for the collective wisdom of the individuals and groups concerned with salmonid recovery across the salmonid landscape and 2) science and traditional ecological knowledge as a mechanism for creating a common understanding of the context in which salmonid recovery might occur, a common story. R2R applied these foundational elements in an inclusive process to define salmonid recovery, identify and characterize other values (e.g., social, cultural, ecological, and economic) associated with or affected by salmonid recovery, and identify, via Structured Decision Making (SDM), preferred suites of actions that recover CV salmonid populations while equitably balancing benefits and impacts across the range of participant values. Phase 1 engaged scientists from diverse constituencies to develop quantitative objectives that collectively define recovery in a broad sense, beyond regulatory definitions. Phase 2 identified the diverse range of other related participant values through a storytelling-based process that provided participants with the opportunity to engage with each other in a way that built understanding and made apparent the many shared values across interest groups, as well as the total body of values held by the collective. Making these values transparent additionally allowed the R2R planning team to share a more comprehensive story of the intertwined recovery opportunities of salmonids and people. Phase 3 utilized the recovery definition and gathered values to update and expand existing salmonid life-cycle models and employed a facilitated-structured decision-making process, for the first time, to explore alternative recovery scenarios that included actions related to habitat, hydrology, harvest, and hatchery management practices. Throughout this three-year project, R2R explored and experimented with how to be successful in cultivating coherence among diverse interests toward a shared vision and set of objectives. Methods and practices that we found essential included: meeting people where they are, listening deeply and repeatedly, incorporating feedback, creating clear and accessible outreach materials, asking people to stretch out of their assumptions and comfort zones after deep listening, facilitating gatherings, working with the California Indian Environmental Alliance as a bridge for indigenous engagement, meeting with specific groups (for example, tribal members) in a separate affinity process that allowed for maximum communication and time-efficiency, building trust through time and consistency, using a consensus decision-making approach held with a belonging orientation, and others.

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Effects of End-of-Century Streamflow Conditions on High-Elevation Streams and Juvenile *Oncorhynchus Mykiss*

Kelly Goedde-Matthews, University of California, Davis, Department of Wildlife, Fish, and Conservation Biology (Presenter, Student) and Co-authors: **Robert Lusardi, Ph.D.**; **Nann Fangue, Ph.D.**, University of California, Davis and Department of Wildlife, Fish and Conservation Biology; and **Sarah Yarnell, Ph.D.**, University of California, Davis, Center for Watershed Sciences

Climate change is altering the environment faster than organisms can adapt. In California, climate change is causing earlier snowmelt, shifting the spring recession flow earlier in the year and extending the summer baseflow period (Reich et al. 2018, Schwartz et al. 2017, Stewart et al. 2005). Some models predict peak surface runoff flows to advance by as much as 50 days in California's Sierra Nevada streams. Reich et al. (2018) and Moyle et al. (2017) found that climate change is already negatively affecting 84% of native salmonids. While climate change is generally expected to advance, the exact effects on individual species and food webs are hard to predict. During the summer of 2024, we ran a 3-month experiment to test the effects of a projected altered hydrograph under end-of-century climate conditions on a mountain stream food web using a series of replicated stream channels at the Sierra Nevada Aquatic Research Lab. We robustly quantified changes in environmental variables, food webs, and juvenile *Oncorhynchus mykiss* physiology, growth, and survival between channels experiencing present-day streamflow conditions and those that experienced a manipulated hydrograph mirroring end-of-century climate predictions. Understanding how organisms and habitats respond to altered hydrographs is the initial step in addressing and minimizing future impacts to ensure the continued existence of ecologically- and culturally-valuable species and their habitats. This experiment will provide a nuanced understanding of how climate change will affect stream food webs, species, and habitats and improve conservation planning during the next century of rapid global change.

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Rapid Evolution in the Face of a Changing Climate: Can Salmonids Keep Up with Rising Temperatures?

Paige Gardner, Ph.D. Student, University of California, Santa Cruz (Presenter) and Co-authors: **Terra Dressler, Ph.D.**, Stillwater Sciences; **John Carlos Garza, Ph.D.**, NOAA Southwest Fisheries Science Center and University of California, Santa Cruz; **Joanna L. Kelley, Ph.D.** and **Eric Palkovacs, Ph.D.**, University of California, Santa Cruz

Rapid adaptation to accelerating environmental changes offers a potentially important pathway for the persistence of salmonid fish species, whose physiologies and life histories are shaped by the temperature of their environment. While current evidence points to potential heritable genetic differences in thermal physiology, how populations vary in their ability to adapt to rapid warming is generally unknown. We seek to understand the adaptive capacity of thermal tolerance traits in steelhead (*Oncorhynchus mykiss*) across the California coast. As the southernmost distributed salmonid in North America, steelhead may be at a high risk of extirpation in the southern portion of their range, in part due to climate-induced warming. To elucidate the evolutionary potential of steelhead populations, we are: 1) testing and measuring the upper limits of thermal physiology and 2) relating differences in thermal tolerance to differences within the genome. Here, we present the findings from the first objective. We measured critical thermal maximum (CTmax) using a heat ramp in three ESA- (Endangered Species Act) threatened populations that experience different thermal regimes: Big Creek in Monterey County (n = 100), the Carmel River further north (n = 100), and Scott Creek in Santa Cruz County (n = 100). To simulate the effects of acute exposures to different warming scenarios, we acclimated fish to one of four temperature treatments for 20 hours leading up to CTmax trials (ambient stream temperature, 20°C, 23°C, and 25°C). Results from CTmax trials show both inter- and intra-population variation in thermal tolerance. Increasing holding temperature enhanced thermal tolerance, demonstrating the ability to acclimate quickly to new temperature conditions. Furthermore, there were significant differences in upper thermal limits among populations. Preliminary data suggests that populations from warmer streams may show greater thermal tolerance than those from cooler habitats. Variations in temperature responses within and between populations suggest a potential role for genetic adaptation in thermal tolerance traits. In the next phase of this study, we will conduct a genome-wide association study (GWAS) to identify any key regions of the genome associated with individual differences in thermal tolerance. By understanding both the physiological variation and the genetic underpinnings of thermal tolerance traits in coastal California steelhead populations, we lay the foundation for identifying if steelhead may be able to keep pace with climate warming. This information can be used to inform management plans to facilitate rapid evolution in climate-vulnerable steelhead populations.

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Spawning Distributions Through Space and Time: Assessing Resilience of an Endangered Coho Salmon Population Complex in a Coastal California Watershed

Rachael Ryan, Ph.D., Center for Watershed Sciences, University of California, Davis (Presenter) and Co-authors: **Stephanie Carlson, Ph.D.**, **Ted Grantham, Ph.D.**, Environmental Science, Policy, and Management, University of California, Berkeley and **Rachel Johnson, Ph.D.**, Center for Watershed Sciences, University of California, Davis and Fisheries Ecology Division, Southwest Fisheries Science Center

When salmon breeding is distributed in several locations across a watershed, their progeny are also distributed. Such spatially distributed production exposes juvenile salmon to different environmental conditions, potentially driving trait variation in offspring and buffering the population against disturbance. Yet, the factors that control variation in the spatial distribution of spawning within and across years are poorly understood. We hypothesize that spawning distributions of Pacific salmon near their southern edge are constrained by rainfall patterns, which influence when flows are sufficient for upriver migration. We test this hypothesis by exploring how spawn timing and location of endangered coho salmon varied in relationship to hydrological variability in the Lagunitas Creek watershed across an 18-year time series. Specifically, we compared the onset, peak, and duration of spawning between two sub-basin populations, one with a regulated flow regime (Lagunitas Creek) and one with a natural flow regime (Olema Creek), and the effects of wet season flow timing, variability, and magnitude on observed spawning variation. Additionally, we used otoliths collected from spawners across 10 years to investigate dispersal patterns of returning adults within and outside of the watershed, giving us insight into the structure of the meta-population of the region. Our results show that in the larger, regulated sub-basin (Lagunitas Creek), the tails of the spawn timing distribution were stable across time and buffered against precipitation variability by regulated flow releases, while the smaller, unregulated sub-basin (Olema Creek) was characterized by highly variable spawn timing, largely driven by inter-annual variability in wet season flows. Interestingly, the central tendencies of spawning were similar between the two basins, suggesting that the timing of winter precipitation events – and not simply flow – is an important cue for initiating spawning. Otolith analysis and spawner age structure records revealed that the Olema spawning population was supported by dispersal from Lagunitas Creek, as well as from dispersal of individuals from outside of the watershed. Drought severely impacted spawn timing and spawner origins in Olema Creek, where spawn timing was delayed and restricted, and some cohorts were "rescued" by dispersing fish from elsewhere (including other age classes). Our findings show that climate variability can negatively impact spawning salmon, yet diverse stream habitats can buffer the metapopulation by giving rise to spawning trait diversity and supporting colonization/ recolonization of smaller subpopulations, contributing to resilience and the persistence of endangered salmon complexes.

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A Model-Based Investigation of Early Marine Growth and Survival for California Chinook Salmon

Kelly Vasbinder, Ph.D. University of California, Santa Cruz (Presenter) and Co-authors: **Jerome Fiechter**, University of California, Santa Cruz; Jarrod A. Santora, **Nate Mantua, Ph. D.**, and **Steve Lindley, Ph. D.**, Fisheries Ecology Division, Southwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration; **David Huff**, Fish Ecology Division, Northwest Fisheries Science Center; and **Brian Wells**, Fisheries Ecology Division, Southwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration and Fish Ecology Division, Northwest Fisheries Science Center

The time from ocean entry to the end of the first year is a critical period for survival in fall-run juvenile Chinook salmon. We developed an ecosystem modeling approach to explore the impact of spatial and temporal variability in ocean temperature, productivity, and salmon predators on juvenile salmon growth potential and predation pressure. Core model components include a regional ocean circulation model and Nutrients-Phytoplankton-Zooplankton (NPZ) submodel for generating ocean temperature and prey fields that are used as inputs for a juvenile salmon Individual Based Model (IBM). The IBM predicts the growth and predation of juvenile Chinook salmon from the moment of ocean entry to the end of the first year at sea. Predation rates depend on both salmon size and the probability of salmon-seabird interactions. These salmon-seabird interactions rely on seabird breeding population sizes, the distribution of seabird aggregations in the modeling domain, and the presence of alternative forage. We explore a range of freshwater juvenile salmon production scenarios featuring different sizes and dates of ocean entry, as well as spatial differences in survival related to marine entry points. Finally, because this early marine growth is dependent on ocean temperature and prey availability, we can investigate the bioenergetic implications of shifts in these factors as climate changes using regionally-downscaled projections from earth-system models through 2100 in the same coupled physical-biogeochemical framework that drives the IBM.

Urban Rivers and Creeks

Session Coordinator: Sam Adelson, Education Coordinator, Coastal Watershed Council

At the interface between urban rivers and those who live along them lies opportunity. This presentation session highlights community connections and relationships to urban rivers and streams and the value of partnerships in restoring salmonid populations. Healthy urban rivers play a crucial role in supporting both aquatic ecosystems and human communities. For salmon and trout, these waterways can provide essential habitats, spawning grounds, and migration routes. Thriving urban waterways also provide numerous benefits to human populations, including access to natural spaces for recreation that significantly enhance mental well-being and physical health. To foster a sense of ownership and connection to the river, community-based restoration projects and environmental education programs engage local residents and youth in the stewardship of their environment. Through the lens of inclusivity and equity, discover how community-based collaboration and partnerships foster a relationship between nature and urban environments to benefit salmonid restoration and community well-being.

Students wave goodbye to the San Lorenzo River after a Watershed Rangers field trip.
Photo: Coastal Watershed Council

Urban Rivers and Creeks

"Where Does Your Water Come From?" A Summary of City of Santa Cruz Water Department Education and Outreach Efforts to Connect the Local Community to Our Drinking Water Sources and the Wildlife that Lives There

Maryna Sedoryk, Water Resources Analyst, City of Santa Cruz Water Department and **Kristoffer Patterson**, Water Resources Analyst, City of Santa Cruz Water Department (Co-presenters)

The City of Santa Cruz Water Department provides drinking water to approximately 100,000 local customers. Drinking water is primarily (~95%) sourced from surface waters in 4 local watersheds that are also home to threatened steelhead trout and endangered coho salmon. Due to the density of people living near local streams, the water quality in all of these watersheds is impacted by illegal dumping, septic tank pollution, sedimentation, removal of riparian habitat, private diversions, and other similar activities. These impacts affect both drinking-water quality and habitat for local steelhead trout and coho salmon. In an effort to encourage watershed protection and environmental stewardship in the community, the Water Department has implemented a variety of education and outreach programs to engage residents of all ages. In collaboration with local agencies and nonprofits, the Water Department connects with the community through classroom outreach and field trip opportunities (700+ students per year), an annual science symposium (100+ attendees per year), and a variety of interpretive events at the reservoir recreation area (100+ attendees per year).

Urban Rivers and Creeks

City Meets Nature: Engaging Los Angeles in Major Dam Removal and Southern Steelhead Recovery

Russell Marlow, CalTrout (Presenter)

Over the past year, as part of the Malibu Creek Ecosystem Restoration Project (MCERP), CalTrout launched a community-science photo-monitoring initiative to track environmental changes at key locations in the Malibu Creek watershed. This program engages frequent visitors at popular sites in Malibu, aiming to raise awareness about MCERP's efforts to remove Rindge Dam and restore the dual-listed Southern California steelhead population.

The community science program will provide crucial data to document environmental changes before and after the dam's removal and will contribute to the broader science of dam removal. Community members can use a simple platform at designated locations to capture and submit photos with their phones, recording estuary processes, coastal dynamics, and headwater habitats.

The success of the Rindge Dam removal hinges on building a strong relationship with the greater Los Angeles region. The program encourages broad participation, fosters community involvement in a transformative restoration effort, and promotes a sense of shared ownership. By combining technology with community engagement, the program generates valuable long-term data to support this and future dam-removal projects, facilitates community dialogue on the role of healthy rivers in urban environments, and serves as a scalable model for similar efforts.

This initiative seeks to shift perspectives on the relationship between urban creeks and their surroundings. To protect the function and integrity of urban creeks and rivers, we must balance humans as part of natural systems and natural systems as part of built environments. The community science effort aims to inspire a diverse population to engage with both the project and the natural environment in their backyards.

Urban Rivers and Creeks

A Multidisciplinary Approach Toward Protecting Beneficial Uses of Water in the Lower San Lorenzo River Watershed

Chris Berry, City of Santa Cruz

The San Lorenzo River has a long history of challenges to the protection of its beneficial uses of water. Between water development, historic industrial activities, flood control, and residential development, the San Lorenzo River watershed is substantially challenged by anthropogenic factors. Additionally, the watershed is challenged by naturally high erosion rates, increasingly variable hydrology, warm water temperatures, and other natural factors that pose challenges to the protection of beneficial uses of water, especially those relative to the protection of anadromous salmonid habitat (Estuarine Habitat [EST], Rare, Threatened, or Endangered Species Habitat [RARE], and Cold Freshwater Habitat [COLD]), etc.).

On top of these pre-existing challenges, management of the houseless population that is often found in the riparian corridors and adjacent upslope areas along the lower, urbanized San Lorenzo River has been an increasingly difficult proposition over the past five years. Destruction of riparian vegetation, discharge of human waste, poaching, and other behaviors associated with this population have encumbered attempts to sustainably manage this urbanized stream reach. This is especially problematic given the other challenges already facing the river and because this reach of the river provides the most important steelhead-rearing habitat in the entire watershed.

Given the recent significant efforts by the City of Santa Cruz to improve conditions in this watershed, including improving instream flows for special-status fish species, this new challenge is especially difficult to accept. With the evolving legal landscape regarding public camping, lack of affordable housing and shelter space, mental health, and substance abuse issues, on top of the pre-existing challenges of managing this urbanized reach of the San Lorenzo River, first responders, social service, and natural resource managers have continuously needed to adapt to changed conditions and maintain creativity in problem solving while balancing the often competing needs for San Lorenzo River health.

The City of Santa Cruz has initiated a multidisciplinary-multifaceted strategy in order to meet these challenges. This includes, but is not limited to, City of Santa Cruz teams focused on preventing illicit camping and mitigating its impacts; a commitment toward broader community engagement, including partnering with organizations such as the Coastal Watershed Council on public events, educational activities, activation of the adjacent Riverwalk, restoration of the San Lorenzo Benchlands, and increased focus on providing shelter and social services to the houseless population, thereby increasing the potential for other watershed restoration efforts to be fully realized and enabling recovery potential for Central California Coast steelhead and coho, as well as the general protection of beneficial uses of the lower San Lorenzo River.

Urban Rivers and Creeks

Fall Salmon in San Jose

Jordan Almaguer, South Bay Clean Creeks Coalition, Intern (Presenter) and
Co-author: **Steve Holmes**, South Bay Clean Creeks Coalition Executive Director

We are South Bay Clean Creeks Coalition, a non-profit operating for the last 12 years. Our mission is to reclaim, restore, and revitalize the waterways in San Jose for the local salmon population. We have worked diligently to remove an accumulation of trash weighing 1.5 million pounds across 459 clean-ups. We conduct cleanups along the Guadalupe River and Los Gatos Creek with groups spanning corporations, schools, and community groups. We also work very closely with the homeless population. Since there are many encampments along the creeks, we often ask for their assistance with removing the trash around their encampments. Engaging all of these groups has proven to be the best way for us to ensure salmon successfully reach healthy spawning ground.

We monitor the Guadalupe watershed by searching for trash, barriers, and illegal fishing, and during the fall salmon run we search for redds (salmon nests) along with live or dead salmon. Some barriers and traps are easy to remove with a bit of force, while other areas require large financial support. We have worked on several projects including gravel augmentation and invasive species removal. Each project was meant to expand viable salmon-spawning grounds. The invasive-species removal is our current project that spans a 10-acre area of Los Gatos Creek. There are several species such as Arundo donax and Himalayan Blackberry that contribute to sedimentation and increased water temperatures, both of which are detrimental to salmon spawning. Another project we wish to conduct is the relief of a 5-foot jump upstream on Los Gatos Creek. This jump is notoriously impassable for migrating salmon but if we could reduce the height of the jump, it would open up a large section of new spawning ground.

During the fall spawning season, we have monitored the migration of salmon throughout the Guadalupe River and the Los Gatos Creek. We track their entrance into these areas and keep track of their numbers and redd location. During this time we may ask for help from Flycasters (a local fishing group), San Jose State University, and De Anza College, along with the houseless, who call in to tell us there is a dead fish we can harvest. This is met with financial support. This data can be found on our website through interactive maps spanning the last 5 years. When salmon complete their life cycles, we collect samples through a permit from CDFW. We collect the otolith and eye lenses. We send these samples to UC Davis for testing. The eye lens helps us determine between hatchery strays (high nitrate concentration) and native salmon (low nitrate). Once this is determined, the ear bone (otolith) is tested for strontium. In conjunction with this test, we test our local waterways in many different locations for strontium. By cross-matching the data, we can determine where the native salmon were born. Our goal is to get federal recognition of Chinook salmon in our waterways so that there can be further protections for the species.

Urban Rivers and Creeks

Reconnecting Communities to the San Lorenzo River: Equity, Education, and Stewardship

Sam Adelson, Education Coordinator and **Maria Rocha**, Environmental Educator, Coastal Watershed Council, Santa Cruz, CA (Co-presenters)

Teamwork makes the stream work! The Coastal Watershed Council (CWC) in Santa Cruz, California, has been engaging the community to steward and celebrate the anadromous San Lorenzo River and its diverse plants, animals, and people since 1995.

The San Lorenzo River flows 29 miles through Santa Cruz County and has historically been a vibrant community hub known for fishing and celebrations. The watershed has been faced with environmental challenges over the decades, including levee construction in 1955, urban and industrial pollution, and impacts from communities experiencing houselessness, all of which disproportionately impact low-income communities of color. This important anadromous waterway remains Santa Cruz's main water source and presents opportunities for community reconnection and environmental stewardship.

This 2024-2025 school year, the Coastal Watershed Council engages its 25,000th youth through CWC's Watershed Rangers program. This community- and equity-focused environmental science program is multidisciplinary and supports students by increasing their access to nature, their passion for protecting the environment, and their confidence in making a real difference.

Learn how you can develop a similar program to engage youth and community along your urban river or creek. In partnership with local organizations, agencies, and your County Office of Education, the youth of your community can grow to love and protect their watershed for the health of people and the planet!

Urban Rivers and Creeks

Rewilding and Resilience in the Urban San Luis Obispo Creek

Freddy Otte, City of San Luis Obispo (Presenter)

The City of San Luis Obispo's Office of Sustainability and Natural Resources (OOSNR) Program in Administration serves as the lead division for collaboration with Public Works, Utilities, all other departments in the City, resource agencies, and other outside non-governmental organizations (NGO's) to complete projects and keep the creek system functional and healthy. South-Central Coastal California Steelhead trout (*Oncorhynchus mykiss*) are listed as threatened under the Endangered Species Act (ESA) and are hanging in the balance from the intersection of threats such as floods, fires, urban development, pollution, and climate change, and we need to act to ensure their long-term survival.

The City's OOSNR is partnering with Creek Lands Conservation (CLC), a local NGO, for the development of the San Luis Obispo Creek Watershed Resilience and Rewilding Plan (R&R Plan). This Plan has a steelhead-centric focus identifying factors needed for protecting the population, such as water quality, water quantity, and habitat enhancement, but also contains a large community-education campaign about how they can act to protect these fish. Under the umbrella of this plan, CLC worked with City Farm SLO, another NGO, to complete an extensive riparian-restoration project, along with the construction of an interpretive trail next to Prefumo Creek, a tributary to SLO Creek. CLC has been hosting tours with students from local schools, educating them about the ecology of the creek system, the impacts of pollution, climate change, restoration efforts, and recreation as it helps with the connection to future stewardship opportunities to protect the local steelhead population. This section of Prefumo Creek was dominated by non-native species, had degraded habitat, and had many illegal encampments, but fostering a positive presence, developing fish passage and habitat restoration projects as identified in the R&R Plan, and additional outreach to the unhoused, the resilience of the creek is starting to be noticed. Planning for the downstream continuation of this project on Prefumo Creek is currently underway and this model is going to be replicated across the watershed for additional educational and recreation opportunities.

In 2021, the City formed a Homelessness Response Team, a multi-departmental-interdisciplinary team to coordinate internal efforts for outreach and support services, encampment clean-ups, and enforcement when required. Working with the County of San Luis Obispo, local service providers, and state agencies like Caltrans and Cal. Fish and Wildlife City staff are looking to maximize coordination efforts for more support for the unhoused including transitional housing programs. Controlling pollution, reducing the risk of human-caused fires in the creek system, and supporting a vulnerable sector of our community highlight the multiple benefits of environmental protection the City of San Luis Obispo is coordinating.

Steelhead can be considered to be the canary in the coal mine and is still present in the urban environment in San Luis Obispo. Educating the community about all the efforts the City is taking to protect this iconic species will help raise the awareness of our residents about the threats facing these fish now and into the future, especially in light of a changing climate.

Room to Roam: Floodplains and the Central Valley

Session Coordinator: Mike Dixon, Trinity River Restoration Program

Floodplains can provide salmonids with particularly-valuable habitat, especially for juvenile rearing. The flat valleys where these habitats typically exist are the same areas favored by humans for agriculture and development. Rivers are often confined to single-thread channels as a result of levees, other human-built infrastructure, and legacy-mining impacts. Floodplain restoration seeks to improve the area, frequency, and duration of inundation, providing fish with room to access complex and high-quality floodplain habitats. Restoration approaches include managing flows, removing levees, altering sediment deposition, and excavation to reduce floodplain elevation and build habitat features. This session will explore a range of floodplain restoration topics, including: 1) groundwater surface-water interactions in restored floodplains; 2) geomorphic changes; 3) biological responses including vegetation, macroinvertebrate production, juvenile salmonid growth and predation, and adult fish migration; 4) lessons learned; and 5) project design and implementation. The session's geographic focus is California's Central Valley, but an Oregon creek is also included.

Room to Roam session will weave together floodplain reconnection efforts from around the state.
Photo: Carson Jeffres

Room to Roam: Floodplains and the Central Valley

Wiggle, Elevate, Connect: Partitioning the Effects of Increased Aquifer Size, Channel Realignment, and Floodplain Reconnection on Streambed Exchange in a Large Scale Channel Restoration

Byron Amerson, M.S., Environmental Science Associates (Presenter) and
Co-authors: **Geoff Poole, Ph.D.**, Montana State University and
Scott O'Daniel, M.S., Confederated Tribes of the Umatilla Indian Reservation

Meacham Creek is a salmon-bearing tributary to the Umatilla River in north-central Oregon. A process-based restoration project at Meacham Creek resulted in increased aquifer volume, a more sinuous, complex channel, and an increased wetted-channel area. We were interested in understanding the relative contribution of each of these components to groundwater-surface water exchange (i.e., hyporheic exchange) for the unrestored and restored conditions due to restoration. We sought to answer the following questions: 1) how does increased floodplain aquifer volume affect streambed flux?; 2) how does increased channel sinuosity affect streambed flux?; and, 3) how does increased wetted area affect streambed discharge?

We modeled a suite of scenarios in HydroGeoSphere (a multi-dimensional, fully integrated groundwater-surface water modeling software) and then used linear models applied to the results to partition the contribution of each factor. We found that restoration actions that induced channel-planform complexity and increased-wetted area were the dominant drivers of streambed exchange, though mediated by stream discharge. In all cases, increasing aquifer volume contributed a minority fraction to the increase in streambed exchange, again mediated by stream discharge. The relative contribution of an increase in aquifer volume on streambed exchange was highest for base flow and decreased at higher flows.

These findings inform restoration planning when considering the effect of restoration activities affecting streambed exchange. For instance, our findings suggest that increasing channel complexity and channel area (i.e., width-to-depth ratio) will yield the most pronounced effect on the rate and magnitude of streamed exchange. Increasing aquifer volume (i.e., via Stage 0 channel restoration strategies) also has a marked, though lesser, effect on stream-bed exchange. While not explored in this study, which was focused on mass exchange, these findings have exciting implications for partitioning the effects of restoration on thermal-energy exchange, because the balance of energy stored in exchanging water and floodplain-aquifer sediment will follow the water balance.

Room to Roam: Floodplains and the Central Valley

Challenges and Lessons Learned Designing Floodplain Rearing Habitat on Central Valley Rivers

Paul Frank, P.E., CED and **Michael MacWilliams, P.E., Ph.D.**, FlowWest (Co-presenters)

Salmonid-rearing habitat in California's Central Valley has been decimated by levees, agricultural encroachment, and flow regulation by dams. These forces have reduced the area of floodplain habitat and the frequency of inundation of off-channel areas where salmonids rear. Designers of new rearing-habitat projects, such as side channels and floodplains, face a multitude of challenges including limited flow and depth, inverted hydrographs due to winter storage behind dams, and sediment transport into these features that can render them ineffective or strand fish. With at least two decades of interventions to create rearing habitat in California's Central Valley already in place and billions in state and federal funding being spent to continue to create these features, we look at what the restoration community of practice has learned, and continues to learn, about how to design and implement these projects, featuring ongoing-project examples on the Sacramento and Feather Rivers.

Room to Roam: Floodplains and the Central Valley

Restored Seasonally Inundated Habitat Supports Juvenile Salmonid Rearing and Growth in California Central Valley Rivers

Kirsten Sellheim, M.S., Cramer Fish Sciences (Presenter) and Co-authors: **Avery Scherer, Ph.D.; Rocko Brown, Ph.D., P.E.**; **Jesse Anderson, B.S.**; **Jamie Sweeney, M.S.**; and **Joseph Merz, Ph.D.**, Cramer Fish Sciences

River habitat-restoration projects are implemented throughout western North America to mitigate long-term anthropogenic impacts on native salmonid (Salmonidae) populations. However, relatively little is known about target species' physiological or behavioral responses to habitat enhancement. We constructed four seasonally-inundated habitat-restoration projects in the Merced (8.5 hectares) and Stanislaus rivers (2.2 hectares) in California's Central Valley. We hypothesized that increasing seasonal-shallow-water-habitat area would increase rearing habitat quantity and quality, improving juvenile salmonid rearing, growth, and variation in migration timing and body size.

To test our hypotheses, we compared Chinook salmon (*Oncorhynchus tshawytscha*) invertebrate prey abundance and juvenile density, residence time, and growth in restored-seasonal habitats with the unrestored-main channel. Invertebrate prey productivity in restored-seasonally-inundated habitat was variable, but generally comparable to the main channel. In both rivers, restored-seasonal-habitats supported increased total salmon growth, through increased residence time in wet years and faster growth rates in a below-normal precipitation year, and a greater diversity in outmigration timing across all study years.

This study demonstrates that expanded-seasonally-inundated habitats support invertebrate prey production and are utilized by juvenile salmon. All sites supported natal rearing and growth, but the strength of restoration response varied by site, flow conditions, and metric. This study approach is being implemented on other Central Valley rivers and these juvenile Chinook salmon rearing behavior and growth parameters can be incorporated into existing models to better predict seasonally-inundated habitat-rearing capacity and growth and survival benefits in these and other Mediterranean-climate rivers.

Room to Roam: Floodplains and the Central Valley

Effects of Predator Density on Predation Rates of Juvenile Salmon in Managed Agricultural Floodplains

Peter G. Aronson, University of California, Davis, Department of Wildlife, Fish, and Conservation Biology (Presenter) and Co-authors: **Alexandra N. Wampler**, University of California, Davis, Department of Wildlife, Fish, and Conservation Biology, and University of California, Davis, Center for Watershed Sciences; **Nann A. Fangue**, **Dennis E. Cocherell**, University of California, Davis, Department of Wildlife, Fish, and Conservation Biology; **Andrew L. Rypel**, University of California, Davis, Department of Wildlife and Fish, and Conservation Biology and University of California, Davis, Center for Watershed Sciences; **Paul G. Buttner**, California Rice Commission; and **Carson A. Jeffres, Ph.D.**, University of California, Davis, Center for Watershed Sciences

There has been a 95% loss of historic wetland, riparian, and floodplain habitat over the last century, driven by water-infrastructure development and management. Many fishes historically utilized seasonal floodplains in California's Central Valley. A primary species of concern, the Chinook salmon (*Oncorhynchus tshawytscha*), has evolved to utilize seasonal floodplains as a rearing habitat. Recent studies have found that many adult spawners utilized floodplains as juveniles. Loss of this critical habitat has contributed to the decline of all four salmon populations in the Central Valley, now listed by California as either endangered, threatened, or species of concern. In recent decades, scientists have investigated the potential of managing agricultural lands within flood basins as seasonal wildlife habitat, which has proven successful for migratory birds. There has been recent interest in managing this habitat for fish. Wild fish spill into the system's cultivated floodplains when the Sacramento River floods. Shallow, carbon-rich conditions on winter-flooded rice fields allow for extremely high zooplankton densities, the primary component of several species' diets, including juvenile Chinook salmon. Managers can imitate this habitat if appropriate water levels are maintained. Preliminary results monitoring the growth and outmigration of floodplain-reared salmon indicate that agricultural-floodplain habitat is beneficial. However, concerns have arisen regarding juvenile salmonids' susceptibility to predation in agricultural floodplains, especially when predator densities are high.

We studied predation rates relative to predator density to better understand predation rates on Chinook salmon in cultivated rice fields. We stocked seven uniform winter-flooded rice fields with varying densities of a predatory fish, the largemouth bass (Micropterus salmoides). We then tethered juvenile Chinook salmon to predation event recorders (PERs) in two-hour increments and recorded the time elapsed before a predation event occurred. We conducted two sets of trials; one occurred earlier in the season under colder conditions, while we ran the other later in the season. We used our results to determine relative predation rates across predator density and seasonal treatments. Our findings will directly address a knowledge gap in the dynamics of predator-prey ecology in managed-agricultural floodplains and will be used to improve management practices.

Room to Roam: Floodplains and the Central Valley

Bringing the Floodplain to Life: Big Notch and Multi-Scale Restoration Efforts in the Yolo Bypass

Dennis Finger and **Brandy Smith**, California Department of Water Resources (Co-presenters)

The Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project (Big Notch Project), led by the California Department of Water Resources and the Bureau of Reclamation, aims to improve fish habitat and passage through adaptive management. The project seeks to enhance hydrologic connectivity between the Sacramento River and Yolo Bypass, supporting state and federally listed fish species. The Yolo Bypass currently provides productive floodplain-rearing habitat, but this benefit is only realized in some winters for short amounts of time during flooding conditions. The Big Notch Project would activate the Yolo Bypass floodplain habitat through a range of hydrologic conditions and across water year types. Key components of the project include a gated notch at the Fremont Weir, intake and transport channels, and additional passage facilities, which collectively aim to increase floodplain rearing habitat and reduce fish stranding and migratory delays.

With an estimated completion time frame of winter 2024/2025, the first year of operations will focus on setting up monitoring protocols and gathering baseline data to guide adaptive management. This adaptive framework allows iterative adjustments based on monitoring results to ensure objectives are met. Monitoring efforts are organized around three primary objectives: increasing floodplain rearing habitat, improving migratory passage, and addressing operational needs. Juvenile-rearing habitat and hydraulic conditions are assessed through telemetry and various fish-sampling techniques, while adult salmon and sturgeon migrations are tracked to reduce delays and improve rescue operations when needed. While data is still preliminary, this talk will focus on a summary of first-year operations, ongoing data collection efforts, and preliminary study results.

Room to Roam: Floodplains and the Central Valley

Butte Creek Floodplain Reconnection and Channel Restoration

Allen Harthorn, M.S., Executive Director, Friends of Butte Creek and
Anthony Falzone, Principal Geomorphologist, FlowWest (Co-presenters)

The Butte Creek Floodplain Reconnection and Channel Restoration Project will restore over two miles of floodplain and side-channel-rearing habitat for juvenile Spring-run Chinook salmon and steelhead. The project covers the Canyon unit of the 287-acre California Department of Fish and Wildlife Butte Creek Canyon Ecological Reserve, which was acquired from a gravel mining company after the flood of 1986. Butte Creek is one of only three Central Valley streams that has a population of Central Valley Spring-run Chinook salmon. The project reach is immediately downstream from the Spring-run spawning grounds in Butte Creek Canyon. The project will provide additional rearing habitat, that is limited in the 30-mile reach between the Spring-run spawning reach in the canyon, to rearing habitat in the Butte Sink. This project will also provide a rearing and resting habitat that may be critical when water conditions in the Butte Sink do not support a Spring-run rearing habitat.

The project reach of Butte Creek is a highly-disturbed landscape following nearly a century of gold dredging and gravel mining that extensively manipulated the floodplain and rerouted the channel. Gold dredging occurred between 1902 and 1949, leaving piles of cobble and gravel tailings and an inverted floodplain soil profile ill-suited to high-quality riparian forest. Subsequent gravel mining of these areas from the 1950s through 1970s created deep off-channel pits that create stranding, temperature, and predation hazards for salmonids. The project seeks to: (a) expand the floodplain with a restored natural soil profile and healthy floodplain forest; (b) improve hydraulic connectivity between the river channel and this restored floodplain habitat; and (c) increase the effective channel length while creating side-channel-rearing habitat for spring-run Chinook salmon and steelhead.

The combination of gold dredging and gravel mining modified the floodplain topography, realigned the channel, and removed spawning-sized sediment and soil from the channel and floodplain. To restore the connection to the floodplain and create riparian habitat, we combine earthwork and construct structures that will restore geomorphic processes that will restore the riparian forest, floodplain, and salmonid habitat. There are no major upstream reservoirs on Butte Creek that trap sediment. Using process-based-restoration design principles, floodplain and channel features will capture sediment to create both floodplain and in-channel habitats for riparian vegetation and salmonids. Channel and floodplain features will increase channel complexity and trap gravel and fine sediment for riparian-forest-natural regeneration and spawning habitat.

To help guide the design process, Friends of Butte Creek has developed a technical advisory committee (TAC) that consists of project stakeholders including the Mechoopda Tribe, CDFW, USFWS, CalTrout, NOAA, Regional Water Quality Control Board, Butte County, and Knife River Construction Company. Building a broad coalition of project supporters is important to securing implementation funding and for support of other restoration projects in the Upper Butte Creek Watershed. This phase of the project will develop design documents, obtain CEQA clearance, and apply for the required permits. Future phases of the project will include implementation and post-project monitoring.

Room to Roam: Floodplains and the Central Valley

Geomorphic Progression, Habitat Use, and Sustainability on a Floodplain Reconnection Project

Sam Diaz, P.E., cbec eco engineering (Presenter), and Co-authors:
Chris Hammersmark, Ph.D., P.E., Stephanie Day, Ph.D., and **Jon Parsons, M.S.,** cbec eco engineering; **Danielle Conway**, South Yuba River Citizens League; and **Avery Scherer, Ph.D.**, Cramer Fish Sciences

The Lower Long Bar Enhancement Plan was constructed on the lower Yuba River in 2022. The project removed over 340,000 cubic yards of material to lower and shape a lateral bar composed of mine tailings so it would inundate more frequently to provide juvenile-salmonid- rearing habitat and stimulate riparian vegetation recruitment. The project explored the use of native cobble material to generate hydraulic complexity, sediment accretion, and vegetation recruitment. The project has experienced numerous moderate flow events and the site has evolved. Changes to the form of the bar have affected the way water flows over it and interacts with design features, and, in turn, the anticipated design performance. The observed geomorphic changes were evaluated to understand how differences in specific design features affected the persistence and sustainability of habitat within the project area and beyond. A combination of field observations, topographic analysis, and habitat suitability modeling was applied to increase knowledge regarding which features were most sustainable and which provide the best habitat opportunities. These evaluations were distilled into lessons learned that can be applied to future projects of a similar nature.

Restoration Assessment and Planning

Session Coordinator: Rachel Shea, P.E., Michael Love & Associates

Monitoring tells us if we are going in the right direction with salmonid restoration and management. This session explores planning, methods, and results of various monitoring projects across the landscape to evaluate physical habitat, habitat selection, growth rates, life history strategies, and fish disbursement in newly-undammed watersheds. Over time, the lessons learned from monitoring can be used to improve planning/ management decisions and restoration methods with a goal to create resiliency in salmon populations across their range. We need more monitoring!

Restoration Assessment and Planning

Boulder Hopping Towards Steelhead Recovery in Jalama Creek

Keith Miller and **Laura Riege**, The Nature Conservancy (Co-presenters) and Co-authors: **Jeff Kozlowski, Rachel Robin, and Tessa Artruc**, ICF; and **Brendan Belby**, Stantec

The Nature Conservancy's Jack and Laura Dangermond Preserve, located at Point Conception in Santa Barbara County, encompasses and protects ninety-four percent of the Jalama Creek watershed. This watershed located in the Southern California Steelhead Distinct Population Segment (DPS) can play a key role in recovering steelhead to this region. However, two barriers located within 1.5 miles upstream of the ocean almost completely blocked steelhead migration in and out of the watershed. The last steelhead was documented in the watershed in 1994. Recent surveys of the watershed document good habitat, but no redds or *O. mykiss* of any size class. The Southern California Steelhead Recovery Plan identified removing barriers as the highest priority recovery action in the watershed.

As we described at the SRF conference last year, we removed the first barrier- a small dam located a half-mile up from the estuary in 2023. The removal of that barrier, along with the heavy rainfall in Winter 2024, "reset" that portion of the creek, resulting in substantial in-stream habitat improvement and access to 1.5 miles of spawning and rearing habitat – up to the next barrier located at a County road bridge.

In September, 2024 we removed the second barrier, opening up a total of 12 miles of critical habitat in Jalama Creek. The second barrier, a concrete apron overhang, was located beneath a County bridge on a public road and therefore presented a different set of design and construction challenges that required balancing barrier removal with protection of a heavily used bridge first constructed in 1948. The solution involved bringing in more than 250 tons of 4-ton boulders and engineered-stream material to build a 150-foot-long roughened-rock ramp that gives steelhead adults and juveniles multiple-passage pathways over a range of flows.

This presentation will describe the in-stream-habitat improvements at the first barrier since 2023, the design and construction challenges at the second barrier, and the changes observed during its first rainy season post-construction.

Restoration Assessment and Planning

Ten-year Summary of *O.mykiss* (Steelhead) Monitoring on San Mateo Creek, California

Richard M. Johnson, Aquatic Biologist, San Francisco Public Utilities Commission

Following a dam- improvement project to Lower Crystal Springs Dam, San Francisco Public Utilities Commission biologists have been conducting extensive monitoring of aquatic resources in San Mateo Creek since 2015. This presentation aims to summarize ten years of monitoring data focused on the creek's Central California Coast steelhead population.

Restoration Assessment and Planning

Hatchery Assisted Re-introduction of Salmonids Post Dam Removal, Utility or Futility?

Samantha Kannry, TRIB Research

The dam-building era in the United States has generally concluded and the dam-decommissioning era is in its nascent stages. The decommissioning of dams and the ability of anadromous fishes to return to their historic habitat presents questions regarding how best to restore salmonid runs in these upper basins. The Elwha and Klamath Dam removals are now complete and anadromous fishes are recolonizing their ancestral waters. The Potter Valley Project (composed of Scott and Cape Horn Dams on the upper Eel River) is on the cusp of decommissioning.

We examined the results of hatchery-assisted and natural recolonization of salmonids in newly-undammed basins. We also investigated the current state of run-timing, life history, and overall-genetic diversity in resident *O. mykiss* above Scott Dam on the upper Eel. Our results, which consider various metrics of genetic diversity, suggest the resident-trout population above Scott Dam would be primed for the reestablishment of steelhead post-dam removal.

Restoration Assessment and Planning

Urban Creeks: Unexpected Refugia for Threatened Salmon

Colton Dixon, M.S., Cal Poly Humboldt (Presenter) and Co-authors: **Darren Ward, Ph.D.** and **Matthew Craig, B.S.**, Cal Poly Humboldt

Urban creeks are often overlooked as potential habitats for sensitive, threatened, and endangered species. However, recent restoration efforts in the City of Arcata have revealed surprising ecological benefits. Following habitat enhancement projects in Janes and Jolly Giant Creeks, juvenile coho salmon (*Oncorhynchus kisutch*) have been observed rearing in these urban streams—despite no documented adult spawning in over 50 years.

The origin of these juveniles remains uncertain, but we suspect most of them are non-natal migrants originating from other Humboldt Bay tributaries, displaced into these small, urban streams during winter flood events. Many coho salmon in the region are tagged with passive integrated transponders (PIT) as part of ongoing population monitoring efforts. While PIT-tagged fish are regularly detected rearing in non-natal tributaries after high flows, we found no tagged individuals in Janes or Jolly Giant Creeks to conclusively support this hypothesis.

Mark-recapture data indicate that coho salmon in these urban streams exhibit low population densities but experience fast growth rates, averaging over 0.5 mm per day. While no evidence of spawning has been documented, these streams provide critical rearing habitat for coho salmon and other species, including coastal cutthroat trout (*Oncorhynchus clarkii clarkii*), steelhead trout (*Oncorhynchus mykiss*), and tidewater gobies (*Eucyclogobius newberryi*).

This study highlights the potential value of urban creeks as refugia for salmonids, supporting alternative- life-history strategies that contribute to the "portfolio effect." Maintaining and enhancing these habitats near intact salmon populations may help buffer against unfavorable environmental conditions, ultimately bolstering population resilience.

Restoration Assessment and Planning

Integrated Ecosystem and Infrastructure Resilience Planning in Scott Creek, Santa Cruz County

Daniel Nylen, Watershed Restoration Program Manager, Resource Conservation District of Santa Cruz County

Since the early 2000s, Scott Creek has been the subject of research, monitoring, education, and targeted restoration. It has been a focal watershed for the recovery of Central Coast California (CCC) coho salmon and harbors a conservation hatchery, lifecycle monitoring station, and has inspired decades of research aimed at informing management and restoration decisions. The Resource Conservation District of Santa Cruz County, in partnership with Trout Unlimited, CalPoly Swanton Pacific Ranch, Caltrans, the Santa Cruz County Regional Transportation Commission, and the Santa Cruz County Parks Department, is currently helping to lead two large-scale planning efforts in the lower two miles of Scott Creek aimed at significantly enhancing ecosystem- and transportation- infrastructure resilience. These two efforts include building a new and longer Highway 1 bridge, spanning over the Scott Creek river mouth, and actively restoring the Scott Creek lagoon, as well as restoring instream and floodplain habitat along the lower portion of Scott Creek upstream of the lagoon. In concert, these two projects aim to realize truly large-scale restoration aimed at moving the needle on salmon recovery south of the Golden Gate while simultaneously improving infrastructure resilience to climate change in an important transportation and recreation corridor. This presentation will provide an overview of these two planning efforts and highlight the strong partnerships and novel models of coordinated conservation embodied by these projects.

Restoration Assessment and Planning

Redwoods Rising's Logging Road Removal in the Greater Prairie Creek Watershed, Orick, CA

Evan Laughlin, Redwood National Park (Presenter)

Redwoods Rising (RR) is an ambitious, landscape-scale project that aims to restore watersheds heavily impacted by logging in the globally significant forests of Redwood National and State Parks. These parks are home to almost half of the world's remaining protected old-growth redwood forests, which store more carbon per acre than any other forests on Earth. These forests safeguard a host of federally threatened and endangered species, including coho and Chinook salmon, steelhead trout, marbled murrelets, and Humboldt martens.

Historic logging practices in the Greater Prairie Creek watershed (GPC), the current focus of RR, were highly destructive to aquatic resources. Approximately 2/3 of the 45 miles of stream channel are buried by many feet of excess logging slash and associated fill. Many streams were buried outright during logging operations, while others have been buried by excess sedimentation, a direct consequence of loss of vegetation, landscape instability, and the unnatural-hydrologic regime of failing-road networks. These segments of buried stream lack any visible-surface flow outside of isolated pools, have no obvious riparian zones or floodplains, and most likely act as barriers to fish and amphibian passage, all of which are critical to Southern Oregon Northern California Coastal (SONCC) coho salmon recovery. Reconnecting these watersheds under Redwoods Rising is two-part: variable-density thinning of the second-growth forest and historic-logging-road removal. This talk will discuss our current methodologies and approaches to road-removal practices, with insight from 40 years of road-removal in coastal-redwood forests.

Redwood National Park began developing road-removal techniques specific to the needs of its coastal forests in the late 1970s. The methodologies have varied and evolved through the decades, arriving at our current approach. We reference historic-aerial photographs of the clearcut landscapes and recent LiDAR imagery to inform our field-mapping efforts, identifying high-priority roads and stream crossings. In the dry summer months, we operate heavy equipment to fully recontour slopes and remove sediment barriers in streams. Our designs are field fit and rely on old growth stumps, buried original topsoil layers on slopes, and buried gravel layers in streams to best restore the pre-disturbance topography. For in-channel work, we typically install a sediment trap at the bottom of each unburied reach to settle out fine material during winter flows and add large wood to stream channels and banks to enhance complexity and protect raw surfaces from erosion. We utilize a novel approach to monitoring our in-stream work, tracking succession (cobble size, pool development, fish cover development), macroinvertebrate assemblages, and water-quality changes pre- and post-restoration with a robust field protocol.

After five years of work in GPC, we have removed 16.5 miles of road, 128 stream crossings, and restored 4.5 miles of buried-stream channel. Under current projections, we plan to remove 60 miles of road over the next 6 years. While we're still hundreds of years out from a fully-reconnected-old-growth forest, we've seen rapid improvement in the unburied-aquatic habitat, including spawning trout and improved water quality.

Restoration Assessment and Planning

Multiple Years of Genetic Monitoring of Central Valley Juvenile Chinook Yields Valuable New Insights into Spatial and Temporal Patterns of Adult Reproductive Success

Jeff Rodzen, Ph.D., California Department of Fish and Wildlife (Presenter) and Co-authors: **Joy Gaines, M.S.**, California Department of Fish and Wildlife; **Sean Canfield, Ph.D., Sarah Brown, Ph.D.,** and **Melinda Baerwald, Ph.D.**, California Department of Water Resources

We present the results from three consecutive years of genetic monitoring of out-migrating spring-run Chinook salmon across the Central Valley. While many genetic studies have focused on patterns of diversity in returning adults, such information on out-migrating juveniles is much more sparse. Our data from 5,000 out-migrating juveniles show interesting temporal and spatial patterns of habitat use and successful reproduction by salmon from the different life-history strategies and genetic stocks that inhabit the Central Valley. Additionally, using genetic-close-kin mark-recapture methods, we estimate the number of family groups within juvenile collections to obtain better insights into adult reproductive success in key tributaries. Our findings will have implications for salmon management and the new juvenile production estimate models.

Landscape-Scale Process Based Restoration for Forests, Floodplains, and Fish

Session Coordinators: **Carrie Monohan, Ph.D.**, Mooretown Rancheria of Maidu Indians; **Ben Cook**, Trout Unlimited; and **Karen Pope, Ph.D.**, Pacific Southwest Research Station USDA

Process Based Restoration (PBR) engages dynamic ecological processes and removes constraints to those processes to encourage ecosystems to thrive and recover from disturbance. The theory and application of PBR continues to evolve and grow from site-level to landscape-scale partnerships ready to tackle increasingly intense and variable disturbance regimes. As PBR seeks to work at effective spatial and temporal scales, the PBR community realizes the need to exchange information and collaborate with a broad contingent with expertise at implementing multi-generational ecological and cultural stewardship models at broad spatial scales. New, increasingly variable disturbance regimes require expansive multi-disciplinary and multi-generational collaborations to work at spatial and temporal watershed scales including: innovative techniques for working with onsite materials in low- and high-energy stream reaches to restore resilient hydrologic regimes, practices for working within forests and other upland areas such as beneficial fire, data fluencies and improved prioritization strategies for realizing multiple and multiplying benefits, and integrated scientific approaches for monitoring multivariate long-term responses to both disturbance and restoration. This session invites real-world examples of collaborations employing these toolsets to work across broad spatial and temporal scales to promote ecological uplift and resilience.

Landscape-Scale Process Based Restoration for Forests, Floodplains, and Fish

Cross-Organizational Collaboration for Watershed Scale Stream Restoration

Nadia Hamey, RPF, Hamey Woods

Since 1999, San Vicente Creek, along the north coast of Santa Cruz County, has been the subject of research and targeted restoration interventions from various entities including Sempervirens Fund, Peninsula Open Space Trust, The Bureau of Land Management, San José State University, University of California, Santa Cruz, Resource Conservation District of Santa Cruz County, and the County of Santa Cruz. This small but unique watershed is an unlikely stronghold for a limited but persistent presence of Central California Coast coho salmon due to conservation land ownership, karst geology, and a permanently open river mouth. This presentation highlights some of the collaborative actions that have taken place, including streamwood augmentation, dam removal, invasive species removal, and student-led research and monitoring. It also highlights future actions, including a large-scale multi-benefit streamwood enhancement, forest health thinning, invasive species removal, and floodplain restoration projects that build on previous actions and lessons learned to benefit multiple stakeholders.

Landscape-Scale Process Based Restoration for Forests, Floodplains, and Fish

Characterizing Watershed Stream Network Geomorphic Conditions in Industrially Logged Watersheds and Developing Strategies for Using Process-Based Techniques to Restore Aquatic Habitat

Thomas H. Leroy, CG, Engineering Geologist, Pacific Watershed Associates (Presenter)

The vast majority of streams, within industrially logged watersheds in Northern California, exhibit geomorphic conditions governed by a legacy of disturbance. In general, the disturbances and impacts occurred similarly throughout the watershed networks of individual subbasins, but how the legacy of these disturbances are currently observed on the ground is arguably related to the watershed area of the impacted watershed. Primary disturbances include: road construction, bulldozer skidding, hillside and riparian vegetative conversion, and disturbances related to timber sorting and extraction. The most impactful aquatic disturbances tended to occur within and along the margins of the streams where bulldozers were used to extract and manage timber. Regardless of the size of the stream, or its location within the watershed, these disturbances typically resulted in the discharge of disproportionally large volumes of sediment and tree debris directly into the stream network. The short-term impacts from this unprecedented discharge of logging debris was to completely overwhelm most streams as the supply of wood and sediment exceeded the ability of the streams to route or locally re-sort much of the introduced material. From this point forward the fluvial-geomorphic landforms that developed in any given stream reach became governed by the size of the watershed area contributing to the stream flow. In smaller watersheds (<250 acres) the streams were limited in their ability to route the accumulated material through the system. Typically, the geomorphic results of this are currently observed as an uneven distribution of wood and sediment throughout the streams, where most of the large wood is accumulated in disproportionately large wood jams with large sediment wedges accumulated upstream. In between the large wood accumulations, where large wood densities were relatively lower, channels tended to incise through the accumulated sediment, resulting in vertical channel margins and simplified fluvial-geomorphic landforms. These conditions have resulted in significant degradation of available anadromous fish habitat within the uppermost extents of their historic habitat as the large wood jams became flow-dependent temporal barriers to anadromous fish. Within the larger medium-sized watersheds (2000 acres), the channels, through time, tend to exhibit the stream power required to route and sort the accumulated logging debris. These are the streams where anadromous fish have been able to maintain a persistent presence and most restoration activities have been focused. The largest subbasins (10,000 acres) tended to be the locations where the routed sediment and debris were deposited resulting in degraded habitat. This talk will discuss strategies to develop prioritized action plans and employ process-based restoration techniques to these watersheds to increase anadromous fish habitat availability and improve aquatic habitat conditions at a watershed scale.

Landscape-Scale Process Based Restoration for Forests, Floodplains, and Fish

Creating Community Stewardship

Garrett Costello, Owner, Symbiotic Restoration Group (Presenter)

Given the need to increase the pace and scale of stream and meadow restoration across California, it is essential that communities begin to take stewardship of their local degraded ecosystems. Through engaging the community with educational experiences, volunteer opportunities, and a sense of ownership and investment, humanity can increase its ability to do this necessary work. Examining the impacts of community involvement on several restoration projects, we can take inspiration and hope that everyday people (and beavers) can become stewards of their communities and help protect California in perpetuity.

Landscape-Scale Process Based Restoration for Forests, Floodplains, and Fish

Bringing Prescribed Burn Associations (PBAs) into Process Based Restoration (PBR): Restoring Fire with Prescribed Burn Associations

Lenya Quinn-Davidson, Fire Network Director, University of California Agriculture and Natural Resources (Presenter)

Just ten years ago in California, the use of prescribed fire was mostly limited to federal and state fire management agencies, leaving communities, tribes, non-governmental organizations, landowners, and others without the training, resources, or support needed to restore fire on their local landscapes. This dynamic had been in place for many decades, and though prescribed fire was not technically disallowed for non-agency practitioners, there was little understanding of or inspiration for community-based models for this work. Likewise, the exclusive, highly specialized nature of prescribed fire implementation meant that it was not widely considered or incorporated in larger ecological restoration efforts, even though fire is currently missing as a critical ecological process across most of California and restoration of beneficial fire is a very real need. In 2017, University of California Cooperative Extension advisors imported the prescribed burn association (PBA) model to California, borrowing inspiration from the Great Plains. PBAs are community-based cooperatives for prescribed fire. Mostly volunteer-based, PBAs provide a venue for training, grant writing, equipment sharing, and project implementation, leveraging local skills and resources to increase the application of prescribed fire. Notably, PBAs are open to everyone, fostering an inclusive, grassroots culture around prescribed fire—one that is radically different than the agency-based approach. California's first PBA was formed in Humboldt County in 2017/ 2018, and the model met with significant interest and demand across the state. Now, only seven years later, there are 25+ PBAs across California and the model is spreading to Oregon, Washington, and other western states. Since 2017, California's PBAs have engaged thousands of volunteers, enabled the implementation of more than 400 prescribed fire projects, and opened prescribed fire up to many communities and sectors for which it was previously unavailable, including restorationists. This presentation will provide background and context for the PBA movement, offer ideas for how prescribed fire might be more meaningfully incorporated into restoration efforts, and inspire new collaborations that bring PBAs into PBR.

Landscape-Scale Process Based Restoration for Forests, Floodplains, and Fish

Structural Characteristics of Beaver Complexes and Implications for Beaver-Based Restoration

Caroline Gengo, Student, University of California, Davis, Center for Watershed Sciences (Presenter)

Habitat structure in streams is created through interactions between flow and sediment to create naturally dynamic patterns of inputs and outputs. Habitat heterogeneity at large scales is impacted by both physical drivers (such as sediment and flow) and biotic drivers (such as ecosystem engineers). Beavers are well-known ecosystem engineers with impacts on large-scale habitat heterogeneity in stream systems through the introduction of systematic, small, semi-permeable dams. As beaver-based restoration of streams and meadows continues to demonstrate long-term impacts, understanding natural densities and structural characteristics of beaver complexes is becoming increasingly important.

In this study, we surveyed 5 beaver dominated stream systems in northern California. At each stream system, we mapped beaver dam locations and structural characteristics, including length, height, width, flow-through type, leakiness, and construction materials. Stream geomorphic habitat characteristics upstream and downstream of beaver dams were also assessed as either pool, riffle, run/ glide, rapid, or dry, based on a combination of depth and velocity measurements. Correlations between structural characteristics and surrounding geomorphic habitat will be assessed to describe how varying structural characteristics of natural beaver dam complexes impact in-stream habitat heterogeneity. This information can help guide structural characteristics of beaver-based restoration when specific in-stream habitat outcomes are desired.

Landscape-Scale Process Based Restoration for Forests, Floodplains, and Fish

A Framework for Using Post-Fire Sediment to Restore Incised Channels

Zan Rubin, Ph.D., Balance Hydrologics (Presenter) and Co-authors: **Brigid Lynch, Ph.D.** and **Carter Boyd**, Balance Hydrologics

Historical and ongoing watershed impacts such as dam construction, channel straightening, and wood removal have impacted channel morphology and, in many cases, have triggered incision and disconnected channels from their former floodplains. As such, many restoration projects seek to enhance floodplain connectivity for the anticipated benefits related to nutrient cycling, water quality, groundwater recharge, flood control, and increasing and cooling baseflow. Concurrently, wildfires, exacerbated by climate change and forest mismanagement, increase sediment delivery to the channel network, presenting the potential for opportunistic restoration planning to utilize the additional post-fire sediment to un-incise channels and increase floodplain connectivity. We propose a restoration planning framework to identify areas within burned river networks with the greatest potential for increasing floodplain connectivity, typically- wider, lower-gradient segments. Rather than starting with a stream reach or meadow and asking how to restore it, our approach instead asks, "Where are the most suitable sites in a watershed for enhancing floodplain connectivity?" This approach could be implemented quickly after a wildfire, taking advantage of increased sediment loads, available materials such as burned trees, and fire access roads that may facilitate equipment access to stream reaches typically beyond the reach of equipment. To demonstrate this modeling framework, we applied it to the Waddell Creek watershed (approximately 26 square miles) in Big Basin Redwoods State Park, which was severely affected by the 2020 CZU Lightning Complex Fire. In this study, we identified potential floodplain reconnection sites using the "rain-on-grid" HEC-RAS methodology to model flood inundation extents at the watershed scale. Using this approach, we identified incised segments where floodplain surfaces are inundated only during extreme flow events (i.e., 100-year and 500-year floods) but not inundated by more regular flood flows; these reaches are the optimal targets for low-cost and effective post-fire restoration because the channels are not so incised that they are completely disconnected from the floodplain, but could benefit from more frequent connection. This approach represents an efficient and inexpensive remote technique that can be used as a screening tool for targeted restoration following a wildfire.

Landscape-Scale Process Based Restoration for Forests, Floodplains, and Fish

Data Fluency in Support of Inclusive Process-Based Restoration

Maureen Johnson León, Doctoral Candidate in Data Science, University of Canterbury (Presenter)

In contrast with data literacy, which facilitates improved, yet often unidirectional communication and interpretation of "thin" (quantitative, numerical, linear) data from scientists to the public or community groups, Data Fluency provides an inclusive framework for data analysis that fosters multi-directional information sharing and analysis and accounts for complex or "thick" (experience-based, place-based, un-written, historic/ prehistoric, qualitative, narrative, imaginative) ecological data, datasets, and data systems.

There are many ways that thin and thick data are considered (or not) in planning restoration interventions that can lead to desirable outcomes. Thick data may be especially useful for assessing ecological responses to restoration approaches that seek to promote overall ecological uplift (i.e. Process Based Restoration [PBR]). Some scientific frameworks may not provide training or tools for accounting for thick data, datasets, and data systems, which may prove critical for gathering and analyzing complex ecological information.

Further, some data analysis frameworks used in planning, documenting, and implementing projects may inadvertently exclude certain practitioners, practices, and the associated and often robust multigenerational place- or experience-based datasets and data systems. Exclusion may inhibit community-centered sense-making processes of aligning data with interpretation, action, history, and culture. Fostering an understanding of both thin and thick data types could contribute to an inclusive and collaborative data fluency that expands our shared knowledge and the range of possible imagined futures.

Foodscapes in Action

Session Coordinator: Gabriel Rossi, Ph. D., Research Scientist, UC Berkeley and California Trout Coastal River Ecologist

Foodscapes are beautiful and full of ecotones! A rain-fed tributary flows into a glacier-fed river—each with unique and asynchronous opportunities for fish to grow.
Photo by Ryan Bellmore

Recent work in watersheds from Alaska to California has emphasized the central role of food in salmon resilience and recovery. A foodscape perspective expands our view of watershed management to consider the sources, phenology, and pathways of key food resources. It also focuses our attention on the conditions that allow salmon (and other mobile consumers) to track and exploit feeding opportunities across the riverscape. Like every aspect of salmon habitat, the foodscape has been (and continues to be) altered, simplified, and often severed. But unlike work on fish passage, water quality, or instream flow, we are only now beginning to realize the challenges and opportunities for recovering and maintaining healthy, functional foodscapes.

Join us as we examine "foodscapes in action" – specific projects and places where foodscape thinking is being applied to salmon conservation and recovery. This session will bring together stewards, managers, and researchers, who are developing methods to study, monitor, and restore foodscapes. We will consider foodscapes in relatively intact watersheds, which shed light on the key trophic pathways and spatiotemporal patterns of foraging and growth potential that support salmon populations. We will also consider foodscapes in heavily impacted systems, which provide a novel lens to consider how alternative restoration actions promote diverse and connected foraging and growth opportunities for fish. In both contexts, foodscape thinking reveals opportunities to find new and productive tools that can help move the needle on salmon population abundance, diversity, and resilience – opening new possibilities for watershed stewardship and bringing optimism in a time of ecological crisis.

Foodscapes in Action

Modeling the Salmon Foodscape

J. Ryan Bellmore, Ph.D., Pacific Northwest Research Station, USDA Forest Service, Juneau, Alaska (Presenter) and Co-authors: **Stephanie Carlson, Ph. D.**, **Gabriel Rossi, Ph. D.**, and **Avi Kertesz**, Environmental Science, Policy, and Management, UC Berkeley, California; **Holly Harris**, Pacific Northwest Research Station, USDA Forest Service, Juneau, Alaska; **Joseph Benjamin**, Forest and Rangeland Ecosystems Science Center, US Geological Survey, Boise, Idaho; **Aimee Fullerton**, Northwest Fisheries Science Center, NOAA Fisheries, Seattle, WA

Salmon life cycle models are valuable tools for identifying population bottlenecks and informing recovery efforts, but these models often lack the spatial, temporal, and ecological resolution of freshwater habitats and food webs that support juvenile salmon. Here we present a novel bioenergetic-based 'foodscape' modeling approach to explore how diverse foraging and growth opportunities across river networks contribute to juvenile salmon abundance and life history diversity. We parameterize the model with food and temperature regimes found in coastal California watersheds, and we illustrate through a series of heuristic simulations, that restoring diverse foodscapes increases salmon life history diversity and in turn population productivity. We deduce two important principles from our model simulations. First, asynchronies in the timing of food availability and fish growth potential amongst habitats (e.g., tributaries and mainstems) beget greater salmon life history diversity by providing opportunities for juvenile salmon to grow and survive in different ways by moving between adjacent habitats. Second, greater life history diversity leads to greater population abundance (a greater number of smolts produced per unit spawner). This is because moving between habitats allows fish to capitalize on peaks in foraging and growth conditions as they shift across space and through time, as well as reduce density dependence by occupying habitats that otherwise might be underutilized. This modeling framework can help identify habitats and food webs—that if restored—would enhance salmon life history diversity and population productivity. It is also a tractable approach that can be adapted to salmon-bearing watersheds from California to Alaska.

Foodscapes in Action

Rediscovering Non-Natal Life Histories to Recover Salmon (On The Case of the Missing Life Histories)

Stephanie Carlson, Ph.D., Environmental Science, Policy, and Management, University of California, Berkeley (Presenter) and Co-authors: **Ryan Bellmore**, USDA Forest Service, Pacific Northwest Research Station, Juneau, Alaska; **Marisa Obedzinki, Ph. D.**, Environmental Science, Policy, and Management, UC Berkeley, California, California Sea Grant, Santa Rosa, California; and **Henry Baker, Rachael Ryan, Avi Kertesz, Amy Fingerle, Phil Georgakakos, Ted Grantham, Ph. D.**, and **Gabe Rossi, Ph. D.**, Environmental Science, Policy, and Management, University of California, Berkeley.

We observe, anecdotally, that many river systems in which salmon were historically abundant in California (and elsewhere) do not appear to have enough rearing capacity in spawning reaches to support historical adult levels. This leads us to ask: what are the missing sources of juvenile production that may have contributed to such abundance? The natal rearing strategy - in which juveniles emerge from the nest and rear near their location of emergence (often in small, cool headwater streams) before migrating to the ocean - is the most commonly recognized life history strategy in many salmon life cycle models. It is also emphasized in education materials and is well established in management, restoration, and public perception.

However, this simplistic life cycle model overlooks non-natal rearing strategies, in which juvenile salmon leave their natal environment and seek habitats for shelter, food, and growth elsewhere in the watershed before ocean entry. We hypothesize that non-natal life histories and the habitats that support them are necessary to explain historical adult returns. Drawing from published research and ongoing studies, we will highlight the benefits of non-natal rearing in alleviating density dependence, allowing fish to take advantage of different growth opportunities across the foodscape, and contributing to a diversity of juvenile life history strategies, all of which influence the abundance and stability of adult returns. We also highlight the widespread loss and degradation of habitats that supported non-natal fish historically - and the potential for restoration actions that support non-natal rearers to contribute to salmon recovery. By drawing attention to the importance of non-natal rearing strategies, we aim to disrupt prevailing concepts around the salmon life cycle that (intentionally or not) tend to predominate within management and restoration decisions, constraining the recovery and resilience of salmon populations.

Foodscapes in Action

Alternative Life-History Tactics Fueled By Warm Habitat: Coastal Cutthroat and Redband Trout Forego Thermal Refuges to Feed in Productive Riffles

Jonny Armstrong, Ph.D., Department of Fisheries, Wildlife, and Conservation Sciences, Oregon State University, (Presenter), and Co-authors: **Hannah Barrett** and **Jordan Ortega**, Department of Fisheries, Wildlife, and Conservation Sciences, Oregon State University.

Large rivers are critically important for migratory salmonids, but they can become warm during summer. Higher temperature increases energetic costs, but the net effect on growth depends on foraging opportunity and thermal tolerance. How these factors interact to shape salmonid growth potential across landscapes is poorly understood, yet critically important for managing salmonids in a warmer future. Here we share results from field studies on coastal cutthroat trout in the mainstem Willamette River and redband trout in the Sprague River (of the Upper Klamath Basin). In both systems, we observed individual variation in habitat use during summer. Fish either used cool floodplain features or warm riffles. Despite the higher metabolic costs incurred in riffles (due to temperature and activity), growth rates were similar, reflecting higher feeding rates. These results exemplify alternative life history tactics of rate-maximizing versus cost-minimizing. Maintaining intraspecific diversity and life history variation is a common goal for conservation. Here we show how main-stem riffles, connected floodplains, and groundwater interact to support life-history diversity.

Foodscapes in Action

River Rest Stops: The Effects of Floodplain Food Subsidies on Chinook Outmigration Transit Time

Adrian Loera, M.S. Student, University of California, Davis (Presenter) and Co-authors: **Jacob Montgomery, Jacob Katz, Ph.D.**, California Trout; **Rob Lusardi, Ph.D.**, and **Elizabeth Crone**, University of California, Davis; and **Derrick Alcot**t, California Department of Fish and Wildlife

The channelization and leveeing of the Sacramento River have largely removed access to critical floodplain environments, eliminating essential Chinook Salmon (*Oncorhynchus tshawytscha*) rearing habitat. One management practice that has been implemented along the Sacramento River and its tributaries is growing floodplain zooplankton in wetlands inaccessible to fish and draining the water and zooplankton back to fish-bearing channels. Research has shown high production of zooplankton on managed floodplains and the improved growth of juvenile Chinook salmon in enclosures at managed floodplain outfalls. Reconnecting the floodplain foodscape throughout the winter and spring in the Central Valley improves growth and phenotypic diversity necessary, in part, to recover depleted Central Valley salmon runs. However, there is currently a lack of understanding of how these managed floodplain resources exported to the river affect out-migrating juvenile salmonid behavior during the floodplain drainage events. In the 2023 and 2024 water years, we worked with landowners to pump managed floodplain water back to the Sacramento River to better understand the growth and movement response of juvenile salmon. We deployed acoustic receivers at a fine scale (10 receivers per 6 river miles) in subsidized and unsubsidized stretches of the Sacramento River allowing us to track the movement response of ATS SS300-tagged out-migrating juvenile Chinook. Further, we quantified food web density during export and enclosure of juvenile salmon growth in the Sacramento River within, above, and below the subsidy footprint. During water exports, zooplankton biomass was approximately four times greater at pump sites than those without subsidies (upstream) in the Sacramento River, and enclosure fish within the subsidy footprint exhibited growth rates seven times greater compared to fish reared immediately upstream of the subsidy. Tagged Chinook motility varied, but acoustic data suggests delayed outmigration, presumably to capitalize on high levels of food resources associated with managed floodplain subsidies. These results have important implications for the role that this novel management practice has in mimicking the historical Central Valley floodplain dynamics that Central Valley Chinook evolved to use, and for the use of the practice as part of a portfolio of management strategies that contribute to salmon recovery in California.

Foodscapes in Action

Location, Location, Location: Stream Type Promotes Variation in *Oncorhynchus mykiss* Life-Histories with Implications for Future Climate Scenarios

Nicholas J. Corline, UC Davis Center for Watershed Sciences (Presenter) and Co-authors: **Tyanna Blaschak, Damon Goodman**, California Trout; **Ate Visser**, Lawrence Livermore National Laboratory; **Jean Moran, Emilio Grande**, Cal State East Bay, Department of Earth and Environmental Sciences; **Sarah Howe** and **Amber Lukk**, University of California, Davis, Center for Watershed Sciences; and **Robert A. Lusardi, Ph.D.**, University of California, Davis, Department of Wildlife, Fish, and Conservation Biology

From giant sequoias (*Sequoiadendron giganteum*) to pacific salmon (Oncorhynchus sp.), species display diversity in life histories due to variations in habitat conditions within their range. Recent research has illustrated stark differences in the emergence timing and growth of young-of-the-year (YOY) rainbow trout (*Oncorhynchus mykiss*) between hydrologically flashy snowmelt and stable spring-fed streams. To further characterize rainbow trout life-history diversity in Northern California, we assessed spawn and emergence timing, and YOY growth in multiple runoff, spring-fed, and hybrid streams (where discharge was made up of both runoff and spring-fed components). Our findings indicate that hydrologic stability, and perhaps productivity, in spring-fed streams in Northern California contributed to early spawning and emergence times for rainbow trout. High productivity in spring-fed streams led to greater growth, where YOY were 2.3X longer and 14.3X heavier in spring-fed than snowmelt streams. Spring-fed fish had fork lengths ranging from 85-136 mm and wet weights from 7-32 grams, while fork lengths ranged from 44-85 mm and wet weights from 1-6 grams in runoff streams. Additionally, we found that fish in hybrid streams exhibited intermediate growth rates compared to spring-fed and snowmelt systems. Using a bioenergetic modeling approach we found that productivity compensated for higher temperatures in some spring-fed streams, while higher temperatures in runoff streams muted growth rates due to comparatively depauperate food resources. These results provide insight into the effects of habitat stability and productivity on salmonid life-history diversity and may guide our understanding of the ecosystem and salmonid response to changing climate.

Foodscapes in Action

Small Streams and Floodplain Wetlands Offer Contrasting Foraging Environments for Salmonids Across a Large Interior British Columbia Watershed

Sean Naman, Research Scientist, Fisheries and Oceans Canada, Freshwater Ecosystems Section, British Columbia, Canada (Presenter), and Co-authors: **Doug Braun**, **Amanda Martens, Daniella Loscerbo, Julian Gan**, Fisheries and Oceans Canada, Freshwater Ecosystems Section, British Columbia, Canada; and **Sheena Parsons**, **Brittany Milner**, **Chelsea Little**, Simon Fraser University

Salmonids use a diverse range of habitats as they rear in freshwater, for example, juvenile coho may use small natal tributaries or off-channel floodplain wetlands. These contrasting habitats offer distinct benefits as well as risks, which are functions of seasonal fluctuations in abiotic conditions (e.g., temperature, oxygen) as well as food quantity and quality. The North Thompson River is the largest tributary to the Fraser River in British Columbia and exhibits considerable diversity in hydrological and climatic conditions. As part of a larger research program investigating habitat-productivity relationships for salmon across this watershed, we explored how streams and wetlands differ with respect to: (1) abiotic conditions (temperature, flow, dissolved oxygen); (2) prey abundance; and (3) prey quality. With this information, we then explored how growth regimes of salmonids shift across contrasting climate and hydrologic conditions.

Foodscapes in Action

Foodscape Perspectives on Salmon in the Russian River Watershed

Marisa Obedzinski, California Sea Grant and University of California, San Diego (Presenter), and Co-authors: **Ted Grantham, Ph.D.** and **Stephanie Carlson, Ph.D.,** University of California, Berkeley

As in many watersheds, the growth of juvenile salmonids in the Russian River basin varies over space and time with higher (though potentially riskier) growth opportunities occurring seasonally in higher-order streams, floodplains, and estuarine habitat when compared to smaller spawning tributaries. Tracking fluxes in growth opportunities can contribute to juvenile life history diversity (and thus higher production and population stability) and likely played an important role in the historically abundant salmon populations in the Russian River.

To investigate juvenile life history diversity in an endangered coho salmon population complex in the Russian River watershed, we characterized patterns in juvenile emigration timing in four tributaries and examined factors contributing to variation among streams and years. Between 2012 and 2022, PIT-tagged coho salmon juveniles were released from a conservation hatchery into four Russian River tributaries and we monitored their emigration timing using continuously-operated PIT detection systems near the mouths of each tributary. For each cohort/tributary (n=40), we estimated the probability that juveniles would emigrate early (< March 4) using an individual-based multistate emigration model. We then evaluated the influence of floodplain habitat, streamflow, and salmonid density on early emigration probability. In streams with less floodplain habitat, early emigration was positively related to winter flow and juvenile salmonid density, whereas early emigration was nearly absent in streams with higher proportions of floodplain habitat. Both life history strategies—early emigrants and those migrating during the typical spring smolt migration—contributed to adult returns.

We conclude by discussing the legacy of habitat loss and degradation that is limiting the recovery of Russian River coho and highlight the importance of restoration projects that increase availability and accessibility to high-growth opportunities across the riverscape, supporting a diversity of juvenile rearing strategies.

From Groundwater to Streamflow: Scaling Up Strategies, Models, and Datasets for Salmonid Success

Session Coordinators: David Dralle, Ph.D., U.S. Forest Service, Pacific Southwest Research Station; and **Monty Schmitt**, The Nature Conservancy

The Marshall Ranch Flow Enhancement project in the South Fork Eel River is a flow augmentation project that benefits juvenile coho salmonids.
Photo: Dana Stolzman

Groundwater plays a vital role in keeping streams flowing during the dry season, especially in watersheds that support salmon. With growing pressures from land use changes, groundwater pumping, and climate variability, it's more important than ever to manage the connection between groundwater and surface water to protect these critical flows.

This session will focus on practical tools and strategies for managing groundwater to maintain streamflows that salmon rely on. We'll cover the latest advancements in large-scale groundwater models that can help predict and address streamflow depletion. We'll also look at regional groundwater management plans that are successfully safeguarding water resources through thoughtful planning and regulation. In addition, we'll explore new research on why some streams dry up and how this affects fish, alongside a discussion on the global issue of aquifer decline and what it means for local water management.

By sharing case studies, management approaches, and the latest research, this session aims to provide practitioners, researchers, and policymakers with actionable insights and tools to support salmon restoration efforts through effective groundwater and surface water management.

From Groundwater to Streamflow: Scaling Up Strategies, Models, and Datasets for Salmonid Success

Marshall Ranch Flow Enhancement Project: The Benefits of Incorporating Hyporheic Processes Into Flow Augmentation Projects

Joel Monschke, PE, Stillwater Sciences (Presenter) and Co-authors: **David Sanchez**, The Marshall Ranch, LLC and The Marshall Conservation Preserve; **Dana Stolzman** and **Katrina Nystrom Sheldon**, Salmonid Restoration Federation; and **Tom Hicks**, Hicks Law

The Marshall Ranch Flow Enhancement Project was constructed in 2023 with a grant from the Wildlife Conservation Board's Streamflow Enhancement Program to the Salmonid Restoration Federation for this innovative project. The Marshall family, of mixed Indigenous and European ancestry, has inhabited their Wailaki Ancestral Land from time immemorial to the present and has been actively involved in all stages of the project through development, construction, and long-term operations and maintenance.

The project is comprised of two off-stream high density polyethylene (HDPE)-lined ponds with a total volume of 10 million gallons filled during the wet season. Flow augmentation releases ranging from ~30 to 50 gallons per minute started on July 1, 2024 and continued through mid-November. Water was primarily released through a "cooling/ filtration gallery" consisting of an intermittent tributary that allowed the water to enter the soil and flow subsurface for several hundred feet before entering Redwood Creek, a tributary to the South Fork Eel River, which provides critical summer rearing habitat for coho salmon and steelhead.

Flow augmentation releases into the cooling/ filtration gallery resulted in significant decreases in water temperature based on monitoring data. The cooling capacity of the gallery decreased during the augmentation period, but water temperatures in Redwood Creek were maintained at a suitable level for coho salmon. Further, the hyporheic flow paths resulting from the flow release into the gallery were much more diffuse than initially anticipated, likely amplifying the cooling benefits by engaging a larger area/ volume of soil/ bedrock substrate, but also challenging the monitoring team's ability to precisely quantify groundwater flow within the gallery.

During the 2024 dry season, surface flow connectivity in Redwood Creek was greatly improved by the project and the cooling/ filtration gallery played a central role in ensuring that suitable water temperatures were maintained. The functionality of the cooling/ filtration gallery is also anticipated to greatly reduce the long-term operational complexity of the project, which is the responsibility of The Marshall Ranch, LLC and is integrated into their broader ownership-wide stewardship goals for all sacred natural resources. Results and lessons learned from this project can help guide other flow enhancement projects and also provide opportunities for furthering scientific understanding of groundwater dynamics in similar settings with relatively shallow impervious bedrock.

From Groundwater to Streamflow: Scaling Up Strategies, Models, and Datasets for Salmonid Success

Scott River Flood - MAR: Setting Protective Flows for Diversions to Enhance Dry-Season Baseflows

Eric M. Ginney, Environmental Science Associates (Presenter) and Co-author:
Jason Wiener, Ph.D., Environmental Science Associates

Groundwater plays a critical role in maintaining streamflow in Scott River (California) during the dry season, especially in the Scott Valley reach. The cumulative impacts of beaver removal, mining, flood control measures, channel straightening, timber harvest, surface water diversion for agriculture, increased groundwater pumping, and decreasing winter snowpack have degraded salmonid habitat and critically threatened the functionality of in-stream and floodplain ecosystems in the Scott Valley reach of the Scott River. Specifically, flows in the late summer and autumn can limit upstream migration of Chinook and coho salmon for spawning and may limit the out-migration success of juveniles because of low flows and/ or high temperatures; theoretically higher flows are necessary to support these species.

Flood-Managed Aquifer Recharge (FMAR) is a strategy for replenishing depleted aquifers which may yield additional multiple benefits including reduction of flood risk and ecosystem enhancement. On the Scott River, coupled surface water-groundwater modeling efforts suggest that implementation of FMAR in the Scott Valley can help to increase flows in late summer and autumn. That stated, effective implementation of FMAR requires careful management to prevent adverse impacts on aquatic ecosystems because those peak streamflows targeted for recharge may also be needed to sustain native salmonids and geomorphic processes such as sediment transport.

We investigate this balance on the Scott River FMAR project initiated in 2016 as the first in California. Diversions (up to 30 cfs during high-flow events) are dispersed onto grazing lands in the valley for recharge, with the intent that such water returns to the river later in the year, enhancing instream flows for fish. We conducted an analysis of the flows necessary to support salmonid life-cycle functions relevant to the period of diversion, including a physically-based hydraulics approach to identify representative low-flow conditions that provide for upstream passage and a novel, data-driven bio-verification approach that couples decades of biological observation data with flow data to provide inferences into the flow conditions that enable adult salmonids to migrate and spawn in various portions of the Scott Valley. We also present limited results related to recharge and associated instream benefits. Lastly, we comment on the lack of a consistent technical approach/ methodology for setting diversion thresholds and/ or for assessing potential impacts to streamflow and key species, and present a new potential method (presently in development) that identifies key species and processes in the FMAR watershed and guides development of diversion criteria that are protective and also maximize recharge opportunity.

From Groundwater to Streamflow: Scaling Up Strategies, Models, and Datasets for Salmonid Success

Floodplain Limbo – How Low Can You Go?

Chris Hammersmark, Ph.D., P.E., CBEC Eco engineering, a Verdantas Company (Presenter)

Within California's Central Valley, the vast majority of floodplains have been disconnected from their rivers. This disconnection has resulted directly or indirectly from a variety of anthropogenic changes, including but not limited to dam and levee construction and flow regulation. Not surprisingly, many native species (e.g., salmonids), that rely upon floodplains to provide vital habitat during some portion of their life cycle, are in decline. Numerous planning efforts are promoting the restoration of "floodplains" or the creation/ enhancement of off-channel areas that provide similar types of habitat that natural floodplains once provided. Potential solutions include increased flows during critical periods, as well as topographic modification to increase inundation duration and frequency under a prescribed flow regime. Given the dire need for more high-quality habitat, a common goal is that floodplain habitat be activated frequently, perhaps as often as annually. While this is a worthy goal, it is not always achievable under regulated hydrologic conditions. Using observations from a variety of implemented habitat enhancement projects, the continuum between perennially inundated and seasonally inundated habitats will be explored to help us understand how low you can go. This topic is of vital importance as opportunities (both flow and non-flow) options are considered in native species recovery efforts under current and future (i.e., with climate change) hydrologic conditions.

From Groundwater to Streamflow: Scaling Up Strategies, Models, and Datasets for Salmonid Success

Fish and Flow in the Scott River Watershed

Betsy Stapleton, Scott River Watershed Council (Presenter) and Co-authors:
Erich Yokel, Harrison Morrow, and **Charnna Gilmore**, Scott River Watershed Council

There is an increasing interest in understanding what stream flows are required to maintain fish in good condition. In-depth investigations have focused on defining stream flows sufficient to allow the robust growth of individual fish and to support a variety of life stages at specific locations, but the question remains- what flows are required to allow the widespread distribution and vitality of a population across a watershed? Observations by the Scott River Watershed Council begin to shed light on this question. Spawning adult coho salmon distribution and juvenile rearing distribution and density were monitored in the Scott Watershed in both a drought and an average water year. These observations can be correlated with flow and tributary access and, along with juvenile growth in a single tributary over the study years, can offer interesting insights into the question.

From Groundwater to Streamflow: Scaling Up Strategies, Models, and Datasets for Salmonid Success

Drivers of Surface Water Response and Persistence in a Non-Perennial Stream Network

Lauren Giggy, Department of Earth and Planetary Sciences, University of California, Santa Cruz (Student Presenter), and Co-author: **Margaret Zimmer, Ph.D.**, Soil and Environmental Sciences, University of Wisconsin, Madison

Stream networks display dynamic patterns of surface water wetting and drying that strongly control the movement of solutes and sediment, biogeochemical processing, and habitat availability. Despite ongoing efforts, the dominant physical drivers of surface water persistence across a broad range of environmental conditions remain unclear, limiting our ability to manage a majority of our stream lengths. To address these challenges, we instrumented a small (0.25 km2) non-perennial stream network in central coastal California, underlain by two distinct bedrock lithologies. We monitored surface water presence and absence at 31 locations for three consecutive water years using modified HOBO temperature and light sensors and coupled these observations with landscape characteristics and weather station data to address these research questions: 1) What are the physical drivers of surface water persistence across a lithologically heterogeneous catchment; and 2) How does variability in the timing, magnitude, and intensity of rainfall influence surface water response and persistence? We observed shifts from dry to flowing conditions across a broad range of environmental conditions. However, extended periods of surface water persistence occurred only during a narrow range of storage states, suggesting seasonal variation in stream runoff generation mechanisms. Across the three study years, we observed declining spatial variability in surface water persistence with ongoing drought despite similar annual cumulative rainfall each year, highlighting the role of storage and precipitation patterns on surface water expression. Despite expectations, as drought conditions continued, most physical landscape attributes and lithology were not significantly correlated with surface water persistence. Together, these observations have important implications for water availability, aquatic and riparian habitat, and stream delineations under changing climate and policy landscapes.

From Groundwater to Streamflow: Scaling Up Strategies, Models, and Datasets for Salmonid Success

Using Ponds for Groundwater Recharge vs Flow Augmentation: A Comparison of Two Pond Projects in the Mattole Headwaters

Walker Wise and **Tasha McKee**, Sanctuary Forest (Co-presenters), and Co-author:
Joel Monschke, Professional Engineer, Stillwater Sciences

Ponds can serve as effective tools for maintaining instream flows during the dry season, supporting aquatic habitats and ecosystem resilience. This presentation by Sanctuary Forest will explore two distinct approaches to using ponds for seasonal flow augmentation: 1) groundwater-interacting ponds that enhance and supplement groundwater resources, and 2) ponds that provide metered flow releases directly into the stream. By examining two pond projects in the Mattole headwaters, we will highlight both the benefits and challenges associated with each method, discussing construction techniques, project design, and key lessons learned.

The Mattole River watershed receives substantial volumes of precipitation during the wet season, however, late dry season streamflow in the Mattole River is driven by seasonally recharged groundwater reserves, some of which drain rapidly via high conductivity subsurface pathways. Sanctuary Forest is working with Stillwater Sciences and other collaborating agencies and partners to address water scarcity impacts on salmonid and wildlife habitat in the Mattole River headwaters. This presentation discusses the results of two recent pilot projects and looks toward the future of flow improvement projects in the Mattole.

From Groundwater to Streamflow: Scaling Up Strategies, Models, and Datasets for Salmonid Success

Santa Cruz County's Updated Well Ordinance - Where Science Meets Policy

Sierra Ryan, Water Resources Program Manager, Santa Cruz County Water Resources Program, Environmental Health Division

Over the past decade, several pivotal factors have reshaped the landscape of water well permitting. The Sustainable Groundwater Management Act, evolving case law related to Public Trust Resources, the California Environmental Quality Act (CEQA), and Senate Bill 552, have collectively propelled counties into a race to adapt. In response, Santa Cruz County initiated a comprehensive two-year process to update its well policies. This endeavor involved a Technical Advisory Committee and collaboration with fishery and streamflow experts. Rigorous analysis, employing advanced analytical modeling, was conducted to establish thresholds for permitting tiers. Critical streams were identified based on their support for threatened and endangered species and assigned "allowable additional depletion" figures derived from the best available data on current conditions relative to unimpaired flows. The result is a scientifically sound policy that safeguards natural resources while recognizing the essential role of wells for large areas of the County and local industry. The ordinance is crafted with flexibility, enabling adjustments to thresholds as new information becomes available or conditions change on the ground. This presentation will discuss the approach that Santa Cruz County has taken and the lessons learned.

Central Valley Spring-Run Monitoring, Modeling, and Reintroduction: Building Tools to Guide and Track Recovery

Session Coordinators: Brett Harvey, Ph.D., and **Pete Nelson**, California Department of Water Resources

Spring-run Chinook in the Salmon River. *Photo: Michael Bravo*

Central Valley spring-run Chinook salmon are protected under both the state and federal Endangered Species Acts, but measures to protect and recover spring-run are challenged by the difficulty in tracking status and life stages of remnant populations across multiple streams and agency programs. The California Department of Fish and Wildlife and Department of Water Resources, U.S. Fish and Wildlife Service, NOAA Fisheries, and Bureau of Reclamation, plus agency partners, are collaborating to develop an approach for calculating an annual spring-run Chinook salmon juvenile production estimate (SR JPE) for the Sacramento River and its tributaries. The SR JPE is a forecast of the juvenile spring-run abundance expected to migrate into the Delta each year. Although its immediate purpose is to support measures to protect and enhance spring-run populations, the SR JPE program supports salmon science and recovery planning beyond a JPE, beyond the Sacramento River, and beyond spring-run. This symposium describes the processes and partnerships formed to support an annual SR JPE and the outcomes of these partnerships, including: expanded monitoring, new genetics tools, a coordinated data management system among more than 20 data stewards across multiple state and federal agencies, a cloud-based data-entry platform that ensures rapidly-reported cross-compatible data from over 40 individual sources, multiple models to track production, survival, and abundance across life stage and locations, and publicly accessible databases and model code. Model development involved coordination of field staff, geneticists, lab technicians, and modelers. Structured-Decision-Making guides development of alternative SR JPE approaches, final approach selection for implementation, and coupled with the data management system, provides a transparent framework to address multidimensional decisions, including updates of spring-run monitoring and models as new information is developed in the future.

Central Valley Spring-Run Monitoring, Modeling, and Reintroduction: Building Tools to Guide and Track Recovery

The Road to Data-Driven Water Management: Re-Envisioning the Data Lifecycle to Support a Spring-Run Juvenile Production Estimate

Ashley Vizek, FlowWest (Presenter), and Co-authors: **Erin Cain** and **Liz Stebbins**, FlowWest; and **Brett Harvey, Ph.D.**, Department of Water Resources

The Spring-Run Juvenile Production Estimate (SR JPE) is an open, accessible, and transparent modeling framework developed by a multi-agency partnership to support automated updates to the SR JPE models, which in turn support timely management decisions to protect and recover spring-run Chinook salmon. The SR JPE system was envisioned to integrate high-quality data from multiple sources in near real-time and has resulted in publically available spring-run datasets and models, and an open-source app that streamlines data entry, integration, and sharing. The data management system provides automated access on a weekly basis to machine-readable monitoring data and metadata from over 40 individual data sources, including abundance estimates of multiple life-history stages spread across eight regions and several agencies. Monitoring data has been collected over many decades for different purposes, are not consistent across regions, and were previously only publicly available in disparate formats. For initial SR JPE modeling, these data needed to be standardized and published on an open data portal which necessitated the cooperation and coordination of at least 20 data stewards and managers and prompted critical conversations and insights about differences in data collection methodologies. Salmonid monitoring data from SR JPE tributaries are now available on the Environmental Data Initiative (EDI) and rotary screw trap data are updated weekly through an automated process. To improve the efficiency of the SR JPE and achieve the program vision, the SR JPE Data Management Team identified a need for shared practices throughout the data lifecycle, not just at the point of data publishing. To bridge the gap between monitoring program methodologies, eliminate data entry time, improve data quality, and provide real-time access to data, the team developed a field-to-cloud data collection application, now available as an iPad app called DataTackle. The SR JPE data management system toolbox will ultimately involve models, integrated datasets, data visualization dashboards, and data collection user interfaces (DataTackle) that are all publicly available and useful for others beyond the SR JPE, further encouraging collaboration and communication across the scientific community.

Central Valley Spring-Run Monitoring, Modeling, and Reintroduction: Building Tools to Guide and Track Recovery

Rapid Genetic Identification of Central Valley Spring-Run Chinook Salmon

Sean Canfield, California Department of Water Resources (Presenter) and Co-authors: **Jeff Rodzen**, California Department of Fish and Wildlife; FlowWest; Noble Hendrix, QEDA Consulting; **Sarah Brown, Brett Harvey, Ph. D.**; and **Melinda Baerwald, Ph. D.**, California Department of Water Resources

The California Central Valley is host to four seasonal runs of Chinook salmon (*Oncorhynchus tshawytscha*): fall, late fall, spring, and winter. Spring-run Chinook have faced steep declines due to the combined effects of habitat loss and anthropogenic climate change, prompting multi-agency efforts to monitor spring-run populations throughout the Sacramento River Basin. One major focus is the development of a seasonal Juvenile Production Estimate (JPE) to monitor the number of out-migrating spring-run juveniles in near real time. However, these efforts are complicated by the fact that juveniles from all four seasonal runs are visually indistinguishable and exhibit considerable overlap in outmigration timing. By leveraging a combination of innovative rapid-genotyping technologies (e.g., CRISPR-based SHERLOCK) and high-throughput sequencing methods (e.g., GT-seq), we have developed genotyping workflows to maximize speed and accuracy in the identification of spring-run juveniles. Using this combinatorial approach, we have produced genetic run-type assignments for thousands of out-migrating juvenile Chinook salmon from sampling years 2022-2024, identifying tributary-specific seasonal trends in run-type composition. Continued development of the spring-run JPE, including the incorporation of probabilistic length-at-date (PLAD) models for run identification and automated genotyping workflows, stands to greatly enhance the speed and efficiency of JPE monitoring efforts. This collaborative effort between the California Department of Water Resources, the California Department of Fish and Wildlife, and the U.S. Fish and Wildlife Service represents a significant development in the conservation and monitoring of threatened spring-run in California's Central Valley and constitutes a crucial component of the spring-run JPE monitoring strategy.

Central Valley Spring-Run Monitoring, Modeling, and Reintroduction: Building Tools to Guide and Track Recovery

Forecasting the Timing and Abundance of Juvenile Spring-Run Chinook Salmon Outmigrants from Sacramento River Tributaries to Support a Juvenile Production Estimate

Josh Korman, Ecometric Research (Presenter) and Co-authors: **Brett Harvey, Ph.D.**, California Department of Water Resources; **Flora Cordoleani, Ph.D.,** NOAA Fisheries, UC Santa Cruz; and **Ashley Vizek** and **Liz Stebbins**, FlowWest

To better inform water management for the protection of Sacramento River spring-run Chinook salmon, we developed an in-season model to forecast the annual abundance and seasonal timing of out-migrating juveniles in tributaries of the Sacramento River. We fit a hierarchical Bayesian model to weekly estimates of juvenile abundance at Rotary Screw Trap (RST) sites in the majority of tributaries used by spring-run Chinook to predict historical patterns of outmigration run-timing. The model can include covariates, such as peak flows early in the outmigration season, to explain some of the interannual variations in run timing. Parameter estimates from the model are then used to forecast the seasonal timing of outmigration in a future year. Given a forecast of run timing and estimates of abundance early in the outmigration period based on trapping in that year (say through January), the model can predict abundance in later weeks and the total run size for the year. Finally, forecasted river survival and travel time estimates provided by a separate modeling efforts would be applied to predictions of weekly abundance at RST sites in tributaries to forecast the timing and total number of spring-run expected to enter the Delta for that year (i.e. a Sacramento River spring-run Juvenile Production Estimate or JPE).

The precision of tributary forecasts of annual outmigration abundance was higher for sites where historical weekly abundance estimates were better defined, which occurs when trap efficiency is higher or when more trap efficiency estimates are available. The precision of forecasts was higher at sites that showed less variability in run-timing across years and based on models that included a covariate that explained some of the historical variations in run-timing. By far the most important determinant of forecast precision will be the time of year when forecasts are made. Forecasts made earlier in the outmigrant season will have lower precision because the proportion of the run passing the RST site, based on historical patterns, is lower. The certainty in JPE forecasts improves for later forecast dates because the historical proportion of the run passing each RST site by that date is higher. Ultimately, this means a JPE forecast with high uncertainty can be made early in the outmigration season to guide management, and this forecast can be repeated serially as the season progresses to refine management decisions.

Our model to forecast outmigration timing and abundance is an "in-season" approach for providing a JPE since it requires estimates of outmigrant abundance and covariate values within the year the forecast is made. This contrasts with a stock-recruit approach, where spawner abundance and a forecastable covariate (e.g., water year type), would be used to forecast annual outmigration abundance prior to the start of juvenile outmigration. The stock-recruit approach provides decision-makers more time to consider alternate water management options, but the precision of a stock-recruit JPE will likely be much lower than a JPE derived from the in-season approach presented here.

Central Valley Spring-Run Monitoring, Modeling, and Reintroduction: Building Tools to Guide and Track Recovery

Uncovering Genetic and Life History Resilience in Spring-run Chinook Salmon

Flora Cordoleani, Ph.D., University of California, Santa Cruz, Institute of Marine Sciences & NOAA Fisheries, Southwest Fisheries Science Center (Presenter) and Co-authors:
Malte Willmes, Norwegian Institute for Nature Research, Trondheim, Norway;
Anna Sturrock, University of Essex, School of Life Sciences, United Kingdom;
Mariah Meek, Department of Integrative Biology, Michigan State University;
George Whitman and **Carson Jeffres, Ph.D.**, University of California, Davis, Center for Watershed Sciences; **Rachel Johnson, Ph.D.**, NOAA Fisheries, Southwest Fisheries Science Center & University of California, Davis, Center for Watershed Sciences

Central Valley spring-run Chinook salmon (*Oncorhynchus tshawytscha*; CVSC) display remarkable life history diversity underpinning their ability to adapt to California's variable climate and to utilize a vast habitat mosaic. However, the conditions that promote life history diversity are rapidly disappearing, as anthropogenic forces promote the homogenization of habitats and genetic lineages. Here we will present a unique natural tag toolbox that combines the use of otoliths (ear bones), eye lenses, and tissue samples to characterize the remnant genetic and life history diversity of CVSC populations. We used this toolbox to: 1) assess the haplotype diversity and genetic integrity of CVSC fish across populations through time, including the most recent wet-drought cycle 2010-2020, and 2) identify the juvenile life history diversity and the importance of natal versus non-natal off-channel rearing habitat use across populations. We will present how this toolbox can help increase our understanding of how juvenile life history strategies vary across CVSC populations and to what extent genetic and habitat diversity might affect spring-run populations' phenotypic diversity and their capacity to respond to future or changing environmental conditions. This work is particularly important for being able to predict the success and resilience of the spring-run stock complex under different management and climate scenarios.

Central Valley Spring-Run Monitoring, Modeling, and Reintroduction: Building Tools to Guide and Track Recovery

Movement and Survival of Acoustic Tagged Hatchery Spring-Run Chinook Salmon from the Feather River

Arnold Ammann, National Marine Fisheries Service (Presenter) and Co-authors:
Jason Kindopp and **Ryon Kurth**, California Department of Water Resources;
Jeremy Notch and **Flora Cordoleani**, NOAA affiliate, University of California, Santa Cruz

We examined the survival and movement of Feather River Hatchery spring-run juveniles during two time periods: 2013-2015 and 2019-2021. Of these six years, only 2019 was classified as a 'wet' year, while the others were "Dry" or "Critical". These fish were implanted with acoustic transmitters (JSATS) and tracked using an extensive array of stationary receivers throughout their outmigration from the Lower Feather River, to the Sacramento River, Delta, and out to the ocean at the Golden Gate. Survival per river kilometer was compared among these regions and years. Survival of these hatchery fish was compared with acoustic-tagged naturally-produced spring-run from the Butte Creek watershed. Correlations between survival and environmental factors of flow, temperature, and turbidity were examined. Understanding how outmigration survival varies with environmental conditions and between fish types is important when designing release strategies, and also for managing flow and restoring habitat to benefit wild spring-run populations.

Central Valley Spring-Run Monitoring, Modeling, and Reintroduction: Building Tools to Guide and Track Recovery

Developing an Improved Understanding of Pathogen Impacts for Feather River Spring-Run Chinook Salmon

Miles Daniels, Assistant Researcher, Institute of Marine Sciences, Fisheries Collaborative Program, University of California, Santa Cruz, affiliated with Southwest Fisheries Science Center, National Marine Fisheries Service (Presenter) and Co-authors:
Scott Foott, Retired, California Nevada Fish Health Center, U.S. Fish and Wildlife Service;
Jason Kindopp, Senior Environmental Scientist, California Department of Water Resources;
Joel Llamas, Environmental Scientist, California Department of Fish and Wildlife; and
Brett Harvey, Ph.D., Environmental Scientist, California Department of Water Resources

Spring-run Chinook salmon in the Feather River are sensitive to the potentially deadly pathogen *Ceratonova shasta* (C. shasta), with the severity of an individual's health outcome mediated by environmental conditions, such as water temperature and exposure duration. Although current evidence suggests C. shasta may contribute substantially to the overall mortality of juvenile spring-run in the Feather River, just how much spring-run populations are impacted by this pathogen remains uncertain, as do potential ways to reduce this impact. To better quantify the infection and mortality risk associated with C. shasta exposure and develop actions to disrupt pathogen transmission, a multi-agency effort was recently initiated to coordinate and synergize data collection and analysis efforts across the Feather River. These efforts are in turn being used to develop a landscape-scale multi-model framework in the form of a dynamic disease transmission model. The framework will enable the prediction of pathogen exposure impacts by accounting for the interactions between the different life stages of C. shasta and spring-run in a variable environment. This presentation will share our most recent progress tracking and modeling C. shasta impacts on the Feather River spring-run.

Central Valley Spring-Run Monitoring, Modeling, and Reintroduction: Building Tools to Guide and Track Recovery

Spring-Run Chinook Salmon Reintroduction Pilot Study in the North Fork Feather River Upstream of Oroville Dam

Michelle Pepping, Ph.D., Senior Environmental Scientist Specialist, Department of Water Resources

Spring-run Chinook salmon populations have been declining in California, despite their threatened status, due to the many environmental challenges they face. One challenge is the limited availability of accessible upstream habitat which was their historic spawning, juvenile- rearing, and over-summer holding habitat. The California Department of Water Resources (DWR) is implementing the North Fork Feather River Above Almanor Fish Passage Feasibility Study to investigate the feasibility of returning spring-run Chinook salmon to historically available, high-quality habitat in the Feather River watershed above Lake Almanor. The study area allows DWR to leverage existing infrastructure, focus efforts in an area of high DWR engagement, and build upon initial evaluations that identified prime salmonid habitat. Here, we show the success of using the hydraulic egg-injection method to deploy hatchery-reared eggs into historic habitats. This method was time- and cost-efficient and allowed for a natural egg and juvenile-rearing environment. Hydraulic egg injections could be favorable to introduce eggs back into a disturbed system, such as a post-fire watershed, or in reintroduction studies. Additionally, this method allows for the ease of collection, spawning, and decontamination of eggs in a hatchery, which can supplement already-present natural spawning or reintroduce eggs without the pathology concerns of transporting adults above dams, above a hatchery, or in new basins.

Science Meets Policy

Session Coordinators: **Kam Bezdek** and **Analise Rivero,** California Trout

This session will explore the intersection between restoration, science, and policy. The focus will be on how restoration science and project implementation need to inform regulation and funding mechanisms, with examples of how these factors have influenced policy change at the state and federal level. Presentations in this session will focus on specific examples of where policy, science, and projects have converged to achieve conservation outcomes and advance strategies for the large-scale restoration of California's native salmonid species.

Example Module:

1. Policy Basics
   - How Bills get implemented and the legislative cycle
   - Budget/ Bond Process
   - Bills affecting natural resources
2. How legislation translates into regulatory permitting–like SERP (Statutory Exemption for Restoration Program). Other streamlining legislation/ Cutting the Green Tape programs?
3. How do policy professionals view science and restoration projects? How does my work influence funding decisions and other regulatory decisions?

Science Meets Policy

Monitoring Dissolved Oxygen in the Lower American River to Inform Real-Time Reservoir Operations to Support Successful Chinook Salmon Spawning

Mollie Ogaz, Cramer Fish Sciences (Presenter) and Co-authors: **Kirsten Sellheim**, Cramer Fish Sciences and **Erica Bishop**, Sacramento Water Forum

Dissolved oxygen (DO) is one of the most important indicators of biological health in rivers, and it can exhibit large fluctuations over a range of spatial and temporal scales. Salmonids are sensitive to low DO conditions, and at DO levels of 6.5 mg/L or less most salmonid species exhibit symptoms of oxygen distress. Salmonids are at risk of exposure to poor water quality (both high temperature and low dissolved oxygen) in the early fall when adults are immigrating into the river. In 2021, during a historic drought period, low dissolved oxygen levels (<5 mg/l) were documented in the lower American River at Nimbus Basin, which is at the base of Nimbus Dam. This area is the coolest portion of the river and upper point of anadromy, thus an area with disproportionately high Chinook salmon holding and spawning activity. As water flowed downstream and temperatures warmed, DO levels improved.

To better understand these water quality dynamics, in summer 2022 we installed dissolved oxygen loggers throughout Nimbus Basin (River Mile 23), at Watt Avenue (River Mile 11), and seasonally in Lake Natoma - just below Folsom Dam (River Mile 30). Each logger measured temperature and DO levels at hourly intervals and was downloaded every two weeks, or more frequently as needed during the fall months to inform water quality management. Throughout this monitoring, we consistently observed that when DO levels approached stressful levels in early fall, Nimbus Dam spill releases from dam gates (i.e., over the top of the dam as opposed to through the powerhouse) significantly improved DO levels in Nimbus Basin, even when DO levels within Folsom Dam were very low. This data was shared with the American River Group, and the Bureau of Reclamation was able to adaptively manage DO using continuous spill releases to maintain water quality for spawning Chinook salmon in 2023 and 2024. Leveraging real-time data to inform dam operations during this critical period in the Chinook salmon life cycle was a key strategy to improve in-river survival and spawning success on the American River.

Science Meets Policy

Development of the California North Coast Water Availability Tool to Support Streamlined Preparation and Processing of Water Rights for Flow Enhancement Projects

Jennifer Carah, The Nature Conservancy, Senior Scientist and **Mia van Docto**, Trout Unlimited, Conservation Hydrology Program Director (Co-presenters)

Voluntary flow enhancement projects to restore flows for salmonids often require new water rights to facilitate shifts in timing of diversion from summer/ fall when water is scarce to winter when water is more plentiful. Acquiring such winter water rights, particularly in the area governed by the State's *Policy for Maintaining Instream Flows in Northern California Coastal Streams* (Policy), may be a long and expensive process. Yet just in the Policy area, there is a need for thousands of such projects to restore dry-season streamflow for salmonids and increase water security for water users in the face of climate change. Through on-the-ground experience developing such projects in the Policy area, Trout Unlimited (TU) and The Nature Conservancy (TNC) have identified several aspects of the permitting process that may slow down permit preparation and processing – with one aspect being preparation and processing of the water availability analysis required by the Policy. To streamline the preparation and processing of such water availability analysis, science and technical staff at TNC, TU, and Foundry Spatial Ltd., with funding from the California Wildlife Conservation Board, have developed a free, online tool that streamlines the development and review of water availability analysis following Policy specifications. This presentation will discuss how project implementation is currently affected by the Policy, how the development of a new science tool may speed up restoration implementation, and will provide an overview of the Water Availability Tool.

Science Meets Policy

A Plethora of Possibilities for Permitting – Useful Updates for Your Projects

Stephanie Falzone, Sustainable Conservation

There is a critical need for more landscape-scale projects that restore degraded habitats, increase habitat connectivity, improve water quality, and boost our resilience to climate change. The Accelerating Restoration Program (Program) at Sustainable Conservation has worked to increase the pace and scale of restoration by making it easier for project proponents to get through the permitting and regulatory review process by helping agencies create expedited, alternative pathways for restoration. The Program also develops online tools that augment agency resources to help guide applicants on the use of these permitting pathways and stays in contact with agencies about updates to their permitting processes and other changes.

The Accelerating Restoration website, launched in 2023, serves as a clearinghouse for information about efficient permitting pathways and resources such as our Protection Measures Selection Tool and Restoration Permitting Roadmap for the Sacramento River Basin (Roadmap). The Roadmap is designed to guide restoration project proponents in the Sacramento River Basin in choosing the most efficient pathways for their restoration projects. Building off that Roadmap, Sustainable Conservation is developing a statewide version, adding agencies and permitting pathways for coastal California and other parts of the state.

Sustainable Conservation will provide a tour of resources on the Accelerating Restoration website and will share updates on efficient pathways from state and federal agencies, including the California Department of Fish and Wildlife's recently expanded Restoration Management Permit, NOAA Restoration Center programmatic biological opinions, South Coast Federal.

Science Meets Policy

FHAST: A Mechanistic Based Tool for Assessing Habitat Effects on Anadromous Fish

Peter N. Dudley, University of California, Santa Cruz, Institute of Marine Sciences' Fisheries Collaborative Program & NOAA Fisheries, Southwest Fisheries Science Center, Fisheries Ecology Division, Santa Cruz, California (Presenter), and Co-authors: **Stephanie G. Diaz**, **Theodore Hermann**, and **Jesse Black**, University of California, Santa Cruz, Institute of Marine Sciences' Fisheries Collaborative Program & NOAA Fisheries, Southwest Fisheries Science Center, Fisheries Ecology Division, Santa Cruz, California; **Kim Kwanmok**, Korean Environment Institute, Sejong, South Korea

In an effort to protect infrastructure, access water, develop agricultural land, etc., agencies, managers, or individuals will often alter anadromous fish habitats along rivers. These same actors may also alter habitat to aid in the conservation of these species ("habitat restoration"). When planning projects that could impact aquatic habitats either positively or negatively, regulatory agencies generally require an assessment of those impacts on native fauna, including fish. These alterations often involve numerous ecological interactions which are difficult to account for simultaneously. To aid in the assessment of how habitat alteration will affect fish, we have developed the Fish Habitat Assessment and Simulation Tool (FHAST). FHAST is a spatially explicit agent-based tool that allows users to simulate the effects of habitat alteration on an anadromous fish species and account for numerous ecological processes. Fish actions are based on mechanistic principles derived from physiological and behavioral studies. We developed the model with continuous input from both a regulator (NOAA) and an agency engaged in habitat alterations (US Army Corps of Engineers). As such, there was a focus on making this scientific tool tailored to the policies and needs of both agencies. We will present the tool's structure and interface, discuss the policy and scientific aspects of its development, and cover the basic mechanisms of the juvenile-rearing module tool.

Science Meets Policy

Reconnection: Integrating Policy and Restoration Science within the Sacramento River Basin

Kam Bezdek, Policy Associate, California Trout

California's Central Valley, to date, has lost 95% of its native wetland habitat and consequently contains less than 5% of its original native fish biomass. To combat this habitat loss and rapid species decline, NGOs (non-governmental organizations) in the Sacramento River basin have collaborated with rice farmers; state, local, and federal governments; and senior water rights holders in the 20th Century to create innovative solutions that maintain productive agricultural practices while simultaneously providing up to 149x the food availability for anadromous fish populations than the existing non-project habitat in the basin. This partnership is called the Floodplain Forward Coalition, and today it boasts a variety of projects and programs that aim to restore natural ecosystem function on managed wetlands while providing multiple public benefits including (but not limited to): outdoor recreation and access, climate-adaptive water supply reliability, groundwater recharge, and flood control benefits.

After five years of relationship building and negotiations, the Sacramento River Basin Interagency MOU (memorandum of understanding) was signed in October of 2024 between multiple state and federal agencies to advance floodplain restoration projects in the Sacramento River basin, and what began as a coalition of individual farmers and organizations has now increased its impact with the goals of population-level response in the anadromous fish and waterfowl populations of the basin. This presentation explores: 1) how the scientific evidence of the effectiveness of floodplain reactivation for salmonid growth and recovery was communicated to senior policy professionals, 2) the events which accelerated the MOU negotiations process, and 3) the ways in which this MOU will be utilized to create additional salmonid restoration and recovery opportunities within the basin.

Science Meets Policy

Integration of Watershed and Fisheries Recovery in California's Private and State Timberland Operations and Regulatory Processes

Richard Gienger, Forests Forever

In 2012, Assembly Bill 1492, became law. It was forged between three 'interest groups': industry, agencies, and 'enviros'. It is quite complicated, and made some significant and complex changes, one very large one is the establishment of a Timber Regulation and Forest Restoration Fund/Program [TRFR]. This is paid for with an assessment on the purchase of most retail timber products. This generally replaced funding through the yearly California budget process – and exempted timber operations from permitting fees and related costs. The bill also set a ceiling on fire liability and extended the time frame for Timber Harvest Plans [THPs], A large industry focus is on streamlining THP approvals.

Other major provisions include greater multi-disciplinary oversight by the Natural Resources Agency, more public transparency and participation, funding forest; watershed restoration projects, and the establishment of Ecological Performance Measures. This EPM approach is meant to be an accountability measure for the multiple State programs that regulate timber management on non-federal forestlands.

Data from existing monitoring programs across State and Federal resource agencies is intended to establish a spatially explicit, consistent monitoring approach to track forest and watershed ecosystem conditions over time at a regional scale. This has made significant progress with continuing issues needing to be addressed.

AB 1492 remains one of the most substantive and controversial laws impacting forest practices and recovery/restoration efforts for forests and forested watersheds in California. The abstract and presentation at SRF 2016 focused on the seminal, 1st of 3 proposed, pilot projects to establish adequate cumulative impacts considerations and response which would enable the information generated by THPs to make significant progress in real recovery measures, for both the forests and watersheds, The information gained was intended to be appropriately applied, under varying conditions, Planning Watershed by Planning Watershed. This 2025 abstract will follow the history of that effort, and, should we say the 'uneven' realities of better multi-disciplinary oversight by the California Natural Resources Agency [CNRA], and the achievement of the goals of forest and watershed restoration called for in AB 1492.

Changing personnel, conditions, programs, and priorities will be explained and brought up to date. Pathways for going forward with the positive intents and implementation of the original law will be examined and brought forward.

Needle in a Haystack – Innovative Approaches to Monitoring of Rare Salmonids

Session Coordinator: Matt Peterson, FISHBIO

Monitoring populations of listed salmonid species forms the foundation for generating data necessary to inform their management and recovery actions. As these populations become exceedingly rare, collecting data to elucidate population dynamics and ecological interactions also becomes challenging. From southern populations of steelhead to coastal coho and Chinook salmon, direct observation of individuals can be exceedingly difficult, and physical capture and collection of length, age, and genetic data is even harder. The difficulties associated with monitoring these dwindling populations is spurring alternative methods, which may include remote observation with sonar or video systems, genetic techniques such as parentage-based tagging or environmental DNA monitoring, or, in the case of steelhead, targeted sampling of freshwater residents. Increasingly, these data are being incorporated into integrated population models, which use complementary data sources to quantitatively model population demographics and estimate abundance. This session will explore the innovative studies and unique approaches that offer insights into monitoring methodologies necessary to collect data on these rare and imperiled salmonid populations.

The proposed format of the session will consist of five presenters that have developed or currently lead sampling programs for rare salmonids throughout California. These presenters will share their advice, experience, and study design elements with the audience during their presentations as well as during a 30-minute interactive session facilitated by the moderator. This session will allow session attendees to share their own experiences and observations, ask questions, and allow the presenters to provide a suite of recommendations for addressing this particular monitoring challenge in the future.

Collecting eDNA water samples using an eDNA backpack sampler.
Photo: FISHBIO

Needle in a Haystack – Innovative Approaches to Monitoring of Rare Salmonids

eDNA Metabarcoding to Characterize the Distribution of Species of Interest to Tribal Nations in Northern California

Alec Bauer, M.S. Student, Fisheries Department, California Polytechnic University, Humboldt (Presenter)

The arrival of European colonizers around 500 years ago led to significant changes in the land and ecosystems of Northern California. These historical events have notably affected the marine and estuary fish communities in the region, including fishes foundational to tribal culture, subsistence, and spiritual practices. The project aims to use environmental DNA (eDNA) metabarcoding to characterize fish biodiversity and study species of cultural and ecological significance, such as Chinook and coho salmon, that have noticeably declined in numbers. The Tolowa Dee-ni' Nation, Cher-Ae Heights Indian Community of the Trinidad Rancheria, the Resighini Tribe of Yurok People, and Blue Lake Rancheria, along with Cal Poly Humboldt, are collecting monthly water samples over the course of a year, from marine and estuary sites, along a 168 km span of the Northern California coast. Using high-throughput DNA sequencing techniques, the MiFish primer, and customized reference database, we will present results from our efforts to describe fish diversity in Humboldt and Del Norte Counties, emphasizing Pacific salmon and other species of tribal concern. This study represents one of the first efforts to comprehensively characterize fish biodiversity in a region that has both been relatively understudied by western scientific techniques and contains some of the most productive river basins in California for Pacific salmon. Using a broad-scale eDNA sampling regime, we seek to better understand tribally important fish species that, despite their high cultural and ecological significance, have noticeably declined due to human-driven climate change. A greater understanding of the fish diversity in the region will allow for more informed management decisions and ideally a greater capacity to sustainably interact with ecosystems that humans have been an integral part of for millennia.

Needle in a Haystack – Innovative Approaches to Monitoring of Rare Salmonids

Juvenile Salmonid Side Channel Restoration Monitoring in the Sacramento River

Greyson Doolittle, Fisheries Lab Manager, California State University, Chico

Juvenile salmonid populations of the Sacramento River in California are struggling due to human alterations of flow regimes, land-use, and access to upstream habitat. From 2014 to 2022, a total of 12 side channels had been restored or created in order to mitigate for this degradation and loss of habitat, restoring over 34 acres of off-channel habitat for juvenile salmonid rearing at base flows. A subset of sites were monitored for abundance and density of fish with monthly snorkel indexes, for a year before and a year after construction, with nearby paired control side channels, to account for annual and seasonal population variability. We found restorations to significantly increase relative abundances of juvenile salmon and trout, with a local decrease in relative densities at 5 sites pooled together. Habitat mapping was used to compare the proportions of juvenile salmonid habitat in restored side channels after construction to habitat in unaltered control side channels considered to be the best habitat in the area. On average, at base flows we measured 26.3 acres (77%) of habitat in 12 restored side channels and 3.3 acres (66%) of habitat in 3 control side channels to meet criteria for suitable juvenile salmonid rearing habitat. Since these mapping criteria were developed on the Trinity River, we implemented micro-use observation snorkels to evaluate how these mapping criteria performed on populations of side channels in the area. We found over 75% of salmonid observations in all groups tested to fit our criteria for the suitable habitat of each individual metric, and found 80.5% of fish to be found in a habitat defined as "optimal". Habitat preference indexes of different cover types generally described juvenile salmonids to have a high propensity for twigs and branches, and a low preference for aquatic vegetation. A brief analysis of aquatic vegetation growth in 2 control side channels and 4 restored side channels revealed that the 2022 drought year increased vegetation in restored side channels from 14% to 46% while decreasing in control side channels from 17% to 14%. Looking at temperatures in a subset of side channels in 2022, and comparing it to temperatures in a typical year, indicate that more downstream side channels were too warm for juvenile rearing in a dry year, while upstream side channels still had rearing potential. We provide an example of ways to evaluate the effectiveness of side channel restorations for juvenile salmonid rearing habitat, highlight changes that could be made to refine monitoring techniques, as well as discuss local impacts seen by these restorations, and ways to improve future restorations.

Needle in a Haystack – Innovative Approaches to Monitoring of Rare Salmonids

Evaluating Salmonids in Humboldt Bay, CA using Environmental DNA Metabarcoding

Johnathon Richardson, M.S. Student, Department of Fisheries Biology, California State Polytechnic University, Humboldt (Presenter) and Co-author: **Andrew P. Kinziger, Ph.D.**, Department of Fisheries Biology, Cal Poly Humboldt

Environmental DNA (eDNA) presents a non-invasive and highly sensitive method for cataloging aquatic biodiversity. In our study, eDNA metabarcoding techniques, employing high-throughput DNA sequencing and fish-specific primers, were used to identify fish species from water samples taken biweekly for one year at an eelgrass bed in Humboldt Bay, California. Over the 26 sampling events, 78 water samples were collected and species were identified using a customized reference database containing all nearshore marine fish known to occur in the study region. While earlier seminal conventional surveys recorded between 47 and 61 species, our study identified nearly double that amount, documenting 116 fish species. Our analysis revealed seasonal variations in fish diversity, with peaks observed in late summer and early fall. Importantly, eDNA analysis detected species often overlooked in traditional field studies. Notable among these were salmonid species previously undocumented in the region and the absence of an expected one. Despite its strengths, eDNA analysis faced challenges in differentiating closely related species and provided limited insights into individual fish conditions, such as size, age, and reproductive status. Therefore, while eDNA analysis is a valuable tool for biodiversity assessment, it ideally complements existing fisheries survey methods.

Needle in a Haystack – Innovative Approaches to Monitoring of Rare Salmonids

Using Environmental DNA in Water Samples to Monitor the Distribution and Abundance of Salmonids

Andrew P. Kinziger, Department of Fisheries Biology, California State Polytechnic University, Humboldt (Presenter) and Co-authors: **Andre Buchheister, Doyle Coyne**, and **Jason T. Shaffer**, Department of Fisheries Biology, California State Polytechnic University, Humboldt; **Eric P. Bjorkstedt**, NOAA Fisheries, Southwest Fisheries Science Center, Fisheries Ecology Division

The use of environmental DNA (eDNA) in water samples has become a popular, inexpensive, and noninvasive method for monitoring aquatic biodiversity. However, the application of eDNA methods requires careful consideration of advantages and disadvantages to ensure proper inference for conservation and management. This paper presents three case studies on the use of eDNA for monitoring salmonids, comparing eDNA methods to conventional fisheries monitoring approaches, including rotary screw traps, underwater visual surveys, and bottom trawling. The first study compared standard and environmental DNA methods for estimating Chinook salmon smolt abundance in the Klamath River, California. Our results suggest that eDNA may potentially be a useful predictor of weekly abundance of out-migrating Chinook salmon smolts, but when estimates of abundance were less than 13,500 smolts per week, the concentration of eDNA was too low to accurately estimate smolt abundance. In another study, we compared eDNA and underwater visual surveys for detecting juvenile coho salmon (*Oncorhynchus kisutch*) in small streams. We show that eDNA methods and underwater visual surveys provided nearly identical patterns of detection and non-detection of coho salmon in small pools, but that eDNA concentrations were poor predictors of coho salmon counts in small pools. In the last example, we compared eDNA and bottom trawling for the detection of coho salmon in Humboldt Bay, California. We found that eDNA detected coho salmon whereas trawl surveys never detected coho salmon. We emphasize that while eDNA approaches are effective for monitoring, future applications should carefully consider study objectives to ensure proper inference for conservation and management.

Needle in a Haystack – Innovative Approaches to Monitoring of Rare Salmonids

Utilizing Otolith Geochemistry to Identify Origins of Juvenile Chinook Salmon Preyed Upon by an Endangered Avian Piscivore

Sami Araya, Department of Wildlife Fish and Conservation Biology, University of California, Davis (Presenter), and Co-authors: **Malte Willmes**, Norwegian Institute for Nature Research; **Meredith Elliott**, Point Blue Conservation Science; **Robert Lusardi**, and **Levi Lewis**, Department of Department of Wildlife Fish and Conservation Biology, University of California, Davis

Wild Chinook Salmon (*Oncorhynchus tshawytscha*) in California have experienced sharp declines in population size due to an array of anthropogenic pressures. Chinook Salmon smolts (juveniles migrating to the ocean) are prey for numerous native species in California, including the endangered California Least Tern (*Sterna antillarum browni*). A large breeding colony of California Least Terns occurs in the San Francisco Estuary at Alameda Point each summer and coincides with smolt outmigration. However, interactions between this endangered avian piscivore and managed salmon stocks are poorly understood. From 2007 to 2018, Point Blue Conservation Science collected and maintained an archive of juvenile Chinook Salmon that were dropped by foraging Least Tern parents returning to the colony to feed their chicks. Here, we used otolith geochemistry to analyze the ratio of Strontium stable isotopes (^{87}Sr:^{86}Sr) in conjunction with extracted coded wire tags (CWTs) to determine the types (hatchery or wild), natal origins, and run timings of these dropped smolts. Our results call attention to a relatively understudied trophic pathway involving juvenile salmon and an endangered coastal avian piscivore. Detailing such interactions among managed species, and across years with different environmental conditions, can help improve future management strategies and, ultimately, the recovery of listed species.

Needle in a Haystack – Innovative Approaches to Monitoring of Rare Salmonids

A Multi-Scale, Collaborative Approach to Monitoring Rare and Imperiled Spring-Run Chinook Salmon (*Ishyâat*) Across the Mid-Klamath River

Amy Fingerle, M.S. Student, University of California, Berkeley (Presenter) and Co-authors: **Toz Soto, Beau Quinter,** and **Harold Mitchell**, Karuk Tribe; **Karuna Greenberg, Andrew Ayers,** and **Sam Stroich**, Salmon River Restoration Council; **Matthew R. Sloat, Ph.D.** and **Tasha Q. Thompson, Ph.D.**, Wild Salmon Center; **Michael R. Miller, Ph.D.**, University of California, Davis; **Theodore E. Grantham, Ph.D.** and **Stephanie M. Carlson, Ph.D.**, University of California, Berkeley

Spring-run Chinook salmon (*Oncorhynchus tshawytscha*) were historically the most abundant salmonid in the Klamath River basin but are now on the brink of extinction. Monitoring population trends of spring-run Chinook in the basin is challenging due to their small population size and the difficulty of distinguishing among Chinook run types by visual characteristics. In 2023, UC Berkeley, the Karuk Tribe, Salmon River Restoration Council, UC Davis, and Wild Salmon Center began a multiyear study in mid-Klamath River tributaries to improve understanding of run-type distribution and the degree to which interbreeding among spring-run and fall-run Chinook is occurring, which will help inform management decisions for Chinook salmon in the Klamath Basin. In the Salmon River, which hosts the largest remaining wild population of spring-run Chinook in the Klamath River basin, we used localized and distributed sampling methods to collect fin clips from live juvenile Chinook and adult Chinook carcasses. At the local scale, we captured juvenile Chinook in three stationary rotary screw traps. We also captured juvenile Chinook via opportunistic seine net sampling at multiple locations distributed throughout the Salmon River watershed, and we collected fin clips from adult Chinook carcasses encountered during spawning ground surveys. Additionally, fin clips were collected through a partnership with the California Department of Fish and Wildlife at rotary screw traps in the Scott and Shasta rivers, where the spring-run phenotype has not been observed in decades. We genotyped these Chinook at the GREB1L genomic region, which is diagnostic for run timing (spring-run or fall-run). Results from our first two years indicate that in the Salmon River, relative abundance of spring-run Chinook varies among subbasins, fall-run Chinook spawn upstream of dynamited seasonal-hydrologic migration barriers that historically maintained a degree of reproductive isolation between runs, and heterozygous Chinook are a major component of the run-type composition of Salmon River Chinook salmon. We also found that heterozygous Chinook are present at very low abundance in other mid-Klamath River tributaries where spring-run Chinook have been extirpated. We share our experience developing and implementing this sampling program that is multiscalar and highly collaborative–two key elements that are important for generating data on rare salmonids.

Needle in a Haystack – Innovative Approaches to Monitoring of Rare Salmonids

O. mykiss Population Growth after Two Wet Years and Water Quality Tolerances within the Lower Santa Ynez River Basin, Santa Barbara County, CA

Timothy H. Robinson, Fisheries Division Manager, Cachuma Operation and Maintenance Board (Presenter) and Co-authors: **Scott B. Engblom**, Project Biologist, Cachuma Operation and Maintenance Board and **Scott J. Volan**, Project Biologist, Cachuma Operation and Maintenance Board

After two consecutive wet years in 2023 and 2024 with extremely high stormflow and sustained baseflow, the Lower Santa Ynez River (LSYR) basin in southern Santa Barbara County has shown a one to two orders of magnitude population growth of *Oncorhynchus mykiss* (*O. mykiss*) within the mainstem and its tributaries. The increased number and distribution of fish can be attributed to multiple factors and have been observed in many areas of the basin. However, those increases have presented many challenges to the fishery and management during the dry season as streamflow and habitats retract. The need for careful monitoring of the fishery, refuge habitats, and water quality has led to a continuous need for fish rescue/ relocation over the dry months. Fish growth rates are high, yet *O. mykiss* water quality tolerances are being pushed to new extremes in many of the marginal habitats with water temperatures soaring above 24 °C and dissolved oxygen concentrations dropping well below 2 mg/L. Monitoring data, actions taken, and an interpretation of the suite of conditions resulting in the population increase and need for management actions will be presented in the context of Southern California steelhead recovery and watershed revegetation after several large-scale wildfires. The presentation will focus on the contrasts between the LSYR mainstem, Hilton Creek, Quiota Creek, and Salsipuedes/ El Jaro Creek plus the innovative approaches to monitor and sustain the fishery. The Santa Ynez River is part of the Monte Arido Highlands Biogeographic Population Group and is a National Marine Fisheries Service designated Core 1 watershed with critical habitat for the recovery of the endangered Southern California steelhead.

The Role of Meadows in Water-Fire-Fish Processes Across the Landscape

Session Coordinators: **Emily Cooper-Hertel, M.S.**, Klamath Meadows Partnership Coordinator, Watershed Research and Training Center; and **Jay Stallman**, Senior Geomorphologist, Stillwater Sciences

Despite their relatively small coverage of area across the landscape, meadows have a landscape scale impact when they are able to retain and slowly release water to lower watershed areas during the dry season. Many wet meadows in the Klamath, North Coast, and Sierra mountain ranges are important not only for their connection to fish habitat downstream, providing cold water refugia required by summer rearing salmonid species, but also for their wildfire refugia capabilities throughout upland areas. This session explores the role of meadows in holistic watershed stewardship, from wildfire resilience in forests to water security in streams. Meadows can act as a geomorphic hydraulic control at the watershed scale; however, altered hydrologic and fire disturbance regimes have impaired the ability of meadows to hold water that supports specific plant and animal communities locally as well as those farther downstream with seasonal water release.

Deadfall Meadows in the headwaters of the mainstem Trinity River near Mt. Eddy showing some channel incision and multiple age-class conifer encroachment. *Photo: Emily Cooper-Hertel*

This session is intended to explore the effects on eco-hydrologic processes at the watershed scale in response to fuels, fire, and instream restoration locally within and around meadows. A better understanding of meadow distribution, condition, and restoration across the landscape can help inform the role and need for meadows as integral components of watershed processes. We would like to explore knowledge of the dynamics between groundwater and surface water from geologic, geomorphologic, vegetation, and climatic conditions. How do upland fire and fuels management pair with meadow restoration regarding surface and groundwater availability? Can targeting upland forest restoration, where there are high densities of meadows, maximize potential increases and durations in water yields due to the natural water storage characteristics of meadows in the watershed? Do dry meadows and grasslands treated with beneficial burning improve forest and stream health? Do healthy meadows improve seasonal fish habitat? What meadow restoration strategies have worked or are desired with integrated forest and instream management? How can traditional ecological knowledge of watershed stewardship highlight the role of meadows in forest and stream health?

This session invites the knowledge, practice, and science behind meadows as they relate to fire, water, and fisheries management and landscape restoration strategies. We also propose to allocate one presenter time slot to a Q/A and discussion between presenters and the audience in the interest of a more interactive experience for all.

The Role of Meadows in Water-Fire-Fish Processes Across the Landscape

Understanding and Restoring Meadows of Northern California through Meaningful Collaboration

Emily Cooper-Hertel, M.S., Klamath Meadows Partnership Coordinator, Watershed Research and Training Center

Despite recognizing the high ecological and water resource values that meadows provide, information is lacking on meadow distribution, condition, and restoration needs throughout the Klamath and North Coast mountain ranges. Hydrologic impairments and fire suppression have contributed to widespread meadow degradation resulting in the loss of hydrologic and biological signatures of former meadows. Studies estimate that meadow area may have historically been three times what is found present day. Meadows can provide synergistic benefits in wildfire resilience and water security through integrated aquatic and fire restoration and management. Therefore, a better understanding of meadow distribution, condition, and restoration across the landscape can help inform the role and need for meadows as integral components of watershed processes. The Klamath Meadows Partnership (KMP) is a regional collective that supports locally led efforts in meadow inventory, assessment, and restoration. The KMP has begun a multi-year effort to identify existing meadows and other related data, conduct GIS and ground-based inventory and assessment, and calibrate a predictive model that will inform potential meadow loss regionally. We are guided by our vested interest in supporting, learning, and demonstrating how meadow restoration multiplies benefits for forest, aquatic, and human health when targeted as opportunities for reducing fuels, providing nature-based fuel breaks, improving groundwater connectivity and storage, aiding in water quality, and supporting human-land relationships. We will share how we have achieved meadow assessments and mapping, targeted large-scale environmental compliance needs, and prioritized restoration opportunities through fostering meaningful collaborations between non-profits, tribes, government agencies, academics, and private consultants.

The Role of Meadows in Water-Fire-Fish Processes Across the Landscape

Fish & Fire: Insights from Three Years of Workshops and Dialogue

Lenya Quinn-Davidson, Fire Network Director, University of California Agriculture and Natural Resources; and **Josh Smith**, Watershed Stewardship Program Director, Watershed Research and Training Center (Co-presenters)

For the last three years, we have hosted Fish & Fire Workshops at the annual SRF conference, focusing on the many areas of overlap and interconnectedness — ecological, social, political — across the two disciplines. Workshops have provided opportunities for shared learning, cross-training, and creative brainstorming, touching on issues like fire-related changes in streamflow and water availability, food webs and habitat impacts, fire ecology, impacts of fire suppression and fire exclusion, post-fire mitigation and restoration, cultural burning and Indigenous fire stewardship, landscape-scale planning, and much more. This presentation will share key insights and connections from those workshops, identifying management implications and opportunities and daylighting potential synergies in policy and action across fish and fire.

The Role of Meadows in Water-Fire-Fish Processes Across the Landscape

"How Do We Get There?" Building a Meadow Restoration Program

Megan Ireson, Mountain Meadows Project Coordinator, Scott River Watershed Council

The Scott River Watershed Council began with a focus on coho salmon and their habitat needs. From the first permitted beaver dam analogs in California to off-channel ponds and wood-loading, much of our early work was focused on the valley floor and low-elevation tributaries. But then we thought about other factors influencing the spawning and rearing of salmon and looked upslope at the upland forests and meadows.

Looking around in the meadows we saw substantial degradation from grazing impacts, conifer encroachment in meadow and aspen stands, dense forests surrounding the meadows, meadow-type conversion, and roads concentrating flow and changing vegetation. We asked ourselves, "How do we address these issues?" and, "Who do we collaborate with?" So we started reaching out to experts and building new projects. Our instream work has largely been oriented towards Process Based Restoration (PBR), so in meadows, we have the same focus.

Over time we have developed relationships with people and organizations with a wide range of expertise related to meadows and PBR, including Quartz Valley Indian Reservation, local Klamath National Forest staff, Karen Pope and Adam Cummings, developers of the Lost Meadows Model, and experts on implementing PBR meadow restoration. We are founding members of the Klamath Meadows Partnership which supports ongoing collaboration and information sharing on meadows work across the region, which benefits us as well as everyone else doing this work in the Klamath Mountains.

Through these connections, we have successfully invited experts to join us in developing meadow restoration projects. Not only do they help guide our project planning, the feedback we receive from them on implementation enables us to identify and solve problems and make adjustments moving forward.

The Role of Meadows in Water-Fire-Fish Processes Across the Landscape

Integrating Forest Health with Meadow Restoration in the Middle Truckee River Basin

Brian Hastings, Professional Geologist, Senior Geomorphologist, Balance Hydrologics and **Beth Christman, Ph.D.**, Senior Director of Restoration, Truckee River Watershed Council (Co-presenters)

Lacey Meadows represents one of the largest meadow complexes in the Middle Truckee River Basin (557 acres) and supports a robust population of willow flycatcher (*Empidonax traillii*) and a recreational population of Lahontan cutthroat trout (*Oncorhynchus clarkii*), but is absent of beaver (*Castor canadensis*). The main channel in the Upper Lacey Meadow was relocated in the 1950s to modify the meadow for sheep grazing. Separately, a network of historical logging roads altered natural flow pathways and contributed to the incision of the main channel in the Lower Lacey Meadow, limiting floodplain access and promoting sagebrush and conifer encroachment. The forested watershed has not been managed for timber or health in decades and wildfires have been absent for over 120 years.

In 2012, Lacey Meadows and adjacent lands were acquired by Truckee Donner Land Trust. Working with the Land Trust, Tahoe National Forest, and Truckee River Watershed Council, Balance Hydrologics used a process-based restoration approach to restore natural flow pathways, reverse an incised channel, and reconnect channel-meadow floodplain dynamics for over 300 acres of meadow and willow riparian habitat. The remote location of the project required the use of on-site, natural materials and avoidance of imported materials.

Restoration was implemented in the Upper Lacey Meadow in 2023 and in the Lower Lacey Meadow in 2024. The restoration was designed to coincide with a proposed timber harvest plan such that natural materials could be sourced from the adjacent forest and used in the design. Together, improved forest health along the meadow boundaries and a wetter meadow may improve resilience under future wildfires in a region identified as moderate to extreme risk for wildfire. We describe our approach, design elements, their geomorphic appropriateness, and present some preliminary post-project results.

The Role of Meadows in Water-Fire-Fish Processes Across the Landscape

Low-Tech Process-Based Riparian Meadow Restoration in Post-Wildfire Landscapes Rapidly Captures Sediment and Reconnects Floodplains

Karen Pope, Ph.D., USDA Forest Service, Pacific Southwest Research Station (Presenter) and Co-authors: **Adam Cummings, M.S.**, **David Dralle, Ph.D.**, and **Joe Wagenbrenner, Ph.D.**, USDA Forest Service, Pacific Southwest Research Station

Headwater stream channels have been modified and simplified, often resulting in an increase in the conveyance of water and sediment through headwater catchments. Severely burned watersheds exacerbate this trend when bare soils enhance the transportation of water and sediment from hillslopes into the simplified stream channels. This post-fire stream sedimentation process can be highly detrimental to fish and other aquatic organisms. One approach to help mitigate this problem is to capture the sediment as high in the watershed as possible, especially in areas where it can be useful. We propose that targeted low-tech process-based restoration actions in degraded riparian meadows in burned catchments can capture some of the expected sediment by slowing water and trapping sediment. Extensive past erosion and channel incisions in meadows provide an opportunity to capture large volumes of sediment while also increasing local floodplain recovery. We conducted an experiment where we applied low-tech process-based restoration in burned and unburned headwater meadows and quantified sediment capture and retention. We also describe a project in which 20 riparian meadows including ~ 14 km of stream were treated in the summer of 2024 by one crew within the Dixie Fire footprint. Evidence thus far suggests that rapid and scaled low-tech meadow restoration treatments capture and store sediment, activating the recovery of these important ecosystems while helping to protect downstream fisheries.

The Role of Meadows in Water-Fire-Fish Processes Across the Landscape

Restoring Meadows and Flows for Eagle Lake Rainbow Trout

Kate Gazzo, American Rivers, Director, Northern Sierra Headwaters Conservation and **Michael Cameron**, Trout Unlimited, Northern Sierra Project Manager; (Co-presenters)

Eagle Lake is a saline, terminal lake east of Mt Lassen, and home to endemic Eagle Lake Rainbow Trout (ELRT). The primary tributary to Eagle Lake is Pine Creek, a roughly 30-mile-long stream that is perennial in its headwaters but otherwise is ephemeral. Pine Creek is fed by springs and snowmelt and historically provided the primary spawning and rearing habitat for ELRT.

Like many Sierra Nevada streams, anthropogenic alterations including historic grazing, railroad and roadbuilding, and logging activities from the 19th and 20th centuries altered the hydrology and geomorphic processes of Pine Creek. More recently, suppression of fire in the forested upland watershed has led to increased forest stand densities and encroachment of conifers into the meadows located along Pine Creek which further reduces the amount of surface and groundwater reaching Pine Creek.

Since the 1950s, flows within the downstream reach of the stream typically dry before the ELRT are able to complete natural reproduction. The relatively short duration of continuous flow annually is a constraint the trout have always had to adapt to, but the current typical duration is below what the fish can naturally manage. The population has been maintained by hatcheries since the 1950s. A gated weir at the mouth of the lake is used to intercept spawning fish to harvest eggs. The weir also prevents fish from migrating upstream in the spring. If fish were able to migrate upstream in the spring, they risk becoming stranded on their return to Eagle Lake when Pine Creek begins to dry.

Efforts to conserve ELRT began in the 1950s, and most recently, the Eagle Lake Rainbow Trout Conservation Agreement (2015) identified restoration of natural reproduction as the key action necessary to ensure the persistence of the species. Several actions are deemed necessary to restore natural reproduction, including the restoration of Pine Creek meadows and geomorphic processes (another is the eradication of non-native brook trout from the headwaters of Pine Creek). As the meadows along Pine Creek are restored, these areas are expected to aid in recharging groundwater supplies and prolong spring stream flows providing increased hydrologic connectivity between the Pine Creek headwaters and Eagle Lake.

In 2015, American Rivers completed meadow health assessments along Pine Creek and prioritized meadows for restoration based on the condition score for each meadow. As of the fall of 2024, three priority meadows in the Pine Creek watershed have been restored and the design process for two of the largest and most important meadows (Champs Flat and McCoy Flat) has just begun, with a goal of having shovel ready projects by spring 2027. This session will describe the unique challenges of meadow restoration in Pine Creek and how the design process is balancing the various risks and opportunities presented by the current landscape condition.

Foodscapes in Action

World-Wide Patterns of Invertebrate Drift Abundance with Implications for Drift-Feeding Fishes

Tyson B. Hallbert, Ph.D., Postdoctoral Researcher, Center for Watershed Sciences, University of California, Davis

The spatiotemporal abundance of food resources influences the productivity and distribution of animal populations. In streams, invertebrates transported within and on the water are a primary food source for many fishes. While invertebrate drift has been widely studied, the scale of variation in drift densities and the factors that influence variability across streams has received less attention. Furthermore, because of the way invertebrate drift is encountered by drift-feeding fishes, handling time should limit continual increases in energy intake as food abundance increases, but few studies have quantified foraging rate thresholds in drift-foragers. Here, we surveyed 69 past studies and compiled invertebrate drift data to identify variations in invertebrate drift abundance across a large spatial scale. Using model selection methods, we examined how invertebrate drift varies across environmental gradients. We performed an additional literature search and collected drift foraging rates from 30 studies to evaluate how foraging rates in drift-feeding fishes change with prey availability. We found most past studies reported low densities of drifting invertebrates and model selection revealed that elevation, global position of streams, and precipitation were significant predictors of the variation in drift density. Moreover, we found fish foraging rates also produced a skewed distribution, and foraging rates increased with prey density but leveled off producing a type II functional response curve. Our study provides further evidence that food limitation may be a primary control on productivity in drift-feeding fish populations, provides insight into the range of invertebrate drift, and identifies factors that influence drift abundance in stream ecosystems.

Foodscapes in Action

Causes and Consequences of Variation in Rearing Strategies in Juvenile Coho Salmon

Henry Baker, Ph.D., Environmental Science, Policy, and Management, University of California, Berkeley (Presenter) and Co-authors: **Mariska Obedzinski,** Environmental Science, Policy, and Management, University of California, Berkeley and California Sea Grant, Santa Rosa, California; **Ted Grantham, Ph.D.**, and **Stephanie Carlson, Ph.D.**, Environmental Science, Policy, and Management, University of California, Berkeley

Mobile consumers like Pacific salmon vary in their strategies for exploiting resource fluxes across connected river networks, but the proximal causes and ecological consequences of this variation are poorly understood. We explored variations in juvenile rearing strategies in a hatchery-supplemented population of endangered Central California Coast coho salmon in the Russian River basin. First, we characterized variation in juvenile down-migration timing and rearing environments across nine cohorts of hatchery releases into Willow Creek. We showed that juvenile coho exhibit two distinct strategies: the canonical 'natal rearing' strategy, in which individuals rear near the spawning habitat until they emigrate to the ocean as smolts, and an early down-migration strategy, in which individuals migrate to lower portions of the tributary and rear for extended periods of time ('non-natal rearing') before out-migrating to the ocean. Differences between natal habitat in shaded, moderate-gradient headwater streams and non-natal habitats, in lower-gradient floodplain wetlands, contribute to variation in growth patterns and emigration phenology between the two life history strategies. Further, we found evidence that non-natal rearing juveniles can successfully complete their life cycle and return as adults and play a role in stabilizing population dynamics. Yet, non-natal rearing is severely reduced in drought years, suggesting that as drought becomes increasingly common with anthropogenic climate change, threats to imperiled fishes may be compounded by losses of critical intrapopulation phenotypic variation. Finally, we describe how habitat in lower Willow Creek is being utilized by juvenile salmon from other tributaries, potentially contributing population resilience of coho salmon within the greater Russian River basin, and discuss how these findings can inform restoration efforts.

Foodscapes in Action

Wildfire Impacts Trophic Supply and Demand in a Coastal Salmonid Food Web

Katie Kobayashi, University of California, Santa Cruz and Stillwater Sciences (Presenter) and Co-authors: **Raymond Hunter** and **David Herbst**, University of California, Santa Cruz and Sierra Nevada Aquatic Research Laboratory; **Rosealea M. Bond** and **Joseph D. Kiernan**, University of California, Santa Cruz and NOAA Fisheries; **Eric P. Palkovacs**, University of California, Santa Cruz

The escalating frequency and intensity of wildfires in recent decades has generated significant concern for the future of at-risk salmonid ecosystems. However, the effects of wildfire on salmonids and aquatic ecosystems remain poorly understood. Here, we develop a framework for thinking about the effects of wildfire through the lens of trophic supply and demand, as influenced by the physical habitat changes caused by wildfire. We then leverage a natural experiment created by a recent wildfire in a coastal California watershed to ask whether fire tips the balance between trophic supply and demand across the landscape. We combine stream habitat surveys, benthic community analysis, field metabolic assays, and juvenile salmonid monitoring to show that fire leaves a complex signature on aquatic foodscapes, including considerable variation in both food availability and metabolic demand, with implications for salmonid size, growth, and population persistence. Despite considerable effects to the physical and ecological landscape, we find that salmonid populations can demonstrate impressive resilience to the effects of wildfire.

Foodscapes in Action

Towards Process-Based Recovery Planning

Jacob Katz, Ph.D., California Trout

"It is the nature of any organic pattern to be contained within a larger one. And so a good solution in one pattern preserves the integrity of the pattern that contains it." — Wendell Berry, 1981

We don't manage salmon in freshwater. Instead, we manage the riverscape on which those populations depend. And in actuality, we don't manage the landscapes as much as the landscape-scale biogeomorphic forces which create and sustain the 4-dimensional mosaic of biophysical conditions to which salmon populations actually react.

This talk will present a systems approach to prioritizing landscape-scale conservation action(s) that can be expected to produce population-level responses.

- Resilience and abundance are the twin drivers of population recovery.
- Longitudinal connectivity > spatial and temporal diversity in spawning > population resilience.
- Lateral connectivity > trophic diversity in rearing > population abundance.
- To achieve recovery, each is necessary yet insufficient on its own. Yet, the two synergistically interact within riverine foodscapes as varying density and accessibility of food and the energetic consequences of foraging vary among locations and through time, giving rise to a shifting riverscape mosaic of spatio-temporal growth opportunities for juvenile salmon.

Come hear how a process-based definition of salmon habitat provides a means to spotlight where human endeavor interrupts the capacity of riverscapes and foodscapes to provide the range of biophysical patterns required for resilient, abundant populations of anadromous salmonids.

A bio-geomorphic process-based definition of salmon habitat: *"The spatiotemporal patterns of biophysical conditions that arise (and to which salmon respond) as water interacts with the riverscape through which it flows."*

For each population, then, we must articulate each interwoven cycle:

- **The Life Cycle:** Characterize each life stage (from gravel to gravel).
- **The Niche Cycle:** Characterize the ecological function(s) required for each life stage to matriculate to the next.
- **The Habitat cycle:** Characterize the sequence of biophysical conditions required to fulfill each link in the niche cycle.
- **The Process cycle:** Characterize the landscape-scale biogeomorphic processes that synergistically interact to create and sustain the 4-D habitat mosaic to which salmon actually respond.
- **A Process Interruption Analysis:** Characterize the human infrastructure and land use(s) that interrupt these biogeomorphic processes thereby limiting riverscape capacity to provision the diverse life-history trajectories from which population resilience emerges.

Foodscapes in Action

Rearing Habitat Alters the Juvenile Salmon Gut Microbiome

Mattea Berglund, Student, University of California, Davis (Presenter) and Co-authors: **Laetitia Wilkins, Ph.D.**, Fisheries Department at the Office for Hunting and Fishing in Graubünden, Switzerland; **Mikaela Provost, Ph.D.**, University of California, Davis; and **Andrew Rypel, Ph.D.**, University of California, Davis.

The gut microbiome, the community of microbes living in the digestive tract, is a promising and under-explored tool to study the impact of diet and habitat changes on salmon health. The gut microbiome is shaped by diet and environment, and impacts host health through physiological functions, such as digestion and immune response. While diet changes are known to alter the salmon gut microbiome in aquaculture settings, changes to the salmon microbiome in the wild are unknown. We present a field experiment testing the impact of natural, artificial, and reconciled habitats on the gut microbiome of juvenile Chinook salmon (*Oncorhynchus tshawytscha*) in the Central Valley of California. Juvenile Chinook salmon were reared in four habitat types: lab, river, managed wetland, and agricultural wetland. Individual growth rates, foregut samples, and hindgut samples were collected from fish in each habitat. Amplicon Sequence Variants (ASVs) were identified from 16s rRNA sequencing data and used to characterize the bacterial community in each sample. Differences in juvenile Chinook salmon gut microbiome were observed between all habitats. Dissimilarity in the microbial community between all habitats was high, with most taxa unique to each habitat and no observed "core community" common across all habitats. The gut microbiome of fish reared in the lab had the highest dissimilarity with all field habitats and was the least variable, likely due to homogenous diet and water conditions. The gut microbiome of fish reared in the river was the most variable, potentially as a result of food limitation. This project represents, to our knowledge, the first characterization of the Chinook salmon microbiome under field conditions and the first characterization of the Chinook salmon microbiome in California. Results will provide necessary baseline data to enable future work on the functional role of the microbiome in salmon fitness and inform the potential use of the gut microbiome to monitor food web changes and salmon health.

Foodscapes in Action

Fish Food: Development of a Conservation Easement Tool

Jacob Montgomery, M.S., Central Valley Regional Manager, California Trout

California's native fish populations are in dramatic decline. This project seeks to help recover fish populations by reconnecting the Sacramento River to productive shallow-water floodplain-derived food webs. Before the Central Valley was developed, aquatic food webs produced on over a million acres of seasonally inundated floodplain marsh supported robust fish and wildlife populations. Over the last century and a half, development—primarily for agriculture and flood control—has drained, leveed, and otherwise cut off 95% of wetlands from Central Valley rivers, effectively starving river ecosystems of the foundation of the aquatic food web: the solar energy captured by plants and algae on floodplains and made available to aquatic food webs during seasonal flooding.

Today, the farm fields and marshes managed for waterfowl habitat that occupy much of the Sacramento Valley's formerly wetted floodplain are "protected" from direct hydrologic connection to rivers by levees. The Fish Food program mimics the timing and duration of natural flood and drainage patterns by re-operating existing agricultural, drainage, and flood protection infrastructure to approximate the biophysical conditions and ecological functions present in pre-development Sacramento Valley floodplain marshes.

During the non-growing season, floodplain farm fields and managed marshlands are intentionally inundated for approximately one month, over which time large quantities of aquatic invertebrates are produced in the nutrient-rich, shallow floodwaters. When these managed floodplain wetlands are drained, abundant floodplain-derived food web resources are exported to fish populations confined to food-scarce, leveed river channels.

Starting from single-field experimental drainage trials in 2018, this idea has rapidly grown into a 25,000-acre-per-year conservation easement management practice that improves fish growth opportunities from December through April. Data metrics that support the positive impact of the program include zooplankton species and density, fish growth rates and stable isotopes, and ATS SS300-tagged fish movement analysis. This highly effective tool deserves a permanent spot in a portfolio of fisheries management actions.

From Groundwater to Streamflow: Scaling Up Strategies, Models, and Datasets for Salmonid Success

Democratizing California's Water Future: Tools for Advancing Inclusive and Integrated Groundwater-Surface Water Management in the Central Valley

Theodore Grantham, Ph.D., University of California, Berkeley (Presenter) and Co-authors: **James Gilbert, Ph.D.**, University of California, Santa Cruz and **Eric Danner, Ph.D.**, Southwest Fisheries Science Center

California has built an expansive network of water storage and conveyance infrastructure to supply surface water to farms, cities, and wildlife refuges throughout the Central Valley. However, when surface water supplies are insufficient, water users often pump groundwater to meet demands. This has resulted in the widespread depletion of groundwater aquifers in the Central Valley, which has contributed to river drying and impacts to groundwater-dependent ecosystems and communities. Despite some progress in addressing groundwater overdrafts, including the adoption of the 2014 Sustainable Groundwater Management Act, the management of groundwater and surface water remains poorly integrated. Further, surface- and groundwater management decisions are constrained by poor water accounting, entrenched power imbalances, and limited public engagement. Building a resilient water future requires new water planning tools that advance integrated, sustainable, and inclusive water stewardship. To meet this need, we launched COEQWAL (COllaboratory for EQuity in Water ALlocations), in which academic research teams are partnering with diverse publics to co-create scenarios representing combinations of water policy, infrastructural, and operational changes under future climates. The goals of the project are to increase understanding and diversify participation and enhance engagement in water decision-making. Water futures are being evaluated using a systems planning model, CalSim3, which represents water infrastructure, regulations, and priorities for allocating surface water in the Central Valley and interconnected regions. The model also includes a groundwater component, C2VSim, that simulates regional groundwater levels and stream-aquifer interactions. We present results from CalSim3 scenarios that highlight the interdependencies of surface water supply management, regional groundwater dynamics, and river flows. We also highlight the collaborative approach being implemented with COEQWAL and share preliminary lessons learned in engaging diverse audiences with highly technical and complex water management issues.

From Groundwater to Streamflow: Scaling Up Strategies, Models, and Datasets for Salmonid Success

Beyond Surface Water and Groundwater: Successful Flow Enhancement and Climate Change Adaptation Requires a Holistic Approach to Managing the Entire Hydrologic Cycle

Jeremy Kobor, M.S., Professional Geologist, Senior Hydrologist, O'Connor Environmental, Inc. (Presenter) and Co-author: **Matt O'Connor, Ph.D.,** President, O'Connor Environmental, Inc.

Traditional water management approaches have compartmentalized the hydrologic cycle with different tools and regulations for surface water and groundwater. With the increasing application of integrated hydrologic models and adoption of regulations such as the Sustainable Groundwater Management Act, increasing emphasis has been placed on managing surface water and groundwater as one interconnected resource. Nevertheless, other hydrologic processes that influence the availability of surface water and groundwater such as evapotranspiration and recharge are generally not considered in a comprehensive manner and thus the tendency to compartmentalize the hydrologic cycle persists.

Evapotranspiration (ET) is of particular importance given that it is typically the largest outflow in a watershed water balance, estimated to be equivalent to ~50% of mean annual rainfall in coastal California watersheds. Modeling analyses from five lower Russian River watersheds reveals that ET is approximately 15 to 160 times greater than all human water use on a long-term annual basis. Given the level of regulation and investigation surrounding the relatively small human use component of the water balance, increasing our understanding and management of the much more significant (volumetrically) ET component appears overdue.

Integrated hydrologic modeling in the lower Russian River Watershed suggests that land use decisions can have profound effects on surface water and groundwater availability and indicates that we need to expand our definition of groundwater management beyond regulation of pumping wells. Landscape-scale actions to manage forests, grasslands, and stormwater runoff can all result in increased groundwater recharge and the groundwater discharge responsible for maintaining dry season streamflows. In each case, more water can be made available for recharge and streamflow, although the mechanisms responsible for the increases vary with forest management reducing ET, grassland management increasing soil moisture holding capacity, and stormwater management reducing runoff.

We investigated the relative efficacy of different flow enhancement strategies in the Mark West Creek watershed and found that on a cost-normalized basis, investment in forest, grassland, or runoff management resulted in streamflow enhancement benefits that were more than an order of magnitude higher than those associated with reducing dry-season groundwater pumping through storage and forbearance efforts. This suggests that effective climate change adaptation to manage coho salmon habitat requires that we avoid over-simplifying the interconnected reality of nature and move towards managing all aspects of the hydrologic cycle.

From Groundwater to Streamflow: Scaling Up Strategies, Models, and Datasets for Salmonid Success

Response Diversity to Acute Climate Conditions Among Streams with Variable Flow Permanence Stabilizes Habitat Availability for Spawning Salmonids

Skylar Rousseau, M.S., Stillwater Sciences (Presenter) and Co-author:
Timothy E. Walsworth, Ph.D., Utah State University

Though intermittent streams represent a substantial portion of aquatic habitat available to spring spawning salmonids, there exists significant uncertainty regarding their contribution to early life history expression, particularly under anticipated climate stochasticity. Our research characterizes the dynamic spatiotemporal distribution of viable spawning habitat for native Bonneville cutthroat trout (*Oncorhynchus clarkii utah*; hereafter “BCT”), identifies physiographic and climatic controls on the probability that habitats support early life history, and documents the timing and use of these temporary habitats by BCT. We present a novel approach to back-cast temperature and flow regimes in ungauged, non-permanent streams. The resulting temperature and flow profiles allow us to characterize suitable spawning windows by comparing observed degree-day accumulation to estimates of requirements for embryo development from the literature. Results suggest that the spatiotemporal distribution of suitable spawning habitats shifts across years and conditions, with colder perennial streams providing more spawning habitat in a drought year, and warmer non-permanent streams furnishing more suitable habitat in a year with a large snowpack. We found that BCT moves to exploit thermally optimal patches as the mosaic of suitable habitats shift across space and time. Spawning-sized adult BCT occupied temporary streams during their known spawning window and emergent fry were present in streams whose flow period varied substantially across years. We also found that the interplay between climate and landscape characteristics had divergent effects on flow and temperature, creating heterogeneous patterns of suitability across the network. Our two-year study period occurred under drastically different climate conditions. However, the ability of different tributaries to exhibit diverse responses to the same climatic stimuli buffered total spawning habitat availability against acute climate changes. Our results demonstrate that maintaining connectivity between diverse habitats, even those unsuitable in some years, maximizes spawning opportunities for BCT during climate extremes.

From Groundwater to Streamflow: Scaling Up Strategies, Models, and Datasets for Salmonid Success

The Impacts of Changes in Precipitation, Plant Water Use, and Groundwater Pumping on Surface Water Presence and Temperature

Dana A. Lapides, Ph.D., USDA-ARS Southwest Watershed Research Center, Tucson, AZ (Presenter) and Co-authors: **David Dralle**, USDA Forest Service, Pacific Southwest Research Center, Davis, CA; **John Hammond**, USGS MD-DE-DC Water Science Center, Catonsville, MD; **W. Jesse Hahm**, Simon Fraser University, Burnaby, BC; **Daniella Rempe**, University of Texas, Austin, TX; and **Sam Zipper,** Kansas Geological Survey, Lawrence, KS

The extent and quality of surface water in streams varies throughout the year. During the dry season, surface water contracts, and water temperatures rise. Some streams may lose headwater reaches or become discontinuous. The water in streams comes from the surrounding hillslopes, so surface water extent and quality depend both on channel processes and water availability in hillslopes. Water availability can fluctuate substantially between years due to differences in precipitation, plant water use, and groundwater extraction. It is important to distinguish between changes caused by these three factors because plant water use and groundwater extraction may be impacted by management actions, whereas precipitation is beyond control. In this presentation, we explore how plant water use and groundwater extraction may impact streamflow and stream temperature using a synthetic modeling framework and observations from intensively monitored sites in California. The synthetic model framework is used to separately explore the signature of groundwater pumping, plant water use, and precipitation changes on streamflow. Then, observations from intensively monitored sites in California will be used to explore how different hillslope structures result in different stream permanence behavior. The findings from this work provide clues about which management actions may be most likely to promote streamflow in different watersheds.

From Groundwater to Streamflow: Scaling Up Strategies, Models, and Datasets for Salmonid Success

Addressing Streamflow Depletion Due to Groundwater Pumping - Unified Modeling Approaches and Process Uncertainty

Nicholas Murphy, The Nature Conservancy (Presenter) and Co-authors: **Monty Schmitt,** The Nature Conservancy; **Sam Zipper**, University of Kansas; **Ian Gambill**, University of Kansas; **Matt O'Connor** and **Jeremy Kobor**, O'Connor Environmental Inc.; and **Ben Kerr**, Foundry Spatial

Functional flows for streams and rivers (with an emphasis on dry season baseflows), groundwater well ordinances that are protective of public trust resources, and sustainable groundwater management protecting groundwater-dependent ecosystems at a statewide level all rely on an in-depth understanding of surface water-groundwater dynamics. Currently, technical gaps exist that limit our ability to evaluate streamflow depletion impacts due to groundwater pumping. This work explores modeling approaches to estimate streamflow depletion due to groundwater pumping across several distinct geographies and geologic environments and presents a suite of possible modeling approaches to evaluate streamflow depletion caused by groundwater pumping in Sonoma County and Scott Valley, CA. Results indicate that based upon the complexity of the hydrogeologic setting, various factors (perennial vs. non-perennial streams, geologic heterogeneity, recharge, phreatophytic evapotranspiration) may or may not be necessary to consider. Working with experts in both analytical and numerical groundwater modeling techniques, these pilot projects serve as use-case investigations, helping to develop unified modeling solutions to evaluate streamflow depletion in these project areas and build towards the development of decision-support tools and best management practices.

From Groundwater to Streamflow: Scaling Up Strategies, Models, and Datasets for Salmonid Success

The California Environmental Flows Framework: Integrating Groundwater and Surface Water Management

Kris Taniguchi-Quan, Ph.D., Southern California Coastal Water Research Project (Presenter) and Co-authors: **Bronwen Stanford, Ph.D.**, The Nature Conservancy; **Sarah Yarnell, Ph.D.,** Center for Watershed Sciences, University of California, Davis; **Alex Milward**, California Department of Fish and Wildlife; **Eric D. Stein**, Southern California Coastal Water Research Project; and **Ted Grantham, Ph.D.** University of California, Berkeley

Groundwater is vital for sustaining instream flow and regulating stream temperature, especially during the summer when flows are at their lowest and temperatures peak. California's Sustainable Groundwater Management Act (SGMA) aims to ensure that groundwater use does not adversely impact interconnected surface waters and instream habitat. However, determining these impacts is challenging because many streams in California lack site-specific flow criteria that describe the surface flows necessary to support aquatic life. Consequently, it is difficult to determine the level of surface water depletion that could cause an undesirable adverse effect.

The California Environmental Flows Framework (CEFF), developed by a statewide technical workgroup convened by the State Water Resources Control Board and California Department of Fish and Wildlife, provides a potential solution. CEFF is a management approach to efficiently develop scientifically defensible environmental flow recommendations that balance human and ecological needs for water. CEFF was designed to help managers improve the speed, consistency, standardization, and technical rigor in establishing instream flow recommendations statewide. CEFF is structured around a functional flows approach that focuses on quantifying and managing key aspects of natural flow regimes that provide the greatest ecological and geomorphic functionality, rather than restoring full natural flows. CEFF can support the quantification of long-term measurable flow criteria based on functional flows for interconnected surface waters and can help evaluate the potential consequences of proposed management strategies. Here, we will provide examples of how CEFF is being applied to interconnected surface- and groundwater systems and describe the features of CEFF that facilitate holistic and integrated approaches to water management.

Progress in Measuring and Predicting Salmonid Habitat in Bar-Built Estuaries

Session Coordinators: Dane Behrens, Coastal Engineer, Environmental Science Associates and **John Largier**, Director, Bodega Marine Laboratory

This session will explore the current direction of approaches for understanding salmonid habitat in lagoons. There have been a lot of novel approaches developed recently to understand how water quality conditions, beach conditions, and flow conditions are changing in these systems between years and gradually over time. Especially over the last decade, we've transitioned more and more toward a position of data wealth and have a new problem of understanding how best to interpret growing sets of data in lagoons/estuaries (and how to continue evolving our approaches as technology changes).

Progress in Measuring and Predicting Salmonid Habitat in Bar-Built Estuaries

A Framework for Condition Assessment and Monitoring of Estuary MPAs in California

Kevin O'Connor, Central Coast Wetlands Group at Moss Landing Marine Labs (Presenter) and Co-authors: **Jan Walker** and **Eric Stein**, Southern California Coastal Water Research Project; **Christine Whitcraft**, California State University, Long Beach; **Brent Hughes**, Sonoma State University; **John Largier,** University of California, Davis, Bodega Marine Lab; **David Jacobs**, University of California, Los Angeles; and **Christina Toms**, Bay Area Regional Water Quality Control Board

The condition of California's diverse coastal lagoons and estuaries has the potential to significantly influence water quality and ecosystem functioning in nearby coastal habitats, including California's offshore Marine Protected Areas. Although California has invested significant funds over the past two decades to acquire and protect estuaries, the State lacks a coordinated, statewide monitoring program for assessing estuary health in a systematic, consistent manner. Answering key questions about the efficacy of the estuarine MPA program, stressor management, and resilience to climate change requires long-term investment in a coordinated monitoring program. To address this challenge, we created a monitoring framework that enables estuaries across California to be systematically assessed and monitored. A key aspect of this program is a focus on ecological functions versus a single type of flora or fauna. This focus on function allows the framework to accommodate different estuary types and assimilate data from diverse existing monitoring programs while maintaining an underlying comparability. In service of assessing functional performance, we have developed standard protocols for assessing key estuarine features across different estuaries, coupled with standard data templates and guidance on analysis, synthesis, and reporting, focused on four guiding principles – flexibility, comparability, interpretability, and practicality. Currently, our team is implementing the monitoring framework across three geographic regions and over 20 estuaries. This framework provides an opportunity to assess the general condition and trends of coastal wetlands that can be used as baselines for regional assessments, proposed restoration projects, and the development of bioassessment tools, as well as help the state assess its large investment in coastal wetland protection, enhancement, and restoration.

Progress in Measuring and Predicting Salmonid Habitat in Bar-Built Estuaries

The Tail of Two Lagoons: Long-Term Monitoring of Two Dynamic Central Coast Bar-Built Estuaries

Michelle Tarian, Water Resource Analyst, City of Santa Cruz Water Department, Water Resource Section

California's bar-built estuaries are dynamic environments that provide critical salmonid habitat. However, such systems are often impacted by adjacent development, which may necessitate the management of the sandbar to alleviate urban flooding and maintain public safety. Given the sensitive and critical nature of these estuaries for rearing salmonids and other species, ongoing water quality and species abundance data are paramount for guiding management decisions.

The City of Santa Cruz Water Department's primary water source for approximately 100,000 customers comprises surface water from four regional watersheds. Two of these watersheds have bar-built estuaries (the San Lorenzo River Lagoon and Laguna Creek Lagoon) and are known habitats for native steelhead and coho salmon. Comparatively, the Laguna Creek Watershed is < 8 square miles, while the San Lorenzo River Watershed encompasses 138 square miles and 65% of the City's water supply. Laguna Creek is formed from relatively pristine headwaters with few anthropogenic impacts, with a lagoon that is not manually maintained or breached. The San Lorenzo River headwaters originate from a more diverse area, including mixed-use developments, and eventually flows through a leveed urban landscape, before ending at a popular recreational beach boardwalk. The San Lorenzo River currently requires sandbar management to alleviate local flooding.

Since 2007, the City has collected water quality and fish population data in both lagoons. While the dataset is highly variable, due to the dynamic nature of bar-built estuaries and multifaceted environmental factors, we are able to uncover unique lagoon characteristics and fish abundance trends as a result of the sampling duration and consistency. In an ever-changing environment, our findings can be used to help support the management of these dynamic habitats.

Progress in Measuring and Predicting Salmonid Habitat in Bar-Built Estuaries

Two Fish Swim into a Bar: A Legacy of Data to Evaluate Salmonid Rearing Potential in the Mattole River Lagoon

Emma Held, Mattole Salmon Group, Cal Poly Humboldt

Despite the contribution of valuable habitat, most estuaries suffer from habitat loss or alteration following human land use, and bar-built estuaries are particularly sensitive to disturbance of their complex ecological processes. In some systems, bar-built lagoons can provide productive rearing habitat that supports successful salmonid life histories. However, recent studies on Chinook salmon in Redwood Creek (California) show that highly altered bar-built lagoons may not provide enough suitable habitat, and thus lagoon-rearing individuals do not contributesignificantly to the spawning population (Chen and Henderson 2021).

The Mattole River in rural northern California flows into a natural bar-built estuary, a feature that has been documented in the watershed since the late 1800s. The annual sandbar forms each summer due to a combination of low summer flows and excess sand deposited by high energy waves. This feature disconnects the river from the ocean for 1-4 months each summer, forcing some proportion of outmigrating juvenile Chinook salmon to remain in the lagoon during the hottest months of the year. Historically, the Mattole lagoon likely had a relatively higher rearing capacity due in part to a complex slough network and moderate summer temperatures. Poor land use practices and large flood events in 1955 and 1964 caused tremendous amounts of sediment to pour in from higher in the watershed, dramatically reducing the size of the lagoon.

Lagoon studies in the mid-1980s documented a sharp decline in juvenile Chinook salmon growth rate and abundance following mouth closure. This decline was attributed to high summer water temperatures and density dependence mortality following mouth closure (Busby and Barnhart 1995; Downie et al. 2003).

These studies sparked decades of research, monitoring and restoration in the Mattole lagoon. These data from water quality and biological monitoring are compiled here, along with a brief overview of restoration efforts. As sediment inputs to the river have declined, the lagoon surface area has increased by over 5x since the 1980s, but changes in the lagoon's productivity for salmonid rearing remain little understood. This presentation will also include preliminar information regarding an otolith microchemistry study conducted by the Mattole Salmon Group and Cal Poly Humboldt to determine the contribution of lagoon-rearing spawners to the Chinook salmon population in the Mattole River.

Progress in Measuring and Predicting Salmonid Habitat in Bar-Built Estuaries

Using Acoustic Telemetry to Investigate Movement Patterns by Juvenile Steelhead in a Central California Bar-Built Estuary

Rosealea Bond, University of California, Davis and National Marine Fisheries Service Southwest Fisheries Science Center (SWFSC) (Presenter, Student) and Co-authors: **Joseph Kiernan** and **Arnold Ammann**, National Marine Fisheries Service Southwest Fisheries Science Center; **Cynthia Kern, Samuel Funakoshi, John Boyce**, and **Jeff Perez**, University of California, Santa Cruz and National Marine Fisheries Service Southwest Fisheries Science Center; and **Robert Lusardi**, University of California, Davis

Bar-built estuaries (BBEs) are dynamic ecosystems that serve a critical role in the early life history of California's coastal salmonid populations. Juvenile steelhead trout (anadromous *Oncorhynchus mykiss*), in particular, are known to utilize BBEs as summer rearing habitat, despite environmental conditions that can periodically be suboptimal and physiologically stressful. Recent research conducted in the Scott Creek Watershed (Santa Cruz Co.) has indicated that recurrent movement into refuge areas may be commonplace and facilitate oversummer persistence when abiotic and (or) ecological conditions become unfavorable. Nevertheless, assessing patterns of fish movement and habitat use in highly dynamic BBEs poses many challenges and critical knowledge gaps remain.

To better understand how juvenile steelhead utilize estuarine and adjacent freshwater habitats during a typical dry season (July through December), we paired intensive environmental monitoring with acoustic telemetry to track fine-scale movement patterns and determine habitat use by steelhead. Specifically, we deployed a series of JSATS (Juvenile Salmon Acoustic Telemetry System) receivers throughout the lowermost 1.2 km of Scott Creek, which included the entire estuary (lagoon) and approximately 400 m of freshwater (riverine) habitat. Juvenile steelhead were captured in the lower estuary and tagged with acoustic transmitters during July and October. A subset of acoustic transmitters deployed during each tagging event reported the internal body temperature of the fish in addition to location, thus allowing us to quantify the thermal environment experienced by various individuals. We concurrently conducted bi-weekly water chemistry vertical profiles to track the longitudinal position of the freshwater-estuarine interface and provided insight into relationships between fish movement and environmental conditions.

The Scott Creek estuary had multiple mouth open-closure cycles over the study period, with distinct open periods that were tidally influenced (salinity range 0.1–32 ppt) and closed periods that routinely trapped saltwater and resulted in vertical stratification and warming (temperature range 13–24°C). Steelhead exhibited high post-tagging survival and we were able to track individual fish over multiple months throughout the estuary. Movement patterns were generally related to estuary conditions; however, habitat use was highly variable among individuals. This study underscores that habitat connectivity is critical for juvenile steelhead persistence in BBEs and provides novel insights into juvenile steelhead behavior and fine-scale habitat use during the critical summer dry period.

Progress in Measuring and Predicting Salmonid Habitat in Bar-Built Estuaries

Using Two Decades of Empirical Data to Inform Habitat Enhancement in the Russian River Estuary

Justin P. Smith, Sonoma Water (Presenter) and Co-authors: **Jessica Martini-Lamb** and **Gregg Horton, Ph.D.**, Sonoma Water

The Russian River Estuary is used by state and federally listed anadromous salmonids, but anthropogenic changes have greatly impacted populations of these species in the watershed. Twenty-five years ago, little empirical data on salmonid habitat availability and use existed for the Russian River estuary and management decisions relied on data gathered in smaller California estuaries and lagoons. Over the past two decades Sonoma Water has collected a large amount of data in the Russian River estuary, including the timing of estuary entry of young-of-the-year (YOY) steelhead, the relative number of YOY steelhead residing in the estuary, estuarine habitat selection, water quality conditions, prey availability, and growth of steelhead YOY. Status and trend monitoring in the greater Russian River watershed allowed us to put trends of estuary residents into a larger watershed context. In the present day, we find ourselves in a much different situation where we are data-rich, yet salmonid populations continue to struggle in the watershed. Looking to the future, we address the question of how we can best use these data to assist in designing estuary management strategies and monitor their effectiveness.

Progress in Measuring and Predicting Salmonid Habitat in Bar-Built Estuaries

Insights Into Potential Future Salmonid Habitat Changes Informed by Several Decades of Monitoring at the Russian River Estuary

Dane Behrens, **Ph.D.**, Coastal Engineer, Environmental Science Associates (Presenter) and Co-authors: **Matt Brennan** and **Chris Fitzer,** Environmental Science Associates: and **Jessica Martini-Lamb**, Sonoma Water

Thanks to many ongoing and historical studies throughout the State of California, dry season lagoonal habitat is now understood to be a crucial salmonid habitat in much of the state, especially in spring when juveniles migrate into estuaries from upstream. The Russian River, designated as a NOAA Habitat Focus Area due to its historical significance for salmonids, provides a unique case study. The Sonoma County Water Agency (Sonoma Water) and its partners have overseen a period of over 20 years of intensive monitoring in the estuary, including studies of salmonid use, invertebrates, and water quality. Different facets of this work will be covered under separate talks from this session. Since its initiation, these studies have included over 250 boat-based water quality profiles from UC Davis, over 12 years of continuous multi-depth sensor data collected by Sonoma Water, and a detailed look by Environmental Science Associates on the linkages between the various seasonal inlet states and resulting habitat conditions. Since 2008, the estuary has also experienced hundreds of inlet closure events, enabling detailed analysis of habitat dynamics. Recent classification of depth and water quality salmonid habitat-suitability ranges by Boughton et al. (2017) allows us to quantify suitable habitat volumes and examine variations over time and space. While this dataset is currently integrated within the adaptive management plan for the estuary, it also allows for a clearer look at future changes, including the potential impacts of global warming, coastal fog changes, and sea-level rise. These insights highlight the critical role of long-term monitoring in conserving salmonid habitats under shifting environmental conditions.

Dams Out: The Next Rivers Poised for Reconnection in California

Session Coordinator: **Charlie Schneider**, California Trout

California has thousands of dams, from small earthen barriers to large dams hundreds of feet tall. Many of them provide critical water supply, flood control, and hydroelectric power, but many have outlived their functional lifespan and the ecosystem and economic benefits of removal far outweigh the cost of leaving them in place. With the Klamath dams gone and scientists tracking ecosystem recovery, which are the next dams in California likely to be removed? This session will explore active dam removal efforts across the state and discuss the who, what, where, why, and how of each effort.

Scott Dam in the Eel River Basin.
Photo: Kyle Schwartz, Cal Trout

Dam Removal as a Strategy for Climate Resilience

Meghan Quinn, California Dam Removal Program Director, American Rivers

The National Inventory of Dams (NID) is comprised of 92,392 of the largest dams in the U.S.; however, the actual number of bank-to-bank barriers impacting rivers and blocking aquatic organism passage is much larger. Recent inventory efforts suggest that as many as 553,557 barriers clog our waterways. While some dams were constructed to provide flood risk reduction, water supply, hydropower generation, recreation, and sometimes maintain environmental flows, many more have outlived their useful life and no longer serve their designated purpose. In the American West, where the effects of climate change are more readily apparent, this begs the question of whether removing dams can be a strategy for climate resilience.

With approximately 2,200 dam removals completed nationwide since 1912, the benefits of dam removal for river restoration are well documented. However, less frequently studied is the connection between dam removal and climate resilience. Studies on dam removal science suggest that barrier removals are quantitatively or qualitatively linked with climate resilience. Studies focus on a range of climate resilience benefits, including connecting habitats and fluxes, supporting fish production, reducing the risk of dam failure given increasing hydrologic variability, delivering coastal sediment, supporting tribal and cultural values, reducing methane emissions from reservoirs, maintaining biodiversity and water quality, and reducing harmful algal blooms. In this context, it becomes clear that dam removals may be one pathway to creating more resilient coastal communities. In this session, we explore the science that demonstrates the importance of implementing dam removal projects for a climate-resilient future, as well as supportive communication and messaging strategies intended to increase the pace and scale of dam removal activity.

Dams Out: The Next Rivers Poised for Reconnection in California

The Past, Present, and Future of Rindge Dam

R.J. Van Sant, Senior Environmental Scientist, California State Parks

Just outside the second largest city in the United States lies the Santa Monica Mountains National Recreation Area, a 157,000-acre open space preserve home to mountain lions, peregrine falcons, red-legged frogs, southwestern pond turtles, and southern California steelhead trout, just to name a few. This area was once almost entirely owned by a single family at the turn of the 20th century and was known as Rancho Topanga Malibu Sequit. The family that owned this massive landscape was the Rindge family, who built several homes, planted crops and orchards, and maybe most notably, constructed a large concrete dam within the largest watershed in the Santa Monica Mountains, Malibu Creek. The private dam was completed in 1926, and unfortunately, has been blocking native species, including the endangered southern California steelhead trout (*Oncorhynchus mykiss*) from moving upstream for nearly 100 years. The dam blocked access to a substantial portion of historic habitat and has also been disrupting sediment movement since its completion. California State Parks is in the process of removing the defunct dam, and in so doing, reconnecting 15 miles of stream habitat for steelhead and other local species. This presentation will focus on the past, present, and future of Malibu Creek and Rindge Dam and include a discussion on the current efforts for removing the dam, including the background studies and modeling that have been completed, the proposed methodology for dam removal, the ecosystem benefits, challenges and opportunities, and next steps.

Dams Out: The Next Rivers Poised for Reconnection in California

Managing Complexity: Planning for the Removal of Matilija Dam

Sam Jenniches, Project Specialist, State Coastal Conservancy and **David Yardas**, Principal, Aqua Currit Consulting (Co-Presenters)

The confluence of Matilija Creek and North Fork Matilija Creek forms the Ventura River, 16 miles from the ocean. Less than a kilometer upstream, Matilija Dam severs the Matilija Creek, preventing access to 17 miles of prime spawning, rearing, and foraging habitat for the southern California steelhead. Removal of Matilija Dam is critical to the recovery of the endangered southern California steelhead distinct population segment (DPS).

Recovery of this DPS of the species could be of special importance because it has evolved in seasonally-disconnected river systems, in warmer waters, with less reliable migratory flows and frequent disruptive events like wildfire. These traits make the DPS a particularly valuable population in the face of the multiple impacts of climate change and provides hope that, given access to habitat, recovery is possible.

Matilija Dam was constructed in 1947 to provide water supply and flood control to the Ventura River watershed. That utility is long gone, with virtually none of its original storage capacity remaining due to "notching" and sedimentation. The dam is in poor condition and has a high downstream hazard classification. In addition to preventing upstream migration of steelhead, the dam has for decades prevented downstream delivery of sediment to the ocean, altering ecological systems and starving local beaches of natural sand supply. It's time to take this dam out.

Our presentation will provide an update on more than 20 years of planning, design, and implementation for Matilija Dam removal. It's no secret that removing large dams is complicated, and every project has its challenges. The Matilija Dam Ecosystem Restoration Project (MDERP) is characterized by significant downstream infrastructure in the form of communities adjacent to or in the floodplain, a critical water diversion facility for water supply, and multiple bridges and levees that will be impacted by the project. Planning for dam removal requires planning for the modernization of this downstream infrastructure as well.

Our presentation will detail how the MDERP has moved on from an ecologically deficient design to a consensus-preferred alternative. This change has brought about new challenges, from modeling sediment response with confidence, to managing uncertainty and risk, to the difficulties of funding large capital projects with long timelines - primarily using grants. We'll discuss these and other challenges, how Ventura County (which owns Matilija Dam) and MDERP partners are managing this complexity with collaboration and consensus building that is based on science and technical analysis, and what the future looks like for the project.

The State Coastal Conservancy has provided funding for Matilija Dam removal and associated projects over the entirety of the project lifespan and is part of the MDERP leadership and the project's large and diverse group of stakeholders. David Yardas consults with the Resources Legacy Fund (RLF), a primary Matilija Project partner for strategic funding and program support through RLF's Open Rivers Fund.

Dams Out: The Next Rivers Poised for Reconnection in California

Managing Fish Populations in Reservoirs and their Downstream Reaches – Insights from Dewatering Projects

Robert Stoddard, Stantec (Presenter) and Co-author: **Jon Walsh**, Pacific Gas and Electric Company

Many dams and their associated reservoirs in California, and throughout the United States, are facing increasing challenges to contend with aging infrastructure and evolving water management needs. Additionally, the rising frequency of recent extreme weather events and sediment input from wildfires have increased the need for repair and maintenance of these facilities.

Modifications, repairs, maintenance, and/or dam removal projects are often complex, of long duration, and require some dewatering components to complete. Reservoirs can harbor large fish populations and their dams are utilized in water management for fish and other aquatic organisms in downstream reaches. Dewatering activities present many challenges in maintaining fish health both in the reservoirs and downstream reaches. This presentation details lessons learned from several reservoir dewatering projects that may provide insight and better outcomes for future projects that include reservoir dewatering and preservation of fisheries resources.

Dams Out: The Next Rivers Poised for Reconnection in California

Removing Barriers to Fish Recovery: A Cooperative Approach to Reconnect Salmonids with Historical Habitat in Battle Creek

Emily Moloney, Project Manager, California Trout (Presenter) and Co-author: **Angelina Cook**, Restoration Associate, California Sportfishing Protection Alliance

Battle Creek, a tributary to the Sacramento River in Northern California, is known for its volcanic springs that result in high, cold summer base flows. This cold water supports the life history of the endangered winter-run Chinook Salmon (*Oncorhynchus tshawytscha*). Battle Creek is also home to the state and federally listed spring-run Chinook Salmon (*Oncorhynchus tshawytscha*) and the federally listed Central Valley steelhead (*Oncorhynchus mykiss*). PG&E operates the Battle Creek Hydroelectric Project, originally constructed between 1901 and 1911 by Northern California Power Company. The Project consists of 17 dams, two reservoirs, three forebays, five powerhouses, and an extensive network of canals that convey water throughout the watershed for power generation. In July 2026, the Federal Energy Regulatory Commission (FERC) license to operate the Project will expire, and PG&E has already notified FERC of its intent to not relicense the Project. This creates an incredible opportunity to restore Battle Creek to near-unimpaired flows and unblocked fish passage. Currently, there are 33 miles of habitat blocked by diversion dams on South Fork Battle Creek. Recently, 13 miles of additional habitat on the North Fork Battle Creek were reconnected with the construction of fish ladders on two diversion dams that previously blocked fish passage for over 100 years. With planning underway for license surrender and decommissioning, we have formed a coalition of NGOs, state and federal agencies, and tribes to engage in and inform PG&E's process to obtain the best results possible for fish and communities in the watershed.

We will discuss the coalition's approach to engage in the license surrender and decommissioning process, with the goal of flow restoration and physical barrier removal, including the need to address institutional, regulatory, and cultural barriers. Finally, we will discuss the need to meet diverse interests, including informed neighbors and supportive officials, responsive hatchery operations, and elevating tribal leadership in watershed governance in order to recover salmonids.

This presentation will highlight how agencies, tribes, and NGOs are sharing relevant data, coordinating navigation of FERC's decommissioning process, and engaging diverse stakeholders to increase chances of timely dam removal in Battle Creek that will substantially contribute to successful salmon recovery in the Sacramento River watershed.

Dams Out: The Next Rivers Poised for Reconnection in California

Restoring the Eel River: Advancing Dam Removal at the Potter Valley Project

Darren Mierau, North Coast Director, California Trout

Lying at the heart of California's North Coast region, the Eel River spans five northern counties and 3,684 square miles, making it California's third-largest watershed. In a 2010 study commissioned by CalTrout, UC Davis scientists estimated the historic run sizes from the early cannery records and concluded that combined runs of Chinook salmon, coho salmon, and steelhead likely totaled more than a million adult fish annually in good years. The current abundance of adult salmonid populations in the Eel River, based on recent SONAR monitoring, is now hovering in the 2.5% to 5% range of historical abundance (14,000–18,000 Chinook salmon, 500–5,000 coho salmon.

Two Pacific Gas and Electric Company dams—Scott Dam and Cape Horn Dam—have significantly altered the natural flow regime, impaired fish passage, and facilitated the introduction and basinwide dispersal of a non-native piscivorous fish – the Sacramento Pikeminnow. These two dams have thus contributed disproportionately to the decline of salmon and steelhead in the basin. With the expiration of the Potter Valley Project's Federal Energy Regulatory Commission (FERC) license in April 2022 and PG&E's decision to decommission the facilities, the project is now at a pivotal crossroads. CalTrout is working with a broad coalition —including tribal nations, conservation groups, local water users, and state agencies—to develop a path forward that prioritizes ecosystem restoration while addressing regional water supply needs. With our partners and with generous CDFW grant funding, we're also facilitating basinwide restoration and conservation planning for long-term recovery and management of this vital north coast river system.

This presentation will provide an overview of CalTrout's role in advancing the removal of Scott Dam and restoring access to over 280 miles of critical habitat in the upper Eel River basin. The overall dam decommissioning process may include: (1) removal of two dams and restoration of the reservoir and riverine project footprints; (2) a large and deleterious winter release of sediment during reservoir drawdown and dam breach; (3) construction of a new water diversion facility for long-term winter diversion to the Russian River; and (4) robust and well-funded restoration, conservation, and science programs with oversight and management by Eel River interests.

As the next chapter in California's dam removal story, the Potter Valley Project offers a unique opportunity to recover endangered salmonid populations and demonstrate how dam removal can catalyze watershed-wide restoration and conservation in the face of climate change.

Dams Out: The Next Rivers Poised for Reconnection in California

Social Impact Assessment of Klamath Dam Removal for Tribal Community Well-Being: Recasting Dam Removal as Eco-Cultural Revitalization

Sibyl Diver, Ph. D., Stanford University and **John R. Oberholzer Dent,** Karuk Tribe Department of Natural Resources (Co-presenters) and Co-author: **Ron Reed**, Karuk Tribe

In this study, we conducted a social impact assessment of Klamath dam removal for tribal community well-being as a collaborative research initiative with the Karuk Tribe. Building on a long-term academic-tribal research partnership, we co-developed an assessment tool using a well-being framework over a one-year planning period. Baseline assessment domains included access to cultural resources, holistic health, self-governance, education, and livelihoods. In the six months prior to decommissioning, we implemented and analyzed surveys and focus groups with Karuk tribal community members through coding and indigenous storytelling methodologies. By introducing Karuk worldviews into how we do assessment, our baseline findings recast dam removal as an eco-cultural revitalization process, emphasizing deep connections between the health of the river and the Karuk people. In doing so, this work conceptualizes a more holistic reference system for Klamath Basin restoration that better accounts for tribal community well-being. Drawing on tribal assessment science, this work also provides a model for building indicators of social well-being into monitoring and evaluation to encourage restoration and repair across interconnected social and ecological systems.

Using Drones for Fisheries Management and Restoration

Session Coordinator: Eric Ettlinger, Marin Water

Unmanned Aerial Vehicles (UAVs) have great potential to collect high-quality, quantitative salmonid habitat data, but most fisheries managers and restorationists are unfamiliar with recent advances in the technology, data collection protocols, and emerging applications. Areas where this technology could be applied include:

- Salmonid habitat typing surveys
- Streambed facies mapping
- Wood loading estimates
- Vegetation mapping
- Pre- and post-enhancement photo monitoring
- Elevation surveys, including water-penetrating LiDAR
- Redd surveys

Practitioners will discuss their experiences using UAVs and the pros and cons of this technology compared with traditional survey methods.

Using Drones for Fisheries Management and Restoration

Using Drones to Monitor the Dry Creek Habitat Enhancement Project (and Beyond): Uses, Benefits, and Challenges

Eric McDermott, Sonoma Water (Presenter) and Co-authors: **Neil Lassettre, Ph.D.**, **Mark Goin**, and **Celeste Melosh**, Sonoma Water

Sonoma Water uses drones to monitor and evaluate fisheries restoration activities within Dry Creek (Sonoma County, CA). The Russian River Biological Opinion directs Sonoma Water to construct six miles of juvenile coho salmon and steelhead rearing habitat along Dry Creek downstream of Warm Springs dam. Sonoma Water partially evaluates the success of the Dry Creek Habitat Enhancement Project using data collected for implementation and effectiveness monitoring. Implementation monitoring evaluates whether projects meet their approved design criteria and effectiveness monitoring evaluates the physical effects of enhancement actions on aquatic habitats.

To monitor the progress and evolution of enhancement sites, Sonoma Water uses traditional survey and flow measurement tools (total stations and flow meters) to collect habitat data. In 2017, we began integrating drone technology into the monitoring toolbox. The speed and accuracy of collecting data with a drone allow field crews to quickly and efficiently monitor the increasing number of enhancement reaches. Currently, the Dry Creek Habitat Enhancement Project covers nearly five miles and encompasses 24 enhancement reaches.

We use a drone to collect overlapping air photos to construct three-dimensional models from Structure from Motion (SfM) and orthomosaics of project reaches before, during, and after construction. For implementation monitoring, these products enable design consultants and contractors to inspect project progress remotely, calculate cut and fill volumes and areas, and generate elevation profiles for comparison to design plans. After construction, Sonoma Water uses orthomosaics to verify the number, location, and orientation of each enhancement feature installed. For effectiveness monitoring, field crews collect detailed bathymetric, depth, velocity, and habitat data to evaluate enhanced habitat against desired performance metrics. These data are combined with drone-derived point clouds of floodplain topography to create digital elevation models of each project reach and detailed maps of depth, velocity, and habitat type. This permits quantification of habitat area by performance metric (singly and combined) to rate habitat enhancement reaches according to criteria in the AMP. Additionally, we can quantify physical change over time in the in-channel and floodplain areas (scour and fill) using geomorphic change detection.

Recently, we began using a drone equipped with a Light Detection and Ranging (LiDAR) sensor to monitor enhancement reaches. The LiDAR sensor collects higher resolution topographic data and penetrates mature riparian canopy to collect topographic data where we have not been able to collect it previously. Because a LiDAR flight can collect topographic data during high flows when we are unable to survey with traditional methods, we plan to use change detection on sequential flights to help quantify areas inundated during winter flows (winter rearing habitat).

Sonoma Water also uses the drone to collect high-resolution video of enhancement sites. The video helps inform and educate the public about the Dry Creek Habitat Enhancement Project in a way that is approachable and interesting and provides context about the proximity of projects to each other.

Using Drones for Fisheries Management and Restoration

A View From Above: Using Drone Imagery to Establish Fish Passage Thresholds

Dana Lee, Fisheries Biologist, FISHBIO (Presenter) and Co-author: **Jack Eschenroeder,** Managing Technical Consultant, Environmental Resources Management

The Salinas River basin is the largest river system providing habitat for threatened South-Central California Coast Steelhead (*Oncorhynchus mykiss*), but it is also heavily impacted by anthropogenic impacts including dam development and agricultural production. Spawning and rearing habitat for the species is confined to three smaller tributaries that are only reachable by steelhead migrating 50 to 130 km upstream through the mainstem Salinas River. The minimum discharge required to provide passage of adult and juvenile steelhead to and from these habitats was previously unknown, but this information was necessary to develop an optimized flow release schedule from upstream dams to ensure migratory success. To facilitate modeling of passage thresholds in the Salinas River basin, we modified the standard critical riffle assessment protocol by using a drone to minimize field effort, increase spatial coverage, and account for shifting substrates in the sand-dominated riverbed of the Salinas. A total of four 2- to 4-km river reaches were selected at strategic locations across the Salinas River and drone photogrammetry was used to create digital elevation models of each reach. Cross-sectional depth profiles were generated for riffles within each reach and estimated water depths at each riffle were calculated across a range of discharges using Manning's equation. Minimum flow thresholds calculated for each transect ranged from 20 to 260 cfs, depending on the location and passage criteria applied. The standard passage criteria established by CDFW generated an average threshold flow that fell between these two extremes at approximately 71 cfs. Model outputs were compared with data collected in the field using either an acoustic doppler current profiler (ADCP) or stadia rod to measure depth at selected riffles within each reach. These field validation data were collected over approximately one year and across a wide range of flows (30 to 230 cfs). The mean depths predicted by the model were 2.9 cm shallower than the mean depths observed in the field, suggesting that the model slightly underestimated the actual depths. The value of the approach used in this study was further demonstrated following a rapid reassessment that was initiated after record flood flows resulted in geomorphic changes in the riverbed. The drone-based approach employed by this study allowed us to re-examine multiple profiles and associated model outputs across these shifts, further bolstering confidence that recommended passage criteria were robust to large changes in riverbed morphology following high-flow events. This study ultimately demonstrated that depth conditions for adult steelhead passage were achieved at lower flows than previously estimated for the Salinas River and provided evidence for the efficacy of drone-based approaches in modeling passage thresholds.

Using Drones for Fisheries Management and Restoration

Building Capacity for First Nations to Map Thermal Refuge Areas for Salmon Using Drones

Dr. Eric Saczuk, British Columbia Institute of Technology Remotely Piloted Aircraft Systems Hub (Presenter) and Co-authors: **Marc Porter** and **Katrina Connors**, Salmon Watersheds Program, Pacific Salmon Foundation

Climate change is emphasizing the need to consider the thermal regime of Pacific salmon-bearing streams in the context of their ability to maintain salmon as water temperatures increase. First Nations communities with strong cultural ties to, and who rely heavily on salmon as a natural resource, have been particularly negatively affected by declining salmon runs. Thermal refuges may become increasingly influential in dictating the population status and spatial distribution of cold-water-dependent salmon. The development of consistent data collection, processing, and analysis methods using color and thermal images acquired by drones can provide First Nations communities with the ability to map, monitor, and work to protect thermal refuges important for salmon during critical times of temperature stress.

The most commonly used methods for obtaining stream temperature data are limited to discrete temperature measurements at specific locations of sensors or tidbits within a stream network. Thus, for most of the stream length, water temperatures can only be inferred and the likelihood of locating distinct cold-water patches that could provide thermal refuge areas for salmon is consequently low.

In contrast to conventional single-point-data temperature measurements, airborne surveys from satellites, crewed aircraft, or drones offer the advantage of providing spatially continuous optical and thermal image data over a wide area. In terms of spatial, spectral, radiometric, and temporal resolution, drone images provide the highest quality temperature data over shorter stream distances (<~50km).

An ongoing partnership supported by BC's Salmon Restoration and Innovation Fund (BCSRIF) between the Pacific Salmon Foundation (PSF), the British Columbia Institute of Technology (BCIT), and multiple First Nations (FNs) communities in British Columbia, is focused on developing robust, repeatable, and consistent methods for collection of high-resolution water surface temperatures using thermal-imaging drones and the associated training to allow FNs to take ownership of long term monitoring. Methods have now been developed and field-tested within a variety of river/ stream networks across the province. Combined with in-situ water temperature data, the resulting radiometric standardized thermal orthomosaics are used to identify and map cold water patches that could serve as potential thermal refuge habitats for migrating, rearing, or spawning salmon. Temperature discrimination with thermal drones can allow the identification of differences as little as 1°, allowing for precise capture of thermal differences along an entire stream network at a single point in time or easily repeated to allow tracking of potentially changing thermal conditions within a stream across seasons or across years.

Future technical work should include the development of an adaptive algorithm by which to adjust standardized thermal images to in-situ conditions based on known environmental factors that could influence stream temperatures, including air and sky temperature, cloud cover, and humidity. While the science around identifying potential cold-water refuges for salmon is advancing, current policy related to the protection and management of identified thermal refuges is weak. Cold water refuges may need to be managed as distinct operational units to help ensure that salmon populations will continue to thrive despite the negative effects of climate change.

Using Drones for Fisheries Management and Restoration

The Bigger Picture: Utilizing Drones to Assist with Fish Monitoring, Fish Passage and Quantifying Vegetation Impacts on Fish Communities

JT Casby, California Department of Water Resources

Unoccupied Aerial Vehicles (UAVs), also known as drones, can be a beneficial tool to supplement monitoring of fish and fish habitat. Within the California Department of Water Resources, the Division of Integrated Science and Engineering (DISE) UAV Program has used drones in several different projects such as: Feather River Salmon Redd Monitoring, Yolo Bypass Fish Passage Investigation, "Big Notch Project" Construction Monitoring, and Fish Habitat Restoration to support salmonids and other fish within the Sacramento-San Joaquin Delta and beyond. This presentation will showcase these projects and present a pilot study focusing on the impact of vegetation on the Yolo Bypass Fish Monitoring Program (YBFMP), a long-term fish monitoring program in the Yolo Bypass.

The Yolo Bypass is a 24,000-hectare floodplain in the California Central Valley that is used by juvenile salmon for rearing during flooding periods. In addition, adult salmon frequently migrate through the Yolo Bypass, with aid from fish passage improvements, on their way to spawning grounds upstream. Long-term monitoring is essential to verify that restored habitat and passage are functioning as expected for salmon and other fishes. It's hypothesized that increased vegetation may be affecting water quality, fish communities, and their food resources in the Yolo Bypass, but the mechanism driving this change is not fully understood and is hard to quantify. To address this, we spent a year using drones to collect monthly high-resolution Red-Green-Blue (RGB) imagery of affected fish sampling sites to evaluate the changes in the total surface area of aquatic vegetation over time. Using this method, we were able to quantify vegetation at our sites and better understand how vegetation affects fish catch. In addition, the Yolo Bypass flooded during this pilot period, and we documented the effect of flooding on aquatic vegetation within the Yolo Bypass, furthering our understanding of how flooding can affect aquatic vegetation. Incorporating this new monitoring technique over the long term is expected to provide a more holistic understanding of the ecology of the Yolo Bypass and the effects of aquatic vegetation on monitored fish communities.

Using Drones for Fisheries Management and Restoration

Independent Testing of PIT Tags for Fisheries Research: A Framework for Standardization and Performance Evaluation

Brian Beckley, Voda IQ, Hammett, Idaho, USA (Presenter) and Co-authors:
Armando Piccinini, Voda IQ, Parma, Italy; **Zachary T. Sherker**, University of British Columbia, Pacific Salmon Ecology and Conservation Lab, Vancouver, BC, Canada

Passive Integrated Transponder (PIT) tags are essential for monitoring aquatic species' movements, survival rates, and broader ecological patterns. This study details the development of a standardized, independent testing framework for PIT tags, ensuring consistent performance across varying environmental conditions. We focus on the evaluation of four PIT tag models: 12 mm, 10 mm, 9 mm, and 8 mm — manufactured by Voda IQ, with testing conducted at the Pacific States Marine Fisheries Commission's facility in Kennewick, Washington. Key performance criteria included physical dimensions, electrical characteristics, detection range, and proximity performance.

Independent testing revealed that the 10 mm and 9 mm tags successfully met all established performance metrics, demonstrating robust detection capabilities, precise adherence to size specifications, and strong noise resistance. The 12 mm tag excelled in detection efficiency and read range but slightly exceeded the weight limit by 0.0022g, a factor considered biologically negligible for most target species. The 8 mm tag, designed to minimize tag burden in smaller or juvenile species, achieved lower detection range and modulation values, which is expected due to its reduced size. However, its specialized design makes it advantageous for applications requiring less invasive tagging methods.

This comprehensive evaluation provides critical insights into the performance reliability of Voda IQ's PIT tags under controlled conditions that simulate real-world environments, such as hydroelectric dams and turbulent riverine systems. By outlining a rigorous, standardized testing protocol, the study aims to enhance the adoption of innovative PIT tag models and support adaptive management strategies for fisheries and conservation projects worldwide.

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