Virtual Salmonid Restoration Conference

April 21-23, 2021

Conference Co-sponsors

Balance Hydrologics, Cachuma Operation and Maintenance Board, California Conservation Corps, Cal Trout, Cardno, cbec, inc., East Bay Municipal Utility District, ESA, Eureka Water Probes, GHD, Green Diamond Resource Company—CA Timberlands Division, Guadalupe-Coyote Resource Conservation District (GCRCD), Hanford ARC of Community Foundation of Sonoma County, HDR, Inc., Humboldt and Mendocino Redwood Companies, ICF International, Lyme Redwood Forest Company, LLC, Marin Municipal Water District, McBain Associates, Mendocino County Resource Conservation District, Michael Love and Associates, MidPeninsula Regional Open Space District, Mother Earth Engineering, Northern California Water Association, Northwest Hydraulic Consultants, Onset, Pacific States Marine Fisheries Commission, Prunuske Chatham, Inc., RES, Redwood Forest Foundation, Inc. and Usal Redwood Forest Company, Rincon Consultants, Inc., SHN Engineers and Geologists, Inc., South Yuba River Citizens League, The Nature Conservancy, Trinity River Restoration Program, Valley Water, Wildlife Conservation Board, William Rich and Associates, WRA, Inc.

CALIFORNIA DEPARTMENT OF FISH & WILDLIFE

res

The Virtual Salmonid Restoration Conference 2021 *Adaptation in Motion*

The Humboldt Wildlife Refuge was my escape place during COVID. What refuge got you through the pandemic? Where were you able to do your best thinking and dreaming about the future?

Like all non-profits and agencies, Salmonid Restoration Federation has had to adapt to working and operating in a fundamentally different way in order to achieve our mission. Producing the annual Salmonid Restoration Conference is our primary venue to promote and advance recovery of wild salmon populations in California. While the temptation to hibernate has been great, the need to assess and adapt to changing conditions has been greater. So here we are, over one year into the COVID-19 pandemic, exploring new ways to work, convene and interact. While we will sincerely miss the lively conversations, bumping into colleagues, and the camaraderie that is a hallmark of the SRF Annual conference, we hope that the Virtual platform will afford networking opportunities, highlight outstanding work, and will enable us to make presentations available as a lasted recording resource.

Additionally, we produced this compiled digital Proceedings to create a lasting resource, and to honor the presenters and coordinators who generously share their knowledge and expertise.

The theme of the Virtual Conference is *Adaptation in Motion* because we have all had to adapt rapidly (and somewhat on the fly) to accomplish our collective work of science and relaying the findings of our science to our larger watershed restoration and fisheries community.

Adaptability—the predominant trait of the salmon and watershed restoration field. Salmon and steelhead survive through adaptation, and so will the restoration field. Protecting, conserving and restoring California wild salmon and steelhead populations will require laser focus on restoration strategies that show a strong fish response. If our best thinking got us to this precipice of salmonid recovery, our way forward will require clarity and acuity beyond what we have practiced in the past decade.

The salmon restoration field intersects with many disciplines including science, engineering, communities, infrastructure, planning, food production, and land use practices. These intersections animate the lively debate and discussions about the most appropriate strategies and techniques to achieve restoration milestones. Nowhere is this more evident than the SRF Conference, where practitioners from many fields converge to address the very issues that are germane to salmonid recovery.

Like salmon, the SRF Conference has had to adapt to cataclysmic changes that limit our movement and pose risks to our health and collective wellbeing. Our movement is nothing if not resourceful and adaptive.

Producing the conference is a yearlong interactive process that engages SRF's Board of Directors, our co-sponsors, and our colleagues. We sincerely thank all of the workshop, and session coordinators who did an outstanding job of creating an adaptive agenda and were able to pivot and lead by example in this trying time. SRF greatly appreciates all of our co-sponsors who generously contribute their ideas, time, and resources to the production of the conference.

Thank you for navigating with us to learn how to best fulfill our recovery goals with an expanded tool set and a year of reflection and re-prioritization.

Onward together,

Dana Stolzman
Executive Director
Conference Agenda Coordinator
Salmonid Restoration Federation

Table of Contents

Wednesday, April 21

Thursday, April 22

Thursday Afternoon Concurrent Session

Friday Morning Concurrent Sessions

Virtual Conference Events

Wednesday, April 21

Professional Development Workshop
2-4pm

Wednesday, April 21

SRF Annual Meeting
via Zoom, 5:30pm

Check out the Online Auction and support SRF!
www.32auctions.com/srfsilentauction21

Film Screening of *Gather*

Register for *Gather* and the film will be available for screening April 19-23

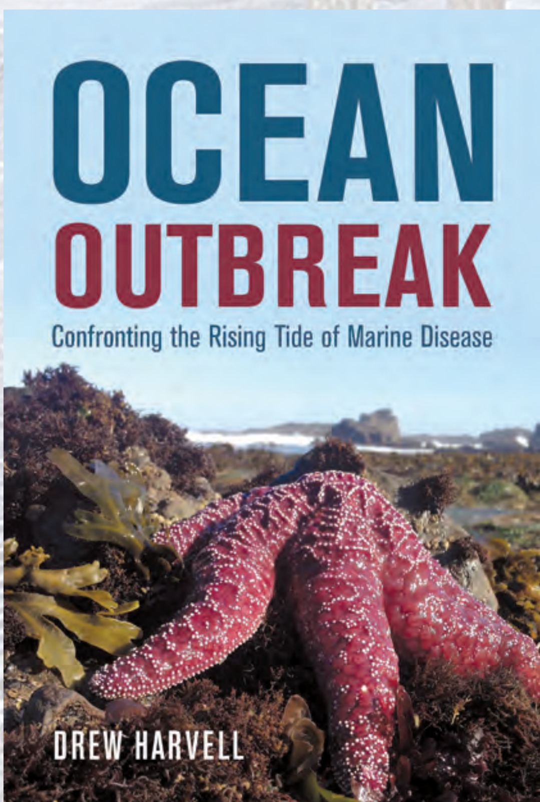
Friday, April 23

Panel Discussion 5:30pm

Join us for a panel discussion with Director Sanjay Rawal and Ancestral Guard and Yurok tribal member Sammy Gensaw.

Thursday, April 22

1pm after Plenary Session
Book Event with Drew Harvell, author of *Ocean Outbreak*



Anyone can register for the event at
https://calsalmon.nationbuilder.com/gather_film_screening

Assessing Ecological Risks from Streamflow Diversions in Coastal California Streams Workshop

Wednesday, April 21

Workshop Coordinators: Bill Trush, *Co-Director HSU River Institute,* ***Valerie Zimmer,*** *State Water Resources Control Board, and* ***Katrina Nystrom****, Salmonid Restoration Federation*

The riffle crest thalweg (RCT) is a familiar geomorphic feature offering an alternative to present-day bypass diversion strategies for managing unregulated California streams. By restricting streamflow (Q) diversions to a relatively small percentage change in ambient RCT depth, the necessary magnitude, duration, frequency, and timing of key ecological processes will be protected. This workshop will: (1) introduce basic RCT concepts, (2) connect stream hydraulics to stream ecosystem processes, (3) review recent RCT research/monitoring, and (4) reserve ample opportunity for discussion and hands-on data analysis. Valerie Zimmer provides an engineer's perspective, while Bill Trush provides that of a stream ecologist. Katrina Nystrom, a recent HSU Masters graduate, will present an RCT diversion risk analysis of Pacific lamprey ammocoete rearing habitat de-watering during spring-through-summer recession hydrographs. Workshop participants will be shown how to quantitatively link RCT hydraulics with stream ecosystem processes, then shown how to apply these linkages practically and quantitatively for evaluating diversion risks. 'Ecological performance' is how well a given instream diversion strategy protects a stream ecosystem's capacity for self-renewal. Ecological performance will be evaluated graphically as a percentage decrease in multiple baseline ecological processes (Y-axis) resulting from a percentage increase in ambient streamflow diversion (X-axis) (i.e., decreasing RCT depth), in short, management prescription on the X-axis and remaining beneficial use (less than the annual 100% baseline established at 0% diversion) on the Y-axis. Many diverse ecological processes, each with their own unit of measurement, can be plotted on a single graph. Last, we'll discuss how and why maintaining ecological performance will require a top-down regional diversion strategy.

Accelerating Coho and Steelhead Recovery Workshop

Wednesday, April 21

Workshop Coordinators*: Matt Clifford, JD,* *Trout Unlimited, and* ***Monty Schmitt,*** *The Nature Conservancy*

In the more than two decades that various coastal California populations of steelhead and Coho salmon have been protected under federal and/or state endangered species acts, a great deal of effort has gone into studying how to recover these species. Federal recovery plans have been completed for all three populations of coastal California steelhead, and both federal and state recovery plans have been completed for both populations of coastal California Coho. But although both the regulatory and restoration branches of the California Department of Fish and Wildlife and the National Marine Fisheries Service have been working for years to implement various actions called for in those plans, populations of both species have continued to decline. This workshop will focus on efforts to re-assess the approaches the agencies and the larger restoration community are taking to recover these species. Topics include: methods for prioritizing specific restoration projects at the watershed level to guide grant funding, more effective implementation of regulatory authority over water diversion and stream alteration, more efficient permitting of habitat restoration projects, and more effective monitoring of populations of both species.

State of Salmonids

Curtis Knight, ***Cal Trout***

In 2017, Cal Trout and UC Davis Center for Watershed Sciences released State of the Salmonids II: Fish in Hot Water—an in-depth report that details the status of California's 32 types of native salmon, steelhead, and trout. The report underscores the need to accelerate salmon restoration on the North Coast and elsewhere in California because if we don't act, we risk losing 45% of California salmonids in the next 50 years.

The presentation will discuss the findings of the report, including an analysis of key threats to the survival of each species, starting with the overarching threat of climate change, which is likely to reduce the availability of cold-water habitat that salmon, steelhead, and trout all depend on for survival. It also highlights various other human-induced threats, such as dams, agriculture, estuary alteration, urbanization, and transportation. Strategies for recovering salmonids throughout California will also be discussed, including prioritizing protection and restoration efforts in three general areas:

Protecting the most productive river ecosystems remaining in California, such as the Smith and Eel Rivers, must be a priority. These strongholds, among others, have the capacity to support diversity and abundance because they retain high quality habitat and are not heavily influenced by hatcheries, thus supporting the persistence of wild fish.

Increasing focus on source waters will keep more water in streams and reduce stress on fish during drought, buffering the effects of climate change. Sierra meadow restoration, springs protection and progressive groundwater management all contribute to this effort.

Restoring function to once productive—but now highly altered—habitats can greatly improve rearing conditions for juvenile fish, especially floodplains, coastal lagoons, estuaries, and spring-fed rivers.

Implementing Priority Recovery Actions for Coho Salmon in the Central California Coast

Stephen Swales, Ph.D., *Fisheries Branch, California Department of Fish and Wildlife*

Coho salmon in the Central California Coast Evolutionarily Significant Unit are listed as Endangered under both the State and Federal Endangered Species Acts. While most populations are declining, some are already extirpated. California Department of Fish and Wildlife and NOAA Fisheries collaborated in initiating and developing a joint agency program entitled 'Priority Action Coho Team' (PACT). Members of the State Coho Recovery Team and other stakeholders participated in several meetings and their input was incorporated into the PACT priorities. The agencies have recently released a PACT progress report.

The main aim of this program is to prevent further extirpations of Coho salmon populations in central coast streams through identifying and implementing priority short-term recovery actions. The PACT recovery actions include; captive rearing/fish rescue, habitat restoration/protection, instream flow conservation, improvements in permitting/regulations procedures and outreach/education. In this presentation, we will outline the structure and function of the PACT program, and discuss measures that can be taken to prevent the further extirpation of CCC Coho salmon. In addition, we will highlight some recovery efforts that have been completed.

The North Coast Salmon Project: A Synergistic Approach to Coho Salmon Recovery

Jonathan Nelson, ***California Department of Fish and Wildlife***

The California Department of Fish and Wildlife has launched a new initiative called the North Coast Salmon Project to enhance the recovery of CESA-listed salmonids on the North Coast of California. In the first phase of this project, efforts will be concentrated on Coho salmon. The Project is guided by a leadership team made up of partner organizations and Department representatives with the goal of evaluating the effectiveness of past recovery efforts and identifying actions that will expedite and improve future Coho recovery methods. The Department will collaborate with local stakeholders and the restoration community to identify high priority recovery actions and develop locally driven conservation efforts. Approaches will focus on reach-specific restoration priorities utilizing the Salmonid Habitat Restoration Priorities (SHaRP) process as an initial framework. Other aspects of recovery, such as Department grant programs, population and habitat monitoring projects, and permitting for habitat restoration, will be evaluated for their efficacy, resulting in meaningful recommendations for improvement. Project efforts have been initiated in four focus watersheds: Lower and South Fork Eel River, Mendocino Coast streams, Russian River tributaries, and Lagunitas Creek. We will present on our progress made to date, next steps in developing a recovery framework, and expected outcomes from Project objectives.

How to Use the Salmon Habitat Restoration Priorities (SHaRP) Process to Enhance Inclusion and Support in On-the-ground Restoration Planning

Julie Weeder, *NOAA Fisheries, and* ***Allan Renger****,*
California Department of Fish and Wildlife (Co-presenters)

Our agencies have developed a process to engage partners in reach-level recovery implementation planning that builds upon the existing recovery plans of the two agencies. This effort, called Salmon Habitat Restoration Priorities or SHaRP, is an open, transparent, inclusive process which is nearing completion in the pilot watershed—the South Fork Eel River. SHaRP starts with identification of the best sub-watersheds within the larger basin to focus on. People with history or local expertise in the sub-watershed (e.g., local NGOs including RCDs, biologists, geologists, and hydrologists from NOAA Fisheries, NOAA Restoration Center, CDFW, other state and federal agencies, academia, and landowners) are invited to participate in a 2-day meeting for each of these sub-watersheds. By the end of each meeting, participants have agreed upon an on-the-ground restoration plan for the sub-watershed which identifies, to a reach scale, what actions should be undertaken in the next ten years to best address the habitat limitations, and threats most affecting salmon and steelhead there.

Accelerating Steelhead and Coho Recovery Using the Habitat Restoration and Enhancement Act and Other Programmatic Permits

Katie Haldeman, *Sustainable Conservation and* ***Lucy Haworth*** *California Department of Fish and Wildlife (Co-presenters)*

Sustainable Conservation's Accelerating Restoration team collaborates with agencies and restoration proponents to create policy and regulatory incentives that save time and resources on project implementation. These actions are essential to help restore habitat at the pace and scale necessary to recover species. Our flagship initiative focuses on developing "programmatic permits" and other efficient permitting mechanisms that seek to expedite implementation of projects, while ensuring essential environmental protections are in place. By creating a separate regulatory pathway, there is also greater opportunity for restoration project proponents and regulatory agencies to partner on common goals and achieve critically needed environmental outcomes.

In 2014, Sustainable Conservation sponsored the Habitat Restoration and Enhancement Act (HREA) and created an alternative, expedited permitting pathway for the California Department of Fish and Wildlife (CDFW) for restoration projects 5 acres or less. More than 45 projects have been approved using HREA and the program can provide a major boost for restoration proponents trying to get steelhead and Coho projects implemented more quickly. The process works in coordination with an existing State Water Resources Control Board programmatic permit for small-scale projects. Along with highlights of approved projects, a primer will be provided on the HREA program, application requirements, and how to best partner with CDFW to successfully utilize the process.

Sustainable Conservation will also provide a brief update on complementary efforts with other state and federal agencies (e.g., Army Corps, NOAA, U.S. Fish and Wildlife, State Water Resources Control Board) to develop expedited permitting pathways for aquatic and riparian restoration projects across the state.

Building Local Capacity: An Overlooked Element in the Implementation of Habitat Restoration

Kellyx Nelson, *San Mateo Resource Conservation District (Presenter)*
and Co-author: ***Matt Clifford,*** *Trout Unlimited*

Federal and state plans for achieving the recovery of endangered salmon and steelhead populations call for extensive voluntary habitat restoration measures to be implemented, predominantly on private land, over the next several decades. The success of these recovery plans depends directly on whether this implementation takes place.

Neither the state nor the federal government has proposed undertaking habitat restoration using their own personnel. Instead, both assume non-governmental entities, primarily locally-based NGOs, will take the lead role in planning, designing, permitting, and implementing restoration projects, using funding awarded on a competitive basis from public grant programs. This model calls upon local organizations to take on a very broad array of complex tasks: developing project ideas, nurturing relationships with private landowners and obtaining legal permission, creating engineering designs, navigating multiple state, federal, and local permitting processes, and hiring and supervising consultants and contractors, all while administering the grant funds themselves in keeping with the detailed requirements of various granting agencies, on strict timelines. While organizations capable of meeting these challenges exist in some regions of California salmon and steelhead country, in others they are essentially nonexistent. This limits the ability to put effective restoration projects on the ground.

Given the central role that locally-based organizations play in current salmonid recovery plans, more attention needs to be paid to the ways in which public grant program policies affect the ability of these entities to undertake habitat restoration projects on a sustainable basis. This presentation will examine the effects of existing policies regarding overhead, budgeting, grant amendments, permitting, and other topics have on the capacity of local organizations, and how those policies could be improved to help give rise to a healthier community of restoration partners capable of implementing habitat restoration across the geographic range of California salmonids.

Wednesday, April 21

Workshop Coordinator: Janine Castro, *Project Leader & River Scientist, USFW Vancouver, WA*

Janine Castro is the Project Leader for the U.S. Fish and Wildlife Service's Columbia River Fish and Wildlife Conservation Office in Vancouver, Washington. After spending many years organizing and attending scientific conferences, she decided that we, as scientists, need to become better presenters … better communicators. Janine's academic background is in Geology and Geography, not Communications, so she comes from a "trial by fire" perspective—learning communication skills on the job.

In 2012, Janine developed an on-going public speaking workshop for scientists that is offered every year at River Restoration Northwest, which has also been conducted for a wide variety of conferences and federal and state agencies.

Janine's science communication focus is public speaking —specifically delivering complex scientific and technical information to the general public. She is a founder of RRNW and co-founder of Science Talk.

Key Messages:

1. Be authentic
2. Have one clear message
3. Practice

Science not communicated is science not completed.

This workshop is focused on improving oral presentation skills for planners, scientists, engineers, and others who participate in restoration and conservation projects. Participants will leave the workshop with an improved skill set, including a checklist to develop and deliver impactful presentations. The workshop is highly interactive and builds on the collective experience of the audience and the instructor.

Topics:

- Audience, venue, organization, size, length
- Main message, title slide, final sentence
- Audiovisuals, lights, sound, computer, timer, pointers, remote, props
- Tone, volume, inflection, pace, pauses, body language
- Answering questions

Thursday, April 22

Deep Restoration (Without and Within): Tending Old Wounds, Healing Systems, and Recovering Belonging

Rene Henery, Ph.D., *Trout Unlimited and University of Nevada Reno—Global Water Center*

Our world is changing… I hear it in the midwinter sounds of my feet treading over rock and dirt where in the past there was snow; I smell it in my summer clothes, saturated with smoke from the worst fire season in history; I taste it in the mineral bite of water from a dear friend's well as it runs low for the first time; I feel it in the way that the pandemic shows up in my dreams, in the stress parents are sharing about the extent of the uncertainty in their children's futures, in the civil unrest, the overt hostility towards people who look different, who come from a different place, who have different beliefs; in the cries for justice, for equity, for reform and for change…

We are embedded in Nature. We belong to ecosystems and are ourselves ecosystems. The nature and condition of our inner worlds, our interpersonal relationships, and our orientation towards other living things are expressed and mirrored in the conditions of the landscapes and species we tend. As the pressures from our changing world intensify, our resilience and efficacy as a conservation community will hinge in large part on our ability to tend to ourselves, to each-other and to the human systems we comprise. Our orientation towards belonging, practices for care, and commitment to healing will be the measures of our capacity to support Nature's reconciliation, restoration, and recovery.

Thursday, April 22

The Difference A Year Makes

Chuck Bonham, Director of the California Department of Fish and Wildlife

California is the nation's most populous state and home to more diverse species and ecosystems than anywhere in the United States. It is a global biodiversity hotspot, but that biodiversity is also disappearing at one of the highest rates. Like California is the international leader on climate change, so too can we be the international leader on biodiversity, conservation, and climate resiliency for natural resources.

One problem is that the scale and pace of restoration is not matching the increasing threats from climate change, wildfire, drought, flooding, escalating human- wildlife conflict over habitat and water, and ultimately species extinction. Permitting, including the permits issued by the California Department of Fish and Wildlife (Department or CDFW), exists in a regulatory framework that avoids risk but results in piecemeal conservation. The Department is pursuing an integrated strategy to change this paradigm, involving reforms to its internal processes, grant making, and organization of its programs to optimize engagement with the salmon restoration community. At the same time, this year's hydrological situation is moving the state back to drought challenges, and over the last year everyone from all walks of life has been affected by the global pandemic.

The Director's presentation will offer reflections on what the last year has been like for the Department and its employees, and walk through these ideas and reforms and lay out a vision for California's salmon restoration with a renewed commitment to partnerships.

Ocean Conditions and the Emergence of Thiamine Deficiency in Central Valley Chinook Salmon

Authors: Nate Mantua, Ph.D. *(Presenter), and Co-authors:* ***Rachel Johnson, John Field, Steve Lindley,*** *NOAA Fisheries;* ***Anne Todgham, Nann Fangue, Carson Jeffres, Heather Bell, Dennis Cocherell,*** *UC Davis;* ***Jacques Rinchard,*** *State University of New York, Brockport;* ***Donald Tillitt,*** *U.S. Geological Survey, Columbia Environmental Research Center;* ***Bruce Finney,*** *Idaho State University;* ***Dale Honeyfield,*** *Retired United States Geological Survey, Northern Appalachian Research Branch;* ***Taylor Lipscomb, Scott Foott,*** *U.S. Fish and Wildlife Service;* ***Kevin Kwak, Mark Adkison, Brett Kormos,*** *California Department of Fish and Game;* ***Steve Litvin,*** *Monterey Bay Aquarium Institute;* ***Iliana Ruiz-Cooley,*** *Moss Landing Marine Laboratory*

Thiamine Deficiency Complex (TDC) is a nutritional deficiency of thiamine (vitamin B1) linked with high mortalities of early life stages of Chinook salmon in California's Central Valley (CV) hatcheries in 2020 and 2021. Clinical signs of TDC are anorexia and sporadic spinning prior to death. Offspring of female salmon with reduced levels of thiamine are prone to TDC. Our current hypothesis is that there was an unusual narrowing of the diversity of CV Chinook salmon marine diet and/or a more southerly ocean distribution of Chinook salmon foraging in 2019-2020 where ocean prey was either deficient in thiamine levels or high in thiaminase. Thiaminase is an enzyme that destroys or inactivates thiamine, and has been identified as the primary explanation for low levels of thiamine and subsequent onset of TDC in Great Lakes and Baltic Sea salmonids. Ecosystem surveys in 2019 found the highest abundances of Northern anchovy off central and southern California on record, and a distinct lack of other common salmon prey like krill and juvenile rockfish. In 2019 fishermen reported catching salmon with stomachs full of anchovy, but not other typical prey items such as krill, squid, juvenile rockfish, or sardines. While ocean surveys were sharply limited in 2020 due to COVID concerns, limited survey trawls, sea bird diet observations, gut contents from ocean caught Chinook salmon, and anecdotal reports from the fishing community all point to 2020 being another year with an anchovy dominated forage base off California's Central Coast. While the cause may be due to unusual ocean conditions and a reorganization of marine food webs, there are significant consequences to salmon populations in freshwater. TDC was first observed in CV hatcheries in broodyear (BY) 2019 spring, fall and late-fall Chinook salmon, and then in BY2020 winter-run and spring-run Chinook salmon. TDC continues to afflict CV salmon stocks and we will continue our surveillance of BY2020 eggs and progeny from other CV populations. Our work to-date has revealed prophylactically treating female winter run Chinook salmon with thiamine resulted in significant improvements to egg thiamine concentration and survival of progeny of this endangered species. Baseline levels of egg thiamine in untreated 2020 winter run were low, resulting in 50% of their fry expressing TDC symptoms. Our work has generated significant insights and necessary data needed to quantify impacts to naturally spawning populations, which remains the greatest data gap relevant for conservation, water project operations, and harvest management. Our rapid scientific inquiry into this new stressor has resulted in actionable science to support salmon hatchery management and assess population-level impacts.

Ocean Outbreaks Heating Up with Climate Change

Drew Harvell, Ph.D.,* *Professor of Ecology and Evolutionary Biology, Cornell University

Oceans and rivers are increasingly impacted by anomalous warming from heat waves. In addition to direct temperature impacts, warming facilitates increased disease risk across biota from land to oceans, although cases are also known of anomalous cooling facilitating disease. In the oceans, major foundation, ecologically and culturally important species are affected by warming-fueled outbreaks, including coral, eelgrass, oysters, seastars and salmon. While it can be difficult to pinpoint the role of warming in disease outbreaks, we have recently shown for Caribbean corals that a forty year disease increase is associated with warming. Our work has also shown the role of warming and intensifying outbreaks from California to Alaska in foundation species like eelgrass and keystones like seastars. Time series show eelgrass meadows in the San Juan Islands are increasingly impacted by outbreak conditions of eelgrass wasting disease. New work using artificial intelligence and drone surveys, shows warming-related impacts of eelgrass wasting disease to eelgrass on a continental scale.

In addition to increasing threats to salmon habitats like eelgrass meadows, work in both rivers and the oceans have shown sensitivity of salmon to warming-fueled disease outbreaks. Disease is a particularly wicked problem because it synergizes with other climate and ecological disruptions and can increase unexpectedly with other disruptions.

New nature-based strategies are needed to fight increased disease risk. Some marine and terrestrial habitats have strong pathogen-reducing components that could be harnessed to increase ecological resilience.

Understanding Historical Context to Inform Current Salmonid Recovery Planning

Thursday Afternoon Concurrent Session

Session Coordinator*: Jay Stallman, Stillwater Sciences*

Aquatic habitat restoration projects typically require a historical perspective to help elucidate unimpaired conditions, the type and effects of past disturbance, and system trajectory. Providing historical context is an essential early step in developing restoration goals, objectives, and appropriate design approaches. Historical context also provides a common reference for landowners, resource agencies, and other stakeholders to determine what conditions are attainable and sustainable within existing constraints. While many types of historical analyses commonly apply to landscape-level changes in physical habitat, the concept of historical ecology equally applies to understanding bottlenecks in salmon and steelhead population dynamics and shifts in the life history strategies of these species resulting from habitat degradation and other stressors. The session will focus on key components of historical analysis, approaches appropriate to different settings, and applications to fisheries habitat restoration planning and design.

What Ancient Salmon Bones Can Teach Us About Recovering California's Salmon Populations

Malte Willmes, *UC Santa Cruz, Institute of Marine Sciences (Presenter); and Co-authors:* ***Rachel Johnson, Ph.D.,*** *NOAA Fisheries and UC Davis;* ***Anna Sturrock,*** *National Oceanic and Atmospheric Administration, Southwest Fisheries Science Center;* ***Jeff Rosenthal,*** *Far Western Anthropological Research Group;* ***Jelmer Eerkens,*** *UC Davis Department of Anthropology;* ***Lewi S. Levis*** *and* ***James A. Hobbs,*** *UC Davis Department of Wildlife, Fish, & Conservation Biology*

Chinook salmon *(Oncorhynchus tshawytscha)* populations in California are in decline due to the combined effects of habitat degradation, water diversions, and shifting climate regimes. Conservation and management of Chinook is dependent on our understanding of their life history variability and their ability to adapt to future changes. Surveys and geochemical tools have provided crucial insights for modern salmon populations in California. However, these data were collected only after significant population declines and extirpation from a large fraction of historic habitat had occurred. Here we contrast our findings from modern (2002-2010, n=755) and historic (~1840 CE, n=49) salmon otoliths (fish ear stones) from the lower Feather River. Specifically, we investigated the age and size of fall-run Chinook and reconstructed natal origins and rearing habitat utilization using strontium isotope ratios (87Sr/86Sr). Modern wild spawned Chinook on the Feather River showed generally younger and more truncated ages (age-2 and age-3 dominated), while their historic counterparts showed generally older ages (age-3 and age-4 dominated) and a wider age distribution. In modern salmon we identified a significant shift from wild-spawned to hatchery-origin fish on the lower Feather River, after the stock collapse in 2008-2009, indicating that the population recovery in 2010-2012 was largely driven by hatchery fish. For the historic Chinook we identify natal origins and rearing habitats that suggest that a diverse range of habitats were used and that variable life history strategies were successful on the lower Feather River just prior to the gold-rush period (~1848-1855). This study presents the first step at unlocking the potential of historic fish bones to better understand salmon populations in California's past and to apply this knowledge for future salmon conservation, management, and recovery.

Yuba River Salmon Impacted Since the Gold Rush: An Analysis to Modify Aging Infrastructure, Restore Volitional Passage and Remove Mercury from the Aquatic Environment

Carrie Monohan, Ph.D., *The Sierra Fund and California State University Chico (Presenter); and Co-author:* ***Allan James, Ph.D.****, University of South Carolina*

The Yuba River was one of the most extensively hydraulically mined watersheds on earth. The use of hydraulic mines was developed in this watershed prior to any regulation on the industry and the impacts were devastating and are still the number one cause of ongoing degradation. The Yuba River, a 1,345 square mile watershed, has 80 significant (>5 acres) hydraulic mines totaling over 8,000 acres. The largest hydraulic mine in the watershed is Malakoff Diggins which releases a ton of suspended sediment each year, almost half of which is delivered during one or two large storm events. With this suspended sediment comes the associated particulate bound mercury which was brought over from the coast range and used in both hard rock and hydraulic mining operations. Of the 26 million pounds of mercury brought to the Sierra Nevada, 10-30% was lost to the environment and remains a threat to public health through sport fish consumption to this day. The largest ongoing impact to the fish are the debris control dams that were built to hold back hydraulic mining debris after the Sawyer Decision of 1884. The Sawyer Decision is often cited as the first environmental regulation in California's history and the debris control dam is the reason that fish can no longer reach their natal waters in the Yuba River. The largest debris control dam that was built was Englebright, which was built by the California Debris Commission in 1941 so that hydraulic mining could resume after WWII. Englebright is blocking spring run and fall run Chinook from 60-150 miles of habitat. The Yuba River was designated as critical habitat for spring run Chinook by NOAA fisheries in 2012. There are currently 23 million cubic yards of sediment behind Englebright. An engineering evaluation and analysis to lower Engleblight to 460ft elevation would allow for a 1,500 ft. fish ladder to be constructed and still allow the local water agency to use it as an afterbay for the larger New Bullard's Bar Reservoir. Lowering Englebright would expose the sediment deposit in the upper reaches of the reservoir and allow for removal of the sediment from the aquatic habitat. The cost of doing nothing has reached a tipping point, not just for the salmon, but for the infrastructure as well. If nothing is done Englebright will fill up and lose all capacity to retain flows in less than 200 years, and the recovery of salmon runs returning to the Yuba watershed may cease to be viable much sooner than that.

Novel Physical Evidence of the Historical Nativity of Chinook Salmon (*Oncorhynchus tshawytscha*) in the Guadalupe River Watershed of Santa Clara County, California

***Richard B. Lanman, M.D.**, Guadalupe-Coyote Resource Conservation District and Institute for Historical Ecology (Presenter); and Co-authors: **Linda Hylkema, M.A.**, RPA, Santa Clara University; **Cristie M. Boone, Ph.D.**, Albion Environmental, Inc.; **Brian Allée, Ph.D.**, South Bay Clean Creeks Coalition; **Roger O. Castillo**, Salmon and Steelhead Restoration Group, Inc.; **Stephanie A. Moreno, B.A.**, Guadalupe-Coyote Resource Conservation District; **Mary Faith Flores**, University of Oklahoma; **Upuli DeSilva**, University of Oklahoma; **Brittany Bingham, B.S.**, Department of Anthropology, University of Oklahoma; and **Brian M. Kemp, Ph.D.**, Department of Anthropology, University of Oklahoma*

Chinook salmon spawning runs peak every November-December in the Guadalupe River mainstem and its primary tributaries, Los Gatos and Alamitos Creeks. These runs approached 1,000 adult fish in the late 1990s but were nearly extirpated after major anthropomorphic alterations to the mainstem to mitigate flooding in the early 2000s constructed by the Army Corps of Engineers and Santa Clara Valley Water District. Historical observer records of salmon spawning in the creek may not be reliable as large steelhead trout (*Oncorhynchus mykiss*) have always been extant and may be confused with salmon. Although initial mitochondrial DNA studies of salmon carcasses in the 1990s found haplotypes consistent with both Central Valley fall-run Chinook (CV) and Russian River Chinook, later studies using more extensive microsatellite DNA analysis suggest that the salmon are most likely hatchery strays from the CV stocks. The size of the runs until the late 20th century and their continued persistence in the last several years, despite extreme drought conditions, suggest that the Guadalupe River watershed may provide suitable spawning and rearing habitat for Chinook salmon, raising the question as to whether they were historically native. We utilized ancient DNA sequencing of salmonid vertebrae identified by ichthyozooarchaeological analysis of excavations at the historic Mission Santa Clara to answer this question.

Archaeological excavation of the Native American Rancheria associated with Mission Santa Clara de Asís was conducted by Albion Environmental and Santa Clara University from 2012-2013. The study site was situated within 2.5 km of the Guadalupe River mainstem, likely along its Mission Creek tributary in Santa Clara County, California, and dates from 1781 to the 1850-60's. Ancient DNA extracted from 55 vertebrae samples identified as salmonids were sequenced at the Laboratories of Molecular Anthropology and Microbiome Research (LMAMR) Ancient Lab at the University of Oklahoma to resolve specific *Oncorhynchus* species type.

Fish remains were analyzed from multiple projects, reaching 17,288 total identifiable fish specimens (NISP). Freshwater fishes comprised 79-95% of the assemblages based on NISP, with the majority of remaining specimens representing indeterminate freshwater/euryhaline species. Less than 1% of specimens were from marine fishes. To date 52 specimens are confirmed rainbow/steelhead and 3 specimens are confirmed Chinook salmon.

This study provides the first physical evidence that Chinook salmon were historically native to the Guadalupe River watershed, the southernmost major metropolitan area hosting salmon runs in the United States. Nativity to the watershed is consistent with apparent habitat suitability and persistence of salmon spawning runs, despite recent extreme drought years and major flood control-related concretization of the river

Years in Their Ears: What do Fish Earbones Tell Us About Spring-run Chinook Salmon Success?

Flora Cordoleani, Ph.D., *UC Santa Cruz and NOAA Fisheries (Presenter); and Co-author:*
Corey Phillis, Ph.D., *Metropolitan Water District;* ***Anna Sturrock, Ph.D.,*** *UC Davis;*
George Whitman, *UC Davis; and* ***Rachel Johnson, Ph.D.,*** *NOAA Fisheries and UC Davis*

The Central Valley spring-run Chinook (CVSC) Environmentally Significant Unit (ESU) was once a major component of the annual salmon runs and occupied the headwaters of all major Central Valley river systems where natural barriers were absent. Now self-sustaining CVSC populations persist only in three tributaries of the Sacramento River: Mill, Deer, and Butte creeks, and the ESU is listed as threatened under the federal Endangered Species Act. One of the objectives of the Southwest Fisheries Science Center is to identify the management actions that could help recover the ESU.

Life history diversity is thought to buffer salmon populations to environmental variability, such as drought and poor ocean conditions, resulting in greater stability of the population or stock through time. CVSC express unique juvenile rearing plasticity characterized by a wide range of size, timing, and age at which they outmigrate from their natal tributaries and to the ocean. However, describing the relative success of these life history strategies under different environmental conditions is challenging because so few juveniles are captured, marked, and recovered as adults. To further describe the juvenile life history diversity in CVSC we used strontium isotopes to reconstruct the juvenile life-history strategies from adult otoliths collected in Mill, Deer, and Butte creeks between 2003 and 2018. The goal was to identify 1) the successful life-history types within the CVCS populations and among years, and 2) potential factors that might influence the expression of a given life history type.

We identify three distinct juvenile life-history types among successful spawners in Mill and Deer creeks characterized by their early-, intermediate-, or late-outmigration strategy from their natal stream. Among Butte Creek spawners, however, only early- and intermediate-outmigrants were observed. In all three populations the relative contribution of each life-history strategy varied between years, perhaps due to variable selection pressures in the freshwater or marine environment. Additionally, we found evidence that an individual's outmigration strategy was correlated with growth in the weeks following exogenous feeding. Our findings are a necessary step toward identifying the management strategies that will protect and promote expression of life-history diversity that contributes to population recovery and stability in California's variable environment.

Forgotten Legacies: Understanding and Mitigating Historical Human Alterations of River Corridors

***Ellen Wohl, Ph.D.**, Colorado State University*

Legacies are persistent changes in natural systems resulting from human activities. Legacies that affect river ecosystems can result from human alterations outside of the river corridor, such as timber harvest or urbanization, or from alterations within the river corridor, including flow regulation, river engineering, and removal of large wood and beaver dams. Human alterations of river ecosystems have been occurring for thousands of years in some parts of the world and are now ubiquitous, yet both river scientists and the public may be unaware of the persistent effects of historical activities. Failure to recognize the legacy of historical activities that no longer occur can skew perceptions of river process and form and the natural range of variability in river ecosystems. Examples come from rivers of the Mid-Atlantic Piedmont with substantial sediment accumulation behind now-abandoned milldams and from the Pacific Northwest from which large wood was removed. In each of these regional examples, river process and form have changed so substantially that the river ecosystems can be described as having assumed an alternative state. The alternative state provides lower levels of ecosystem services such as habitat, biodiversity, and attenuation of downstream fluxes of water, sediment, organic carbon, and nutrients. River management designed to enhance and restore these ecosystem services can be more effective if the continuing effects of these historical legacies are recognized. The existence of forgotten legacies challenges river scientists to recognize the continuing effects of human activities that have long since ceased and also poses challenges for the application of scientific understanding to resource management. Societal expectations for attractive, simple, stable rivers are commonly at odds with scientific understanding of rivers as dynamic, spatially heterogeneous, nonlinear ecosystems. Knowledge of how human actions, including historical actions that have long since ceased, continue to alter river ecosystems can help to bridge the gap between societal and scientific perceptions of rivers.

Legacy Effects of Timber Harvesting on Salmonid Habitat at Caspar Creek and Avenues for Improving Habitat During Future Timber Harvests

Paul Richardson, Postdoctoral Fellow, *USDA Forest Service Pacific Southwest Research Station (PSW) (Presenter); and Co-authors:* ***Diane Sutherland,*** *Geomorphologist, USDA Forest Service PSW;* ***Joe Wagenbrenner,*** *Research Hydrologist, USDA Forest Service PSW; and* ***Sue Hilton,*** *Hydrologist (retired), USDA Forest Service PSW*

Most forests in the United States have been logged, often multiple times. Consequently, these prior timber harvests have dramatically altered channel morphology and habitat. There is a strong need to understand the consequences of prior timber harvesting and to continue refining best management practices to restore salmonid habitat. At Caspar Creek, located in the Jackson Demonstration State Forest in northern California, downed wood and stumps in or near channels were often removed to aid floating cut old-growth logs to mills during splash dam releases before ~1905. Removal of wood led to decreased channel morphological complexity that negatively impacted salmonid habitat. In addition, old-growth logging contributed to channel incision, terrace development, and substantial gullying which produced headcuts that are still prevalent and can limit fish passage. With this timber harvesting legacy and almost 60 years of monitoring, the Caspar Creek Experimental Watersheds are excellent sites for assessing the consequences of timber harvest and developing and testing best management practices. Here we focus on how large downed wood and bed load transport have influenced stream habitat. Experimental timber harvesting occurred in the South Fork catchment from 1971 to 1973 and then in the North Fork catchment from 1985 to 1992. The quantity of in-channel wood in the North Fork remained low following old-growth logging until the 1990s when a series of blowdowns along recently exposed buffer strips dramatically increased the amount of downed wood in the North Fork channel. This created a fortuitous, semi-natural experiment to investigate the consequences of increasing the quantity of in-channel wood. To aid this investigation, we reconstructed an annual record of bed load yields for the North Fork catchment from 1962 to 2017. We compared these yields to annual bed load yields predicted by a bed load transport model to identify major departures between the predicted and reconstructed yields. We found that decreased bed load yields, which are associated with gravel aggradation along the North Fork main stem, occurred shortly after the blowdowns occurred. The aggradation is likely the direct consequence of increased in-channel wood and new in-channel storage space created by logjams. The quantity of wood has remained stable following the last of the major blowdowns in 1995. Ultimately, the blowdowns led to gravel aggradation and the development of pools and logjams, which increased channel habitat complexity along the North Fork. Continued monitoring of in-channel wood is necessary to fully assess the long-term consequences of the blowdowns on stream habitat and the mass balance of in-channel wood, which is controlled by the input rate of new in-channel wood relative to the rate of physical weathering, decay, and downstream transport of existing in-channel wood. The results of this semi-natural experiment suggest that adding large wood to channels during timber harvests may improve salmonid habitat and help restore channels to conditions that existed prior to old-growth logging.

The Science Informing Salmonid Reintroductions

Friday Morning Concurrent Sessions

Session Coordinator*: Carlos Garza, Ph.D.,* *NOAA Fisheries, Southwest Fisheries Science Center and UC Santa Cruz*

This session will bring together a variety of fields of experts that are involved in efforts to reintroduce salmon and steelhead to their historic freshwater habitats. The talks will discuss the state of knowledge in reintroduction science and cover projects throughout the state (and further afield) that are utilizing a variety of techniques, including dam removal, passage facilities, and trap & haul, and in various stages of completion, from successfully completed to early conceptual planning.

The Science Informing Salmonid Reintroductions

Carlos Garza, Ph.D., ***NOAA Fisheries, Southwest Fisheries Science Center and UC Santa Cruz***

A surge in efforts to reintroduce salmon and trout to their historic habitat is the result of a confluence of different factors, including completed recovery plans, changes in attitudes regarding resource management, and advances in biological science. These efforts include projects in a variety of stages, from conceptual planning to post-dam removal ecosystem recovery.

I will present an overview of the science behind reintroductions of salmon and trout to their historic habitat, or in some cases novel habitat. I will draw primarily on experience from involvement in numerous projects in California, including the San Joaquin River, Yuba River, Carmel River, Battle Creek, Clear Creek, and the Klamath River. I will discuss how science factors into source stock selection, habitat restoration, release strategies, and population reconstitution processes. I will further discuss the paramount importance of careful monitoring of reintroduction projects to evaluate the performance of particular strategies and adaptively manage the projects for successful outcomes.

Genetic Monitoring of Reintroduction and Supplementation Efforts in Central California Populations of Endangered Coho Salmon

Bob Coey, *NOAA Fisheries, Southwest Fisheries Science Center (Presenter); and Co-authors:* ***Eric C. Anderson,*** *NOAA Fisheries, Southwest Fisheries Science Center;* ***Benjamin White,*** *U.S. Army Corps of Engineers/Warm Springs Hatchery;* ***Michael Reichmuth,*** *National Park Service;* ***Robert Coey,*** *California Coastal Office, NOAA Fisheries, West Coast Region;* ***Devon E. Pearse*** *and* ***John Carlos Garza,*** *NOAA Fisheries, Southwest Fisheries Science Center*

Populations of Coho salmon *(Oncorhynchus kisutch)* in central California are critically endangered as a result of human activity and environmental conditions during the past century. Habitat loss, drought, wildfire, and variable ocean conditions have adversely impacted this species, resulting in severe genetic and demographic consequences, including local extinctions, small effective population sizes, inbreeding, and low diversity. In many basins where Coho salmon persist, extinction risk is high and ever-present. In spite of an overall trend of declining numbers in rivers throughout California, some watersheds, such as Lagunitas Creek, continue to sustain populations with relatively high genetic diversity. Warm Springs Hatchery (WSH), a mitigation facility on the Russian River, operates a captive breeding program for Coho salmon, and is a hub for recovery and conservation efforts in Marin, Sonoma, and Mendocino counties. Genetic broodstock management techniques are employed in the hatchery setting (e.g., inbreeding avoidance and managed outbreeding) to produce juveniles for reintroduction and population supplementation in the Russian River and other area watersheds. This captive breeding is coupled with several recently adopted reintroduction strategies, including adult releases, rescue, rear and release programs, and streamside incubation of fertilized eggs. These methods are evaluated here using genetic parentage and sibling analyses to assess their efficacy. The adult release strategy involves WSH broodstock individuals being released as mature adults directly into spawning habitat. This strategy has been employed since 2004 in Salmon and Walker creeks, from which Coho salmon had been previously extirpated. Parentage analysis of wild-born juveniles revealed evidence of successful natural spawning by adults released there, as well as spawning by unsampled parents, presumably naturally spawned ocean returns. The presence of juveniles in Walker Creek in subsequent years, when no adults were released, suggests continued natural spawning by the descendants of the released adults and/or ocean returns. In Redwood Creek (Muir Woods National Monument), wild Coho juveniles from three consecutive brood years were rescued from drying habitat during California's 2012-2016 drought, reared to maturity at WSH, and released as adults back into their natal stream. Juveniles sampled in each of the following summers were found to be offspring of these released adults. Finally, a remote site incubator (RSI) was tested in the Russian River in 2019, and parentage results from initial post-release juvenile monitoring will be presented. By analyzing data spanning the past fifteen years of reintroduction and supplementation efforts in central California, we characterize efficacy, highlight key outcomes, and address how our findings might inform reintroduction approaches going forward.

Recolonization Potential for Coho Salmon in Tributaries to the Klamath River Above Iron Gate Dam

Max Ramos, M.Sc. Student, *Humboldt State University (Presenter);*
and Co-author: ***Darren Ward, Ph.D.,*** *Humboldt State University*

Four major dams on the Klamath River are slated for removal in 2022, restoring access to hundreds of miles of potential habitat for anadromous fishes. The Coho salmon *(Oncorhynchus kisutch)* in the Klamath River are classified under the Southern Oregon/Northern California Coast evolutionarily significant unit as a threatened species. We are using physical habitat and biological features of low-order tributaries to the Klamathv River above the dams to assess available habitat and its fundamental capacity to support Coho salmon post dam removal. The intrinsic potential (IP) modeling approach developed by the National Oceanic and Atmospheric Administration (NOAA) and the habitat limiting factors model (HLFM) developed by the Oregon Department of Fish and Wildlife (ODFW) will be utilized to assess habitat. In addition, we are developing an occupancy model using program "PRESENCE" and data from reference sites below the dam and from other watersheds to estimate the potential distribution and abundance of juvenile Coho salmon at the sites. Results from this analysis can be used to make management decisions for habitat restoration efforts and future Coho salmon population goals.

Dam, That Was a Wild Ride—Steelhead Passage Up, Down, and Around the Los Padres Dam in California

Haley A. Ohms, Ph.D., *Institute of Marine Science, UC Santa Cruz and NOAA, Southwest Fisheries Science Center (Presenter); and Co-Authors:* ***Gabriel T. Brooks,*** *NOAA, Northwest Fisheries Science Center; and* ***David A. Boughton, Ph.D.,*** *NOAA, Southwest Fisheries Science Center*

Fish passage is a concern at many dams in the U.S. and is one consideration when deciding whether to remove dams approaching the end of their useful lives. This scenario is currently playing out at the Los Padres Dam on the Carmel River in California. The Los Padres Dam has a trap-and-haul system for adult upstream passage and a newly installed floating-weir collector for downstream juvenile and adult passage. To test the effectiveness of the floating-weir collector, we tagged juvenile and adult steelhead and rainbow trout and monitored their movements through the reservoir and around the dam in the winter of 2018/2019. Only one adult moved downstream through the floating weir collector, while all other adults moving downstream used the spillway (n=60). More juveniles moved downstream using the floating weir collector (8%), however juveniles moving downstream were still twice as likely to use the spillway (17%). Additionally, 75% of all juveniles that entered the reservoir remained there, either through mortality or for rearing. These 'lost' juveniles could represent a life history that rears in the reservoir for a season before continuing downstream migration, but some may also represent predation by brown trout inhabiting the reservoir. Spillway passage survival was high for both adults (89%) and juveniles (95%), indicating that this route of passage may not represent a problem for survival. These preliminary results suggest that despite the new fish passage infrastructure, the spillway remains an active route of passage at the Los Padres dam and the reservoir still functions as either a mortality or behavioral sink for most downstream migrants. Additionally, and in terms of broader application, studying fish movements and life histories within a system prior to building expensive infrastructure is a worthwhile investment.

The Return of the King: Reintroduction of Chinook Salmon to the San Joaquin River

Anthony Clemento, Ph.D., *NOAA Fisheries SWFSC, Santa Cruz Lab and University of California, Santa Cruz, Institute of Marine Sciences (Presenter); and Co-author:* ***John Carlos Garza, Ph.D.,*** *NOAA Fisheries SWFSC, Santa Cruz Lab*

The San Joaquin River in California's southern Central Valley historically contained vast numbers of spring-run Chinook salmon. However, with the opening of Friant Dam in 1942, the population would rapidly disappear as a majority of the water was diverted to agriculture and irrigation. Now, some 65 years later, after a federal lawsuit and millions of dollars spent on habitat restoration and hatchery supplementation, spring-run salmon are once again swimming and spawning in the waters of the San Joaquin. In this talk we will review the multi-faceted approach being taken to reintroduce salmon to the river, with a particular focus on the utility of genetics in supporting the goals of the restoration program. This will include a look back at the factors considered in choosing a broodstock and then how genetic data is being integrated into the adaptive management of these fish at a variety of life-history stages. We will highlight the many challenges associated with implementing such a large and dynamic reintroduction plan and how genetic analysis is being used to monitor progress and define success. Finally, we will touch briefly on future goals and directions for the program.

Capacity of Two High Sierra Rivers in California for Reintroduction of Anadromous Salmonids

David A. Boughton, Ph.D., *NOAA Fisheries SW Fisheries Science Center (Presenter); and Co-Author:* ***Lee R. Harrison, Ph.D.,*** *NOAA Fisheries SW Fisheries Science Center*

Historically, anadromous steelhead and spring-run Chinook salmon used high-elevation habitats in the Sierra Nevada for a significant portion of their life-cycles, but are currently extirpated from most of these montane streams by impassable dams. Recovery plans for both species envision reintroducing them to some of their former montane habitats by establishing passage across dams and reservoirs for both upstream and downstream migrants. Passage, however, is only useful if the habitats above the dams possess the capacity to support viable populations of the two species. In this talk we describe how we used remote-sensing and habitat modeling to produce quantitative, high-resolution, dynamic estimates of habitat capacity for each species in the upper Tuolumne and Merced rivers in the central Sierra Nevada.

Head of Reservoir to Ocean; Innovations Connecting Restoration and Reintroductions for ESA Listed Salmonids

Stacie Fejtek Smith, D.Env., *NOAA Fisheries, West Coast Region, California Central Valley Office*

Completion of the hydropower projects on Battle Creek in early 1900's and Shasta Dam in 1945 cut off Sacramento winter-run Chinook from 100% of their historical holding, spawning, and rearing habitat. Shasta Dam and many of the Central Valley rim dams are recognized by the California Water Action Plan as "too integral to California's water infrastructure to consider removing, but, where feasible, passage around the rim dams may be necessary to recover salmon." Developing a methodology to transport juvenile fish from above rim dams is the last major technological hurdle for non-volitional fish passage above high-head dams throughout the Central Valley in order to prevent extinction and facilitate species recovery. No "head-of-reservoir" collection systems currently exist. However, while no rim dams in California's Central Valley currently provide passage for native California salmon, similar fish passage approaches are standard practice at many larger dams in Oregon and Washington. Many of the lessons learned from successful fish passage programs in Oregon and Washington will now be tested and evaluated for the first time as part of the Juvenile Salmonid Collection System Pilot Project (JSCS Pilot Project).

The JSCS Pilot Project is an ongoing effort to implement fish passage for Endangered Species Act (ESA) listed Sacramento River winter-run Chinook salmon above Shasta Dam in a step-wise science informed fashion. The pilot project provides an innovative experimental technology that accounts for the unique circumstances and environmental elements present above Shasta Dam. In order to move fish around the dams and reintroduce Chinook salmon to habitats that have been inaccessible for more than 70 years, a multi-agency and stakeholder working group determined that a key element for project success would be the ability to manage these ecologically significant headwaters for multiple uses. Therefore, in addition to answer key biological and engineering questions regarding collection of out migrating juveniles, this project also seeks to address important multi-benefit questions regarding resident-recreational fish migration, impacts to recreational resources during project implementation, and furthering engagement and education for local stakeholders and residents on the value of reintroducing winter-run Chinook to the McCloud River.

The Influence of Food Webs on Salmonid Growth and Performance: a Forgotten Link to Species Resilience

Friday Morning Concurrent Sessions

Session Coordinator*: Robert Lusardi, Ph.D., Center for Watershed Sciences, UC Davis*

Efforts to conserve at-risk populations of anadromous Pacific salmon *(Oncorhynchus spp.)* often focus on the restoration of physical habitat features (e.g., water temperature, pool frequency and depth, large wood abundance, etc.) associated with enhanced juvenile production in freshwater. However, there is growing recognition that restoration and protection of suitable habitat must consider interactions between physical habitat features, ecosystem productivity, and fish performance. Recently, numerous scientists have called for a broader understanding of how prey availability and food webs affect the growth, persistence, and survivorship of juvenile salmonids. This session will examine the effects of food webs and aquatic habitat productivity on the growth of juvenile salmonids, particularly in productive ecosystems or where food webs strongly interact with physical habitat attributes to influence growth.

Food Webs and Juvenile Steelhead Behavior in Coastal California—Towards a Foodscape Perspective

Gabriel Rossi, Ph.D., *UC Berkeley (Presenter); and Co-Authors:* ***Mary Power, Ph.D., Stephanie Carlson, Ph.D., Ted Grantham, Ph.D.,*** *and* ***Shelley Pneh, Ph.D.,*** *UC Berkeley*

The seasonality of stream food webs exert a strong effect on the behavior, physiology, growth, and life history of rearing salmon and steelhead. This is especially true in Mediterranean streams—characterized by strong inter- and intra-annual hydrologic variability. However, the term "Mediterranean stream" encompasses a wide range of hydrologies from perennial to nearly arid systems. Here we present a study of how the foraging behavior, physiology, and life history of juvenile steelhead *(Oncorhynchus mykiss)* track food web and hydrologic phenology in two radically different Mediterranean streams—one perennial and the other intermittent. Late-spring growth potential was higher in the intermittent stream, but conditions favorable to growth declined sharply to an inhospitable, low oxygen environment with high fish mortality by mid-summer. In the perennial stream, late-spring growth potential was lower, but conditions suitable for growth increased through June, with positive growth and with low mortality even in late summer. The life history implication for anadromous salmonids between these streams are pronounced, with strong differences in growth, foraging phenology, apparent lipid allocation, and outmigration constraints.

The principles learned from studying tributary food webs can be expanded to the entire river network. Salmon are fed by different trophic pathways, varying both with season and habitat type along the river network. These different trophic pathways produce asynchronous pulses of growth potential for juvenile salmonids in time (winter, spring, summer, fall) and space (tributary, mainstem, floodplain, estuary). Life history diversity within and between species allows population of sympatric salmonids to exploit this shifting mosaic of growth potential, but human manipulation of the watershed affects both the productivity and exploitability of salmon rearing habitats. In the second part of this talk we will explore what we know and what we still need to learn to develop and apply a foodscape perspective on salmon recovery.

Abundant Prey Availability Improves Juvenile Coho Growth Under Warming Stream Temperatures

Robert Lusardi, Ph.D., *UC Davis Center for Watershed Sciences and California Trout Coldwater Fish Scientist (Presenter); and Co-authors:* ***Bruce Hammock, Ph.D., Carson Jeffres, Ph.D.,*** *and* ***Randy Dahlgren, Ph.D.,*** *UC Davis; and* ***Joseph Kiernan, Ph.D.,*** *NOAA Fisheries*

Despite its importance in bioenergetics, aquatic ecosystem productivity remains relatively understudied when compared to the effects of water temperature and physical habitat on the growth of juvenile salmonids. Productive aquatic ecosystems, however, may exhibit enhanced secondary production with important implications for salmonid growth. Using a series of in situ mesocosms, we show that prey availability is the predominant factor influencing age-0+ Coho salmon growth over a natural gradient of temperature and prey abundance during the summer low flow period. Coho salmon absolute growth rates peaked at a mean daily average water temperature of 16.6 ºC and an associated maximum weekly maximum temperature (MWMT) of 21.1 °C. Juvenile growth under these thermal conditions was six-fold greater than the growth rates observed for conspecifics rearing in the coolest study reach (mean T = 13.0 ºC; MWMT = 16.0 °C). Even at the highest rearing temperature (mean T = 18.1 ºC; MWMT = 24.0 °C), growth rates remained positive and above the study-wide average, although overall survival was reduced. The results suggest that ecosystem productivity could help buffer the negative effects of elevated water temperature on fish growth with important implications for climate change.

The Influence of Food Webs on Salmonid Growth and Performance: A Forgotten Link to Species Resilience

Friday Morning Concurrent Session

Carson Jeffres, Ph.D., Center for Watershed Sciences, UC Davis

In the Central Valley, California (USA), floodplains are critical nursery habitat for juvenile Chinook Salmon yet few quantitative tools exist to estimate contributions of these habitats to Chinook Salmon populations. Previous work has demonstrated across multiple years how juvenile Chinook Salmon reared on the Yolo Bypass have reduced 34S/32S isotopic signatures in their diets ($\delta^{34}S$ = -3.467‰ ± 2.27) and tissues, relative to salmon collected in the adjacent Sacramento River ($\delta^{34}S$ = +2.32‰ ± 2.50). These isotopic signatures are permanently archived within the protein-rich eye lens and for the first time will be used to quantitatively estimate the survival benefits Chinook Salmon receive from rearing on floodplains. This was done by identifying the $\delta^{34}S$ value in individual lens layers from Chinook Salmon as both juveniles prior to ocean entry as well as those from the same cohort that returned to spawn. By looking at these individual lense layers and known $\delta^{34}S$ signature from a variety of locations throughout the Central Valley, we can identify which fish used a variety of habitats during their migration to the ocean and what proportion of those fish ultimately returned as adults to spawn.

Making Sense of Making Salmon: Recipes for Routing Landscape Carbon into Fisheries Biomass

Jacob Katz, Ph.D., *Lead Scientist, California Trout*

Natural processes operating at the landscape scale create and maintain diverse habitats in both space and time facilitating the expression of diverse life history strategies by native species adapted to these patterns of resource availability.

Ok, that's the super jargony science-speak way to say that in order to recover salmon populations we will need to manage the landscape in such a way as to let salmon recognize the rivers that they evolved in and are adapted to.

In this presentation we will explore how the patterns of water flow across the landscape facilitate the flow of energy and matter into robust river food webs. We will map how ecologically-functioning river ecosystems route carbon from the terrestrial landscape into the water, thus controlling the capacity of watersheds to make abundant salmon. We will conclude by sharing some recipes for recovery—landscape-scale investments capable of instigating population level responses from fish populations.

Water Residence Time Drives Aquatic Ecosystem Productivity on a Managed Floodplain

Jacob Montgomery, ***California Trout***

Extremely high rates of invertebrate production relevant for creating high-quality forage for rearing juvenile salmonids are generated in seasonally hydrologically-activated floodplains.

This presentation will report recent results from a replicated mesocosm experiment conducted at landscape-scale and designed to test the effect of water residence time on aquatic ecosystem productivity. Three aspects of the aquatic food web—benthic invertebrate density pelagic zooplankton density, and fish growth—were measured for their response against three replicated treatments of water residence time.

Equal flow of Sacramento River water was pumped across 9 replicated experimental fields of equal length. Residence times were manipulated by field dimensions (field widths of 8, 30, and 80 feet, respectively) and water residence time of treatments (30 min, 1.5 hrs, 4.5 hrs) was calculated as flow*cross sectional area*field length. All three measures of food web productivity increased in correlation with longer durations of water residence time.

Most human landscapes are modified to expedite drainage. This is particularly true of large river valleys, which have been heavily modified by levees. Levees and drainage infrastructure decrease frequency of floodplain inundation and increase drainage rate of floodplain habitats during flood events. Taken in tandem these two alterations to native floodplain hydrology short circuit the aquatic food webs which once fueled production of fish abundance. Without restoring some semblance of more natural, longer residence times of floodwaters to hydrologically connected off-channel habitats, recovery of abundant native fish populations is likely impossible.

Summer Foraging Behavior in Juvenile Coho Salmon and Steelhead Trout Across a Heterogeneous Landscape

Rachael Ryan, *University of California, Berkeley*

Lagunitas Creek is a small, coastal watershed that drains into Tomales Bay and provides habitat for critically endangered Central California Coast Coho Salmon (*Oncorhynchus kisutch*) and threatened Central California Coast Steelhead Trout (*O. mykiss*). The fish in this watershed are not supplemented by hatcheries, providing an opportunity to understand the habitats that support wild fish in this system for informing conservation and restoration actions. In this study, we focus on the juvenile summer rearing phase of the coho and steelhead life cycles to explore how different landscape and local features influence juvenile salmonid foraging activities. We selected sampling sites to capture habitat heterogeneity across the watershed, contrasting the regulated, larger mainstem Lagunitas Creek with smaller, unregulated tributaries and identifying sub-watershed classes based on geology, topology, and climate. Using underwear video footage as a non-invasive method of sampling, we deployed GoPro cameras in 33 pools across 11 sites at three different points in the summer: early summer (June), mid-summer (July/August), late summer (September) of 2020. From our video footage, we explored patterns of foraging behavior across space and time, including drift attempts per fish and estimating each individual's fork length. We found that foraging behavior was dominated by drift foraging in early summer but shifted to "floater" search foraging later in the summer. Interestingly, we observed that the time at which the dominant foraging mode shifted away from drift foraging differed across study sites. Our preliminary results show how different habitats across the watershed support different juvenile foraging traits and sizes of fish. For summer 2021, we aim to expand this study to better understand the biotic and/or abiotic factors driving this variation in foraging behavior across the summer and among sites, including differences in stream flow and fish density. This study is ongoing with additional data being collected this upcoming spring and summer; as such, we welcome any feedback on study design and questions.

(Un)Dam it! Dam Removal and Fish Passage Projects in California

Friday Afternoon Concurrent Sessions

Session Coordinators*: Darren Mierau,* *CalTrout North Coast Director, and* ***Redgie Collins,* *CalTrout*

Throughout the United States, aging dams and fish barriers of all sizes represent an unprecedented opportunity for salmon restorationists. By removing barriers to migration, we can restore fish access to spawning and rearing habitat, as well as increase streamflows and reduce harmful temperatures and algal blooms. This session will explore the many facets and stages of successful and ongoing dam and fish barrier removal projects throughout California, from permitting and project initiation to decommissioning and river restoration.

The Impacts of Dam Construction and Removal on the Genetics of Recovering Steelhead (*Oncorhynchus mykiss*) Populations Across the Elwha River Watershed

Alexandra K. Fraik *(Presenter),* ***Joanna L. Kelley,*** *School of Biological Sciences, Washington State University;* ***John R. McMillan,*** *Trout Unlimited;* ***Martin Liermann, Todd Bennett, Garrett J. McKinney, Gary Winans, George R. Pess, Krista M. Nichols,*** *Northwest Fisheries Science Center, National Marine Fisheries Service, NOAA;* ***Michael L. McHenry,*** *Lower Elwha Klallam Tribe Natural Resources; and* ***Abigail H. Wells,*** *Lynker Technologies, Conservation Biology Division, and Northwest Fisheries Science Center, National Marine Fisheries Service, NOAA*

Dam construction and longitudinal river habitat fragmentation disrupt important life histories and movement of aquatic species. This is especially true for *Oncorhynchus mykiss* that exhibits both migratory (steelhead) and non-migratory (resident rainbow) forms. While the negative effects of dams on salmonids have been extensively documented, few studies have had the opportunity to compare population genetic diversity and structure prior to and following dam removal. Here we examine the impacts of the removal of two dams on the Elwha River on the population genetics of *O. mykiss*. Genetic data were produced from >1200 samples collected prior to dam removal from both life history forms, and post-dam removal from steelhead. We identified three genetic clusters prior to dam removal primarily explained by isolation due to dams and natural barriers. Following dam removal, genetic structure decreased and admixture in-creased. Despite large *O. mykiss* population declines after dam construction, we did not detect shifts in population genetic diversity or allele frequencies of loci putatively involved in migratory phenotypic variation. Steelhead descendants from formerly below and above dammed populations recolonized the river rapidly after dam removal, suggesting that dam construction did not significantly reduce genetic diversity underlying *O. mykiss* life history strategies. These results have significant evolutionary implications for the conservation of migratory adaptive potential in *O. mykiss* populations above current anthropogenic barriers.

If It's Broke, Why Fix It?
Crumbling Concrete Coming to a Small Hydro Project Near You

Chris Shutes, California Sportfishing Protection Alliance

Much of America's infrastructure is crumbling. Dams are no exception. In previous SRF sessions, the presenters have discussed how changing energy markets have decreased the value of many small hydropower projects. Projects that cannot add flexible generation to regulate the power grid can't compete with lower cost wind and solar generation of electricity. Small hydro's problem is made worse by old age and large footprints. Bad economics have contributed to deferred maintenance of aging dams, canals, tunnels, penstocks, and powerhouses. In 2020, as parts of these projects begin to fail, many utilities are choosing to send much of the old hydropower fleet to the scrapyard instead of the repair shop.

This session will provide a survey of both worn and worn out small hydropower projects in northern and central California. It will suggest ways that stakeholders, power companies, and state and federal authorities can work together to get in front of decomposing infrastructure on a planned and proactive basis. It will examine the different approaches that utilities have used to get these projects off their books. For projects that are worth fixing, it will suggest initiatives that can retain the non-power values of aging hydropower projects such as water supply, recreation, and fishery support. For projects that are not worth fixing, it will discuss more collaborative ways to develop removal plans.

Battle Creek Salmon and Steelhead Restoration Project

***Mary Marshall** and **Trang Nguyen,** USDOI, Bureau of Reclamation (Co-presenters)*

Battle Creek has the unique geology, hydrology, and habitat suitability to support threatened and endangered Chinook salmon and Central Valley steelhead. The Battle Creek Salmon and Steelhead Restoration Project, located in Shasta and Tehama Counties near Manton, California, is among the largest cold-water anadromous fish restoration efforts in North America. The project is restoring approximately 42 miles of habitat on Battle Creek and an additional 6 miles of habitat on tributaries to Battle Creek, while continuing hydroelectric power production at Pacific Gas and Electric Company's (PG&E's) Battle Creek Hydroelectric Project—Federal Energy Regulatory Commission (FERC) Project No. 1121.

The project is a partnership between PG&E, the Bureau of Reclamation, U.S. Fish and Wildlife Service, National Marine Fisheries Service, and the California Department of Fish and Wildlife. In addition, numerous stakeholders, including the Battle Creek Watershed Conservancy, the Greater Battle Creek Watershed Working Group, landowners, and funders have made and continue to make important contributions to the project.

Project implementation includes modification of Battle Creek Hydroelectric Project facilities located on North Fork Battle Creek, South Fork Battle Creek, and Baldwin Creek in three phases. By removing five diversions dams and constructing fish screens and ladders on three other diversion dams, the project is providing safe passage for anadromous fish to reach the cold water and habitat needed for them to successfully spawn and increase their populations. The project is also preventing false attraction by stopping the mixing of North Fork Battle Creek and South Fork Battle Creek waters, through the construction of powerhouse bypass and tailrace connectors; protecting a trout hatchery from diseases carried by anadromous fish, through the construction of a fish barrier weir; increasing instream flows; dedicating water rights for instream purposes at dam removal sites; and implementing adaptive management to ensure fisheries objectives are met.

To date, a dam and canal system have been removed; and, two fish screens and ladders, a powerhouse bypass and tailrace connector, and a fish barrier weir have been constructed.

Due to PG&E's intent to not renew their FERC license in 2026, the project is currently moving forward with removal work only.

The Potter Valley Project- Dam Removal on one of California's Wildest Rivers

Redgie Collins, *California Trout (Presenter);*
and ***Curtis Knight*** *and* ***Darren Mierau,*** *California Trout*

The Eel River Dams—Scott Dam and Cape Horn Dam—are owned and operated by Pacific Gas and Electric (PG&E) as part of the century-old Potter Valley Project (PVP). Historically an important source of "clean" hydro-electric power and both domestic and irrigation water supplies to Southern Mendocino and Northern Sonoma counties, the PVP in the 21st C is at a critical infrastructure cross-roads. The power generation is marginal, and, unable to capitalize on the trans-basin delivery of 70,000+ acre-feet of water from the Eel to the Russian, PG&E has been incurring annual financial losses of $5-7 million. In 2018, facing millions of dollars in FERC relicensing costs and tens-of-millions in capital investments to enable fish passage for threatened fall-run Chinook salmon and winter-run steelhead, PG&E settled on a seldom-used license pathway—abandon relicensing the project. Only a few months later PG&E entered Chapter 11 Bankruptcy.

The Potter Valley Project has always been a regional project, and now it needs a regional solution. In a somewhat unprecedented step, five disparate stakeholder groups have stepped forward to lead the project through uncharted waters toward an undetermined outcome, defined only by individual interests and a pledge to pursue Congressman Huffman's mandate of a "two-basin solution". Those five groups: Sonoma Water, Mendocino County Inland Water and Power Commission, Humboldt County, the Round Valley Indian Tribe, and California Trout are bidding to find a feasible solution to the outdated PVP infrastructure, one that continues to provide critical water supplies to a burgeoning region while restoring the wildness to the Eel River and its once abundant salmon fisheries. A successful solution will require immense trust and cooperation among stakeholders, flexibility on the part of FERC, likely investment of public funding to complement millions of dollars eventually expected from PG&E, and a clear desire by political leaders, water users, and conservation organizations to abandon outdated conflicts and seek regional infrastructure solutions we can all support.

Progress Towards Removal of Rindge Dam in Malibu Creek

Sandra Jacobson, Ph.D., *California Trout, South Coast Region, and* ***Danielle LeFer,*** *California Department of Parks and Recreation, Angeles District (Co-presenters)*

Dams built along the Pacific Coast over the past 150 years were constructed for flood protection, water security and energy, yet the magnitude and scope of their disruption to ecosystems has been slow to realize and reverse. Rindge Dam is an obsolete structure in Malibu Creek that has not functioned as intended for 80 years. The dam not only disrupted the geomorphic, hydrologic and aesthetic character of the stream but has blocked migration of endangered Southern steelhead through designated critical habitat, thereby excluding them from 18 miles of historic spawning and rearing habitat. The dam has also trapped > 780,000 cubic yards of sediment naturally destined for the coastline that would support beach nourishment, prevent coastal erosion and maintain estuary integrity. The Project known as the Locally Preferred Plan is now poised to proceed into design phase. This follows recent authorization of the Project's feasibility study led by the U.S. Army Corps of Engineers, which was commissioned by Congress in 1992. Next steps will be presented as the project enters design phase focused on sediment transport studies and stream channel modeling post-dam removal.

Update on Klamath Dam Removal

Mike Belchik, *Senior Water Policy Analyst for the Yurok Tribe, Yurok Tribal Fisheries Program*

In February 2010 the original Klamath Hydroelectric Settlement Agreement was signed in Salem Oregon. After Congress failed to pass enacting legislation, the agreement was modified and re-signed in 2016. The Amended KHSA called for the ownership of the dams to be transferred to a nonprofit organization (Klamath River Renewal Corporation) who would then demolish them. The Federal Regulatory Energy Commission oversees hydropower licensing, relicensing and decommissioning in the United States, and in July 2020, FERC issued its first ruling directly relevant to the amended KHSA and determined that the license for the Klamath Hydroelectric Project (KHP) could not be transferred to the KRRC, and instead PacifiCorp must remain on as co-licensee throughout the decommissioning process. The parties were able to agree to a way forward despite this challenge.

The purpose of this talk is to update conference attendees on the regulatory, engineering and science process status of the Klamath Dam removal project. Included will be a discussion of regulatory processes, environmental permitting and associated science, NEPA process, and progress on engineering plans for the decommissioning of the project which is scheduled to begin in earnest in January, 2023.

Anadromous Salmonid Habitat Suitability Criteria

Session Coordinator*: Mark Gard, Ph.D., California Department of Fish and Wildlife*

This session will synthesize available information on spawning and rearing habitat and an analysis of what should be considered in the design process. The focus is the design of habitat restoration and water projects for anadromous salmonids in the Central Valley of California. The session is primarily focused on the intersection of biology and restoration strategies.

Large Scale Floodplain Rearing Habitat Rehabilitation: Southport Levee Setback

Chris Bowles, *cbec eco engineering (Presenter); and Co-authors:* ***Sam Diaz*** *and* ***John Stofleth,*** *cbec eco engineering and* ***Paul Dirksen,*** *West Sacramento Area Flood Control Agency*

Studies have hypothesized that there is very little remaining floodplain in California's Central Valley due to the combination of flow regulation, channel incision, and levee construction. Areas where floodplains can be restored should be high priorities for the restoration community, presenting the opportunity to increase essential ecosystem functions and provide anadromous fish habitat. The Southport Levee Improvement Project is one such opportunity. The multi-purpose project, situated along 5.6 miles of the right bank of the Sacramento River in West Sacramento, includes a major levee setback that is under construction. This project is an important step toward combining flood-risk reduction with significant ecological restoration.

The levee setback will create 150 acres of reconnected floodplain habitat. The restoration design creates riparian, perennial marsh, and floodplain habitat and accommodates compatible public recreation. The design will reduce habitat fragmentation, spatial/temporal losses, provide ecological uplift, and incorporate a watershed scale approach to ecosystem enhancement and flood protection. The establishment of ecological and physical design criteria are necessary to ensure creation of high-value habitat is maximized, species benefiting from restoration are maximized, and restoration design observes constraints of the Southport Project.

We will review the multi-disciplinary approach employed to integrate hydrodynamic modeling with ecological design to maximize the habitat enhancements of the restoration design. Our approach utilized a 2-dimensional hydrodynamic and morphological model as an analytical tool for assessing floodplain inundation dynamics to support restoration recommendations and optimization of ecological benefits. We will emphasize the benefits of using a 2-dimensional hydrodynamic model as a tool to describe hydrodynamic and ecological processes, inform restoration design, and satisfy ecological criteria and constraints.

We will also discuss how levee setback projects represent a significant opportunity for achieving increased flood protection and restoration of critical habitat for Delta and anadromous fish species and in turn, provide multiple benefits to society.

Review of Central Valley Anadromous Salmonid Habitat Suitability Criteria

Mark Gard, Ph.D., P.E., ***California Department of Fish and Wildlife***

The presentation will provide an overview of methods and Habitat Suitability Criteria (HSC) for both Chinook salmon and steelhead spawning and juvenile rearing, as well as results of biological verification of the criteria. Seventeen sets of Central Valley site-specific HSC for Chinook salmon spawning, twelve sets of HSC for Chinook salmon fry rearing, ten sets of HSC for Chinook salmon juvenile rearing, five sets of HSC for steelhead spawning, and three sets of HSC for steelhead fry and juvenile rearing were identified. Biological verification was successful in ten out of thirteen cases. Differences between criteria were largely due to differences in methods used to collect data and develop the criteria.

Using Aerial Redd Survey Data and Two-dimensional Hydraulic Models to Construct a Temperature Dependent Spawning Resource Selection Function for Winter-run Chinook Salmon

Peter N. Dudley, *Southwest Fisheries Science Center, National Marine Fisheries Service and Cooperative Institute for Marine Ecosystems and Climate (CIMEC), UC Santa Cruz (Presenter); and Co-authors:* ***Sarah N. John*** *and* ***Miles E. Daniels,*** *Southwest Fisheries Science Center, National Marine Fisheries Service and Cooperative Institute for Marine Ecosystems and Climate (CIMEC), UC Santa Cruz; and* ***Eric M. Danner,*** *Southwest Fisheries Science Center, National Marine Fisheries Service, Santa Cruz, California*

Impassable barriers have cut off a great deal of historic salmonid spawning habitat. This habitat reduction has spurred efforts in spawning habitat restoration and modeling. These efforts require information on spawning site velocity and depth preferences, which may change as the environment changes. Gathering these data can be time-consuming and costly. This presentation uses available historic redd aerial surveys; 2D hydraulic modeling; and Bayesian, multivariate polynomial, logistic regression to calculate velocity and depth spawning resource selection functions and examine their interactions with temperature. Our methods result in univariate and multivariate resource selection functions, and find no interaction between velocity and depth preference, no interaction between depth preference and T, but a credible interaction between velocity preference and temperature. We find the best multivariate resource selection function is a model which includes temperature and interactions between depth, velocity, and temperature. According to the area under the curve metric for a receiver operating curve, this model is “useful”. Finally, we apply this model in a web application to allow managers to visualize the resource selection function.

Increasing Lateral Connectivity to Benefit Juvenile Salmonids on the Lower Yuba River: The Hallwood Side Channel and Floodplain Restoration Project

April Sawyer, *cbec, inc. ecoengineering (Presenter); and Co-authors:* ***Chris Hammersmark,*** *cbec, inc. ecoengineering;* ***Sam Diaz,*** *cbec, inc. ecoengineering;* ***Matthew Weber,*** *cbec, inc. ecoengineering;* ***Jon Parsons,*** *cbec ecoengineering, inc.;* ***Paul Cadrett,*** *United States Fish and Wildlife Service, Anadromous Fish Restoration Program;* ***Joe Merz, Kirsten Sellheim, Philip Colombano,*** *and* ***Michael Beakes,*** *Cramer Fish Sciences;* ***Rachel Hutchinson,*** *South Yuba River Citizens League; and* ***Paul Bratovich,*** *HDR Inc.*

Anthropogenic actions on the Lower Yuba River dating back to the Gold Rush altered geomorphic and hydraulic conditions and subsequently the available habitat for rearing juvenile salmonids. The Hallwood Side Channel and Floodplain Restoration Project was developed to address the United States Fish & Wildlife Service Anadromous Fish Restoration Program's goal to double natural production of anadromous fish in Central Valley rivers. Specifically, the Project was designed to restore and enhance ecosystem processes, focusing on juvenile rearing fall and spring-run Chinook salmon and California Central Valley steelhead. The Project is supported by numerous agencies and stakeholders and leverages relationships with aggregate mining landowners to facilitate economically efficient habitat enhancement. After several years of planning, design, permitting, and pre-project monitoring, Phase 1 began implementation in late summer 2019. The design process targeted increasing inundation frequency and duration during the rearing period in a network of perennial and seasonally inundated side channels and removing large, unnatural constraints separating the main channel from its floodplain. Focused riparian planting was paired with predictions for natural recruitment in an experimental setting. The full Project will proceed over 4 to 6 years and will create or enhance up to 157 acres of seasonally inundated floodplain habitat, 1.7 miles of perennial channels, and 6.1 miles of seasonal side channels and alcoves. Two-dimensional hydraulic models and habitat suitability indices were used to predict habitat benefits, including an increase in suitable acreage for rearing and wetted edge habitat. Due to a design based on restoring lateral connectivity and removing unnatural constraints, coupled with a robust monitoring program, the Project will provide a wealth of information regarding restoration success at a large scale.

Wanted: Project Site—A Framework for Evaluating Possible Restoration Sites

J.D. Wikert, *U.S. Fish and Wildlife Service (Presenter);*
and Co-authors: ***Rocko Brown, Ph.D.*** *and* ***Joseph Merz, Ph.D.,*** *Cramer Fish Sciences*

Salmonid habitat restoration often occurs at locations that are available and accessible (low hanging fruit). In order for restoration to achieve larger watershed-scale goals, it is necessary to approach planning with a biological goal in mind (e.g., providing off-channel Chinook salmon rearing habitat in the spring). In addition, riverine landscapes are not random canvases. Even degraded river corridors follow basic gradients that need to be considered when planning habitat enhancement actions. Empirical or modeled data can enable a determination of how much habitat is necessary, when it needs to function, and how it needs to be distributed to maximize benefits. Logistical and efficacy considerations are also important factors as projects need to fall within available funding limitations and because increased budgetary efficiency can translate into greater amounts of restored habitats. Ultimately, restoration actions must be put into a context of ultimate goals for a population, watershed, or program to determine total effort needed, timelines, and track success. In this presentation, we will discuss the process used to evaluate restoration opportunities to enhance the migratory corridor for fall-run Chinook salmon and steelhead in the Stanislaus River, San Joaquin Basin, Central Valley, California and put it into the context of overall watershed restoration goals.

Quantifying Dynamic Floodplain Habitat for Juvenile Salmon Using a Hydrospatial Approach

Alison Whipple, Ph.D., *San Francisco Estuary Institute (Presenter); and Co-Authors:* ***Gloria Desanker,*** *San Francisco Estuary Institute;* ***Joshua Viers, Ph.D.,*** *UC Merced;* ***Ted Grantham, Ph.D.,*** *UC Berkeley;* ***Lisa Hunt, Ph.D.*** *and* ***Amy Merrill, Ph.D.,*** *American Rivers;* ***Jacob Katz, Ph.D,*** *CalTrout; and* ***Rene Henery, Ph.D.,*** *Trout Unlimited*

The restoration of floodplain functions is critical to the recovery of healthy salmon populations in the Central Valley and beyond. Seasonally inundated floodplains provide productive rearing habitat for juvenile salmonids, supporting their rapid growth and increasing the likelihood of survival on their journey to the ocean and within the marine environment. Achieving these salmon benefits, however, requires floodplain habitat restoration that considers the dynamic interactions of floodwaters and the landscape, which vary in space and time. Habitat quantification tools help scientists and natural resource managers evaluate the effects of land management, flow manipulation, and structural habitat improvements on the amount, quality, location, and timing of habitat available for target species. We used hydrospatial analysis—a spatially- and temporally-discretized approach that combines two-dimensional hydrodynamic modeling output with a daily flow time series—to evaluate physical metrics like depth and velocity, as well as inundation duration, timing, and connectivity, using juvenile Chinook salmon habitat suitability criteria. Habitat availability over a twenty-year period was quantified for several restoration sites within the Central Valley. Total annual habitat, measured in acre-day units, was summarized from daily spatially-resolved (grid-based) estimates of suitability. Results indicate where and when (within and across years) restoration sites may provide the greatest habitat benefits to salmon, as well as the sensitivity of habitat quantity to the suitability criteria applied. Results also reveal a high degree of variability in suitable habitat within and among sites and illustrate that flow-habitat relationships are non-linear and mediated by complex floodplain environments. This approach improves assessment of spatially- and temporally-variable floodplain habitat conditions and is being employed as part of the Chinook salmon Habitat Quantification Tool (HQT) of the Central Valley Habitat Exchange to guide the restoration and management of floodplains for salmon benefits.

Hydrologic Management Insights from Instrumented Watersheds

Friday Afternoon Concurrent Sessions

**Session Coordinators*: Tim Bailey,* *Watershed Research and Training Center;*
and ***David Dralle, Ph.D.,*** *Pacific Southwest Research Station, USDA*

Successful watershed management requires a process-based understanding of the outcomes of management alternatives and treatments. Long-term ecological research sites and shorter-term intensively monitored sites both provide important insights into watershed hydrologic response to management strategies and natural variability. Well-designed experiments are needed to understand emerging management techniques. Data from all these approaches will be critical for formulating management responses to the myriad of ecological stressors faced by California's freshwater fisheries including declining summer baseflows. This session will be an opportunity to share data-driven insights into hydrologic responses to climate, disturbance and vegetation management (e.g., fire and timber harvest), restoration, and management interventions such as enhanced groundwater recharge.

Hyporheic Restoration: Lessons From Meacham Creek, OR

Byron Amerson, MS, *Environmental Science Associates (Presenter), and Co-authors,* ***Geoff Poole,*** *Montana State University; and* ***Scott O'Daniel,*** *and* ***Mike Lambert,*** *Confederated Tribes of the Umatilla Indian Reservation (CTUIR)*

In summer of 2011 the Confederated Tribes of the Umatilla Indian Reservation restored a one-mile reach of Meacham Creek, a tributary to the Umatilla River in north central Oregon. The baseline channel was an incised, wall-based channel with a homogenous and coarse bed with a shallow alluvial aquifer. In contrast, the restored channel was more sinuous with increased depth and substrate heterogeneity. For over five years we monitored the effect of the restoration on both floodplain hydrology and temperature via a network of water level and temperature loggers installed in 19 wells throughout the floodplain. We also modeled floodplain hydrology and temperature using the water table elevation and temperature measurements for calibration. We found that post-restoration the alluvial aquifer depth had increased by an average of 1.5 m. Our modeling indicated that channel planform had a strong effect on floodplain hydrology, shown by a decrease in maximum residence time of floodplain hyporheic water from about 680 days to 380 days. Given the increase in the floodplain water table elevation, the hyporheic volume increased from 1.6 m3 to 1.95 million m3. This increase in storage of 345,000 m3 yielded an increase in hyporheic flux (total hyporheic volume per meter of valley length) of 436 m2 pre-restoration to 529 m2 post restoration. Furthermore, floodplain temperature heterogeneity increased concomitantly with channel planform and floodplain residence time. While residence time and temperature heterogeneity were altered by restoration, the mean temperature of upwelling water was similar pre- and post-restoration. Hence, the frequency of potential thermal refugia increased along the channel while mean channel temperature was essentially unchanged.

Effects of Flow Augmentation on Coho Salmon Smolt Passage in Porter Creek, a Tributary to the Russian River, California

***Sarah Nossaman Pierce**, California Sea Grant (Presenter); and Co-authors: **Mariska Obedzinski** and **William Boucher,** California Sea Grant; and **Mia van Docto,** Trout Unlimited*

Insufficient spring and summer streamflows have been identified as significant bottlenecks to salmonid recovery in tributaries to the Russian River. In low water years, many of the tributaries that provide critical Coho and steelhead habitat, including Porter Creek, disconnect during smolt emigration and extensive stream drying limits survival of rearing juveniles.

In collaboration with multiple organizations, a private vineyard company dedicated water from an off-channel retention pond to be released into Porter Creek, but guidance is needed to determine the best practice for distributing the limited quantity of water available over the spring and summer months. We developed a study to determine the amount of flow required to maintain stream connectivity through the smolt emigration season and to examine the effects of flow augmentation on smolt passage. Streamflow gaging, wet/dry mapping, and time-lapse cameras were used to document disconnection and combined with PIT-tag detection data to evaluate the effects of the augmentation on emigrating smolts at different flow release levels. In 2018, we estimate that 25% of the annual smolt run was provided passage as a result of implemented flow releases. We are continuing our investigation in order to provide long-term guidance as to the timing, quantity, and duration of releases that will most benefit fish populations in Porter Creek.

Advancing Voluntary Flow Enhancement Projects in California's Small Streams and Rivers

Amy Campbell, *The Nature Conservancy, Environmental Water Transaction Project Director*

The next decade will be critical in the fight against the impact of climate change on California's natural resources. The effects of rising temperatures are already occurring as evident in recent extreme droughts and floods across California. These types of events over the last decade have raised awareness that current approaches to managing California's water are increasingly failing to meet the needs of both people and nature and it's essential that we work to protect and enhance biodiverse strongholds across the State. Inadequate flows in California's unregulated and smaller streams are prevalent during the dry season, which are causing freshwater species populations to decline and increasing water supply insecurity for the people and communities which rely on freshwater. These smaller streams and rivers are home to over 80 percent of California's freshwater biodiversity, and in these systems, almost half of the native salmon, steelhead, and trout are predicted to be extinct in 50 years.

To advance efforts to preserve and protect water in California in the most critical streams and rivers, the California Salmon and Steelhead Coalition, made up of The Nature Conservancy, Trout Unlimited, and California Trout, is developing a California Environmental Water Network (Network). The goal is to support the work of people and organizations working on-the-ground with building the technical skills and capacity needed to implement more voluntary and flow related projects across the State. Join the members of the California Salmon and Steelhead Coalition for an interactive session to learn more about the California Environmental Water Network and to provide feedback around this idea and how this Network might support your work on-the-ground.

Quantification of Water Storage and Non-perennial Runoff Dynamics in a Semi-arid Catchment

Amanda Donaldson, Ph.D. Student, *UC Santa Cruz (Presenter);*
and ***Margaret Zimmer, Ph.D.,*** *UC Santa Cruz*

Although non-perennial streams only flow seasonally or during precipitation events, they provide important ecosystem habitats for many freshwater fish species' life cycles and deliver sediment, water, and solutes to downstream reaches. Our ability to manage and conserve these riverine systems hinges on a mechanistic understanding of the drivers of flow in non-perennial streams. At a 3.5-hectare oak woodland headwater catchment in the Blue Oak Ranch Reserve (coastal central CA), we investigated how the shallow soil properties and the degree of subsurface rock weathering influence catchment water storage capacity and the release of water to streamflow using a combination of hydrometric, isotopic, and geophysical approaches. We found that distinct antecedent wetness and subsurface critical zone characteristics influence the timing, magnitude, and duration of streamflow response to precipitation. This work highlights how the implementation of instrumented watershed-scale analyses can improve our scientific understanding and predictive power of non-perennial streams in the face of a rapidly changing world.

Developing California's Stream Gaging Plan (Senate Bill 19)

***Valerie Zimmer,** State Water Resources Control Board (Presenter); and Co-authors:*
***Teresa Conner,** Department of Water Resources; **Todd Carlin,** Department of Fish and Wildlife, and **Dan Schultz,** State Water Resources Control Board*

A robust stream gage network is essential for effective water management, especially during times of extreme water shortage or flooding. Almost three-quarters of California watersheds do not have a federally or state-operated streamflow gage and the majority (~85 percent) of these un-gaged watersheds have surface water diversions. The existing gage network is insufficient to address key management needs (e.g., water supply management, flood management, water quality management, and ecosystem management).

Senate Bill No. 19 (SB 19) (Statutes of 2019, Chapter 361, Dodd) enacts Water Code section 144, which directs the Department of Water Resources (DWR) and the State Water Resources Control Board (State Water Board) to develop a plan to address gaging information gaps through the deployment of a network of prioritized stream gages in consultation with the California Department of Fish and Wildlife (CDFW), Department of Conservation (DOC), the Central Valley Flood Protection Board (Flood Board), and interested stakeholders. The stream gaging plan will identify significant gaps in the stream gaging network to meet the wide variety of water management needs, which are increasingly important in the face of a changing climate.

This presentation will introduce the overall effort and discuss the development of prioritization criteria to support ecosystem management.

Where Will Salmon Spawn? Variability of Headwater Stream Network Length is Highly Sensitive to Projected Climate Change

***Christine LeClerc** (Presenter), **Dana Lapides, W. Jesse Hahm, Simon Fraser** University; **Hana Moidu,** University California, Berkeley; and **David Dralle, Ph.D.,** Pacific Southwest Research Station, United States Forest Service*

Headwater stream networks expand and contract over time, increasing and decreasing available aquatic habitat in the process. Although recent advances improve prediction of headwater stream network length based on streamflow at watershed outlets, controls on stream network length variation over time remain poorly understood and unquantified. As climate change in key salmon-supporting watersheds of the North American West Coast is projected to result in less frequent but higher magnitude precipitation events, a better understanding of the dependence of stream network length on flow variability is needed. Using an analytical framework and a globally comprehensive dataset of co-located channel length surveys and streamflow records, we found that headwater stream network length variability increases disproportionately for a given increase in streamflow variability. We also found that USGS 7.5-minute maps commonly used in decision-making typically underestimate stream network lengths compared to the empirically derived lengths used in our study. These maps of static stream network length misrepresent the highly dynamic nature of wetted channel length, which we suggest—analogously to flow duration curves—may be more appropriately captured using “network extent exceedance curves” to anticipate habitat variability and its dependence on climate-driven flow regimes.

Salmonid Restoration Federation

Board of Directors

Don Allan (President)
Restoration Consultant

Eli Asarian (Vice-President)
Riverbend Sciences

Brian LeNeve (Treasurer)
Carmel River Steelhead Association

Sarah Phillips (Secretary)
Marin Resource Conservation District

Anna Halligan (alternate)
Trout Unlimited

Jennifer Hemmert (alternate)
CA Department of Fish and Wildlife

Cynthia LeDoux-Bloom, Ph.D.
HSU Department of Fisheries Biology

Freddy Otte (alternate)
City of San Luis Obispo

Alison Willy
USFWS (retired)

Dan Resnik (alternate)
CA Department of Fish and Wildlife

Dougald Scott, Ph.D. (alternate)
Professor Emeritus

Staff

Dana Stolzman
Executive Director
srf@calsalmon.org

Katrina Nystrom
Streamflow Monitor and Project Associate
katrina@calsalmon.org

Denise Dills
Bookkeeper
denise@calsalmon.org

Lindsay Kelsey
Project Assistant
lindsay@calsalmon.org

SRF 425 Snug Alley, Unit D, Eureka, California 95501, (707) 923-7501

Presenter Directory

Byron Amerson
ESA
BAmerson@esassoc.com

Tim Bailey
Watershed Research
and Training Center
tim@thewatershedcenter.com

Michael Belchik
Yurok Tribal Fisheries Program
mbelchik@yuroktribe.nsn.us

Chuck Bonham, JD
California Department
of Fish and Wildlife
Director@wildlife.ca.gov

David Boughton, Ph.D.
National Marine Fisheries Service
David.Boughton@noaa.gov

Chris Bowles, PE
cbec, inc.
c.bowles@cbecoeng.com

Amy Campbell
The Nature Conservancy
acampbell@tnc.org

Janine Castro
Columbia River Fish and Wildlife
Conservation Office
janine_m_castro@fws.gov

Anthony Clemento, Ph.D.
NOAA's National
Marine Fisheries Service
anthony.clemento@noaa.gov

Matt Clifford, JD
Trout Unlimited
mclifford@tu.org

Robert Coey
NMFS
bob.coey@noaa.gov

Redgie Collins
Cal Trout
rcollins@caltrout.org

Flora Cordoleani, Ph.D.
UCSC - NMFS
flora.cordoleani@noaa.gov

Amanda Donaldson
UC Santa Cruz
amdonald@ucsc.edu

David Dralle, Ph.D.
U.S. Forest Service
david.dralle@usda.gov

Peter Dudley
NOAA Fisheries
peter.dudley@noaa.gov

Alexandra Fraik, PhD Candidate
NOAA Fisheries
alexandra.fraik@noaa.gov

Mark Gard, Ph.D.
California Department of Fish
and Wildlife, Conservation
Engineering Branch
mark.gard@wildlife.ca.gov

John Carlos Garza, Ph.D.
NOAA
carlos.garza@noaa.gov

Katie Haldeman
Sustainable Conservation
khaldeman@suscon.org

Drew Harvell, Ph.D.
Cornell University
cdh5@cornell.edu

Lucy Haworth
California Department
of Fish and Wildlife
Lucy.Haworth@Wildlife.ca.gov

Rene Henery, Ph.D.
Trout Unlimited/ UNR
RHenery@tu.org

Libby Gilbert-Horvath
NOAA Fisheries Service
libby.gilbert@noaa.gov

Sandra Jacobson, Ph.D.
California Trout
sjacobson@caltrout.org

Carson Jeffres, Ph.D.
UC Davis Center
for Watershed Sciences
cajeffres@ucdavis.edu

Jacob Katz, Ph.D.
Central California Region, CalTrout
jkatz@caltrout.org

Curtis Knight
California Trout
cknight@caltrout.org

Richard Lanman, MD
Institute for Historical Ecology
ricklanman@gmail.com

Christine LeClerc
Simon Fraser University
leclerc@sfu.ca

Danielle LeFer
California Dept. Parks and Rec.
danielle.lefer@parks.ca.gov

Robert Lusardi, Ph.D.
UC Davis
- Center for Watershed Sciences
ralusardi@ucdavis.edu

Nathan Mantua, Ph.D.
NOAA/NMFS SW
Fisheries Science Center
nate.mantua@noaa.gov

Mary Marshall
U.S. Bureau of Reclamation
mmarshall@usbr.gov

Darren Mierau
California Trout
DMierau@caltrout.org

Carrie Monohan, Ph.D.
The Sierra Fund
carrie.monohan@sierrafund.org

Jacob Montgomery
California Trout
jacob@caltrout.org

Jonathan Nelson
CA Dept of Fish and Wildlife
jonathan.nelson@wildlife.ca.gov

Kellyx Nelson
San Mateo County RCD
kellyx@sanmateorcd.org

Trang Nguyen
US Bureau of Reclamation
trangnguyen@usbr.gov

Sarah Nossaman Pierce
CA Sea Grant
snossamanpierce@ucsd.edu

Katrina Nystrom
Salmonid Restoration Federation
katrina@calsalmon.org

Haley Ohms, Ph.D.
NOAA Fisheries/UCSC
haley.ohms@noaa.gov

Max Ramos
Yurok Tribe
Humboldt State University
mmr37@humboldt.edu

Allan Renger
California Department
of Fish and Wildlife
allan.renger@wildlife.ca.gov

Paul Richardson
USDA Forest Service
paul.richardson@usda.gov

Gabriel Rossi, Ph.D.
UC Berkeley
rossfactor@berkeley.edu

Rachael Ryan
UC Berkeley
rachael_ryan@berkeley.edu

April Sawyer
cbec ecoengineering, inc
a.sawyer@cbecoeng.com

Monty Schmitt
The Nature Conservancy
monty.schmitt@tnc.org

Erin Seghesio
NOAA Fisheries
erin.seghesio@noaa.gov

Chris Shutes
California Sportfishing
Protection Alliance
blancapaloma@msn.com

Stacie Smith, Ph.D.
NOAA Restoration Center
stacie.smith@noaa.gov

Jay Stallman
Stillwater Sciences
jay@stillwatersci.com

Stephen Swales, Ph.D.
California Department
of Fish and Wildlife
stephen.swales@wildlife.ca.gov

Bill Trush, Ph.D.
HSU River Institute
bill.trush@gmail.com

Julie Weeder
NOAA Fisheries
julie.weeder@noaa.gov

Alison Whipple
San Francisco Estuary Institute
alisonw@sfei.org

Madeleine Wieland
California Department
of Fish and Wildlife
Madeleine.Wieland@wildlife.ca.gov

J.D. Wikert
USFWS
John_Wikert@fws.gov

Malte Willmes
UC Santa Cruz
mwillmes@ucsc.edu

Ellen Wohl, Ph.D.
Colorado State University, Fluvial
Geomorphology Department
Ellen.Wohl@colostate.edu

Valerie Zimmer
State Water Resources Control Board
valerie.zimmer@waterboards.ca.gov

Join Salmonid Restoration Federation and Sanctuary Forest for a Virtual Flow Enhancement and Restoration workshop to explore the evolving restoration in Redwood Creek and the Mattole, May 8, 2021. These two connected watersheds are intertwined historically, geologically, and from a fisheries recovery perspective. Restoration techniques and flow enhancement strategies have evolved to address climate change resilience and longer dry seasons. This workshop will be held via Zoom and will be available later as a video recording.

See *https://www.calsalmon.org/node/1093 or scan QR Code* for more info and to register for this workshop!