39th Annual Salmonid Restoration Conference

April 19 - 22, 2022 Santa Cruz, CA

Reconnecting with Resilience

Conference Co-Sponsors

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Welcome to the 39th or is it 40th Annual Salmonid Restoration Conference

Reconnecting with Resilience

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?

As I write this, the SRF Conference is just a few weeks away. Most of SRF's supporters and meeting attendees know that the 2020 Conference was planned in Santa Cruz—just two years and a seeming lifetime ago. As SRF burrows out of the hole of COVID, it's hard not to feel like we are living in a perpetual Groundhog Day, repeating the same myriad tasks that it takes to produce the annual Salmonid Restoration Conference but with a renewed sense of commitment, collective concern, and an ever-evolving assessment of mitigated risk.

The salmonid restoration field is one that constantly must assess, evaluate, and mitigate risk. It is a core principle that underlies watershed restoration activities. But as humans that learn from one another, the calculus of gathering now includes a responsibility to one another's well-being. It is both surreal, and I am afraid our new reality, that we must plan, prepare, and practice with an abundance of caution in order to safely gather again. I am heartened that virtually all of our conference attendees are willing to make the small personal sacrifices needed in order to be able to convene in person to rejuvenate, learn, and get inspired.

The theme of this conference is *Reconnecting with Resilience* 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 research to our larger watershed restoration and fisheries community. 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.

Producing this conference has been years in the making so SRF owes a great deal of gratitude for our many restoration partners who stayed the course with us to build this dynamic agenda, present at the virtual conference last year, and reconfigured workshops and field tours. It has been an immense honor to witness your dedication and share this Groundhog Day *déjà vu* experience together!

I also want to thank the SRF Board of Directors who were not adverse to the risk of producing an "in-person" conference and have been steadfast in their desire to protect the most vulnerable amongst us so the Conference could be accessible. SRF greatly appreciates all of our co-sponsors who generously contribute their ideas, time, and resources to the production of the conference. We sincerely thank all of the workshop, and session coordinators who did an outstanding job of creating a dynamic agenda that highlights some of the most exciting restoration practices and tools to address current climate and drought conditions.

Thank you to all of the SRF members, presenters, and conference attendees who have showed up and join us in as we convene with caution, excitement, and hopefully a renewed sense of purpose.

For wild salmon and steelhead,

Dana Stolzman
Executive Director,
Conference Agenda Coordinator

Cover photo: Chris Berry

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Dancing to *Edge of the West*

Thursday, April 21

Plenary Session at the Cocoaunut Grove

SRF Membership Meeting 12:30pm

Poster Session 7-10pm

Friday, April 22

2022 SRF Banquet

Awards Ceremony

and Dancing to *Papiba and Friends of Sambada*

Fish Passage Design for Road Crossings Workshop and Field Tour

Tuesday, April 19

Workshop Coordinators: ***Michael Love, P.E.,*** *Michael Love & Associates, Inc.,* ***Ross Taylor,*** *Ross Taylor and Associates, and* **Kristen Kittleson,** *County of Santa Cruz*

This two-day workshop will focus on fish passage design approaches and techniques for road-stream crossings and other low-head barriers. The course will be structured around Part XII—Fish Passage Design and Implementation—of the CDFW California Salmonid Stream Habitat Restoration Manual. The workshop is intended for participants with a variety of backgrounds, including engineers, biologists, geologists, planners, and project managers.

Covered topics include:

- Biological imperative of providing passage
- Assessing geomorphic risk for a fish passage project
- Pre-design and selection of project approach
- Stream simulation design and reference reach characterization
- Roughened channel design
- Use of boulder and log weirs
- Retrofits and technical fishways

The workshop will have participants work on sample problems taken from real projects, including analysis of thalweg profiles, developing designs for a stream simulation culvert crossing, and sizing material for a roughened channel. Participants should bring a calculator and a ruler. The second half of Day 2 will include a field tour to a range of fish passage sites within Santa Cruz's Corralitos Creek. Sites include full replacements and retrofits of stream crossings and a fish ladder, illustrating the various design approaches covered in the workshop and described in CDFW Part XII.

Salmonid Recovery in the San Lorenzo River Watershed

Tuesday, April 19

Field Tour Leaders*: **Chris Berry,** City of Santa Cruz, and **Sierra Ryan,** County of Santa Cruz*

The San Lorenzo River runs from near Castle Rock State Park to the historic Santa Cruz Beach Boardwalk on beautiful Monterey Bay. The watershed historically hosted the largest steelhead runs south of San Francisco Bay and was the first watershed in the State of California to benefit from a watershed management plan. The watershed has a long history of anthropogenic influence—including the Ohlone habitation around the San Lorenzo River lagoon, the Mission-era water system impacts of the late 1700s, the "lumber, lime and leather" era starting in the late 1800s, the year-round occupation of upper watershed former summer homes by urban refugees in the late 1960s—early 1970s and the more recent focus on fisheries conservation.

Recent restoration efforts in watersheds are focused both on drinking water source protection, groundwater sustainability planning, and anadromous salmonid recovery. Given the watershed's provision of drinking water or over 100,000 people, tension between competing beneficial uses of water is omnipresent. However, watershed conditions supporting cold water fisheries are also protective of drinking water source quality—an ongoing challenge in a watershed that is heavily populated and has a long history of industrial and residential development. Leveraging requirements under the Safe Drinking Water Act and the Sustainable Groundwater Management Act along with Endangered Species Act and Fish and Game Code requirements can create a synergy for watershed recovery that is unique.

Among the important processes that will help with the watershed's recovery are various TMDLs, Drinking Water Sanitary Surveys, the Regional Conservation Investment Strategy, Karst Protection Zone Planning, Riparian Conservation Plan, Conservation Blueprint for Santa Cruz County, and Santa Cruz Anadromous Salmonid Habitat Conservation Plan. The tour will focus on some of the primary issues challenging the watershed's recovery, recent successes, and future opportunities for salmonid recovery and overall watershed protection.

Scott Creek Field Tour: Ground Zero for Central California Coast Coho Salmon Recovery

Tuesday, April 19

Field Tour Leaders*: Ben Cook, Trout Unlimited, Lisa Lurie, Santa Cruz Resource Conservation District, and Joseph Kiernan, Ph.D., NOAA Fisheries*

Scott Creek is the only watershed south of the Golden Gate Bridge that continues to support all three cohorts of CCC Coho and this watershed is mission critical to coho recovery in the Santa Cruz Mountains Diversity Strata. As coho struggle to keep a foothold south of the Golden Gate, a unique collaboration of scientists, restoration practitioners, geneticists, transportation planners, and farm managers are working in tandem to keep this population from going extinct. The field tour will focus on two ecological restoration efforts, the details and new science being developed through the NOAA Science Center's monitoring and research work, and the struggles and achievements of our small local coho recovery hatchery.

Of the two restoration projects that participants will learn about, is a precedent-setting collaboration with Caltrans and nearly all of the local, state, and federal resource agencies focused on restoring the Scott Creek Lagoon through removal of the massive Highway 1 fill prism that sits right in the heart of the historic lagoon footprint. This effort is in its 7th year and the project was highlighted as a top priority in NOAA National Species in the Spotlight report. Project partners will discuss the collaboration, how this effort is shifting the planning paradigm for Caltrans and the technical work completed to-date. In addition to this project, which is still in its planning phase, we will also walk lower Scotts Creek on the Cal Poly Swanton Pacific Ranch and hear about the nearly 6,000 linear feet of instream and floodplain restoration designed by Cal Poly graduate students and implemented over the past 6 years. The project utilizes novel restoration techniques focused on the use of on-site materials such as local hardwoods for LWD to rock from local defunct quarries.

While these projects are unique, the watershed also supports the only life-cycle station in the region, and with researchers from NOAA's Science Center, supports a state-of-the-art research program. Staff from the NOAA Science Center will discuss not only novel monitoring techniques that they are experimenting with, but also cutting-edge science they are developing to inform recovery and restoration.

Finally, staff from the Science Center also help run, along with the Monterey Bay Salmon and Trout Program, the Kingfisher Flat Hatchery. Due to low numbers of naturally returning coho, this hatchery has transitioned from a steelhead hatchery to a coho recovery hatchery and is a critical piece of the recovery puzzle. The tour will end at the hatchery, where we will discuss the efforts to avoid genetic bottlenecks, keep the facility running in the face of constant funding shortages, and get to see some healthy broodstock fish.

The three legs of the recovery tool (restoration, monitoring, and hatchery) will be discussed in the context of the 2020 CZU Complex Fire, which burned heavily in the Scotts Creek watershed, and present and projected climate change impacts.

Los Padres Fish Passage Field Tour

Tuesday, April 19

Field Tour Coordinators*: Brian LeNeve,* *Carmel River Steelhead Association,* ***Haley Ohms, Ph.D.,*** *University of California, Santa Cruz & NOAA Southwest Fisheries Science Center, and* ***Beverly Chaney,*** *Associate Fisheries Biologist, Monterey Peninsula Water Management District Cal Am Dam Keeper*

The Los Padres Dam tour will focus on how to improve fish passage over and back down from an existing dam, along with habitat improvements below an existing dam. With presenters from NMFS, Monterey Peninsula Water Management District, California American Water, and the Carmel River Steelhead Association participants will learn about 40 years of work to benefit steelhead.

This tour will drive south to the Carmel River and visit the Los Padres Dam site 24 miles from the ocean. When Los Padres Dam was built there was no fish passage considered and as a consequence many projects have been built to allow steelhead, and rainbow to migrate up to the headwaters and back down as adults.

To get fish over the dam, three different ladder and trap structures have been built and are still visible including a wood ladder and trap, a metal and concrete ladder, and the Alaska Slide ladder and concrete block trap used today. Spring will be prime steelhead migration time, so if we are lucky, one or more fish will be in the trap so we can see them trucked over the dam.

To get fish downstream, boulders were blown up to prevent fish from crashing into them from the spillway. A metal extension was added to the spillway to get fish past remaining boulders, a berm was installed on the spillway to channel water into a concentrated area, a "notch" was cut in the top of the spillway, and a 4.8-million dollar water slide and behavioral guidance system was installed. There is also evidence of gravel injections done several years ago and more are planned in the future.

Your guides from the Carmel River Steelhead Association and Cal-am Water Co. will explain how each of these systems are working or have worked, and a representative from the NMFS Southwest Fisheries Science Center will talk about what we have learned about fish passage through the dam as a result of a study started last year.

Restoration Approaches to Large Wood Augmentation Workshop

Tuesday, April 19

Workshop Coordinators*: Anna Halligan and Daisy Schadlich, Trout Unlimited*

Due to the important role of large wood in restoring and maintaining instream salmonid habitats, wood augmentation has become a common element in stream restoration. Given the frequency and intensity of instream large wood restoration efforts in California over the last several decades, restoration practitioners and agencies alike have learned a great deal about the success and applicability (or lack thereof) of a wide variety of large wood implementation methods. In order to help improve the efficacy of these types of projects, and to help identify when and where specific application of these methods may be the most appropriate, it is important for restoration practitioners to communicate their lessons learned and experiences with one another. This workshop will focus on presenting several instream large wood implementation methods and techniques, followed by a discussion of where and when it is best to apply specific methods.

A Quantitative Map-Based Approach to Identifying Hazards and Assessing Risk for Large Wood Structure Installations

Rachel Shea, P.E., *Michael Love & Associates, Inc., (Presenter),*
and Co-author: ***Michael Love, P.E.,*** *Michael Love & Associates, Inc.*

Risk assessments are necessary when installation of large wood may threaten public safety or nearby infrastructure such as roads, buildings, or utilities. A risk assessment is the processing of identifying hazards and assessing the associated risks. A hazard is a condition or process that has the potential to threaten public safety, property, or operations. A risk is the product of the hazards' severity and probability.

This talk presents a case-study of a quantitative map-based methodology to identify hazards, their severity, extents and consequence, and determination of the associated level of risk. The analyses were broken into reach-scale and localized areas where hazards are present that increase risk. The results of the analyses were used to develop location-specific mitigative measures for each hazard, dependent on level of risk.

Go Big or Go Home—The Use of Large Wood in Stream Habitat Restoration

Kristine Davis Pepper, P.E., *Sr. Hydraulic Engineer, California Department of Fish and Wildlife*

Natural unaltered riparian zones supply large wood to a stream through various processes. This large wood provides an instream structural element important to salmonid habitat. Unfortunately, in California, there are few examples of riparian zones or streams which are unaltered by human land use activities. This has left a legacy of streams deficient in large wood, which is necessary to create and maintain salmonid habitat. Opperman et al. (2006) defines large woody debris as "trees, logs, root wads, and large tree branches that fall into streams and interact with water, sediment, and organisms in the channel". To facilitate the reestablishment of stream processes, the addition of large wood is a restoration technique that benefits streams on a range of scales (Cederholm et al. 1997, CDFG 2004, Opperman et al. 2006, Jones et al. 2014, National Marine Fisheries Service 2014, Roni et al. 2014). Large wood projects aim to improve channel and floodplain function, provide habitat to salmonids, and add nutrients to the stream.

The impact of large wood on a stream depends on the geomorphology of the stream, the stream size relative to the dimensions of the wood, and the hydrology of the stream, thus providing a range of benefits.

Large wood in streams serves an important role in creating and maintaining salmonid habitat. As adult salmonids return to their natal streams to spawn, large wood provides winter concealment habitat and low velocity resting places. Gravel deposition and sorting associated with large wood creates spawning habitat. In-channel wood provides juvenile salmonids with cover and protection from predation, as well as refuge from high flow velocities. Large wood creates and maintains a physically complex channel that locally controls streamflow hydraulics that form pools, riffles, bars downstream in the form of point bars, alcoves, back eddies, side channels, and establishes floodplain connectivity. Large wood accumulations promote gravel deposition upstream, and bed scour downstream that form pools, which are a preferred habitat for juvenile salmonids. Pool scour creates sediment deposits that serve as spawning habitat and maintains the hyporheic zone. In the hyporheic zone, shallow groundwater mixes with surface water, cooling the overall water temperature. Wood in streams supports a food resource for invertebrates that in turn provides food for juvenile salmonids. Large wood accumulations also trap fish carcasses that contribute nutrients such as carbon, nitrogen and phosphorous to the stream.

Large Woods Relation to Process Based Restoration in Heavily Logged Watersheds

Thomas H. Leroy, Engineering Geologist, Pacific Watershed Associates

Large wood loading into streams is a popular approach to improving aquatic habitat for fisheries recovery, particularly in rivers that have been subjected to past anthropogenic disturbances. Typically, the large wood structures are installed to provide aquatic habitat at site specific locations. Although providing immediate habitat is prudent and appropriate in many locations, these types of individual structures often do not address the dysfunctionality of the processes that collectively, over time, provide the dynamic elements of a naturally self-sustaining fluvial geomorphic environment conducive to developing and maintaining aquatic habitat. The dynamic interactions between sediment, wood and water are what "create" aquatic habitat for fish. When changes occur to any one of these 3 stream elements, they impact the other 2 elements, which in turn results in a dysfunctionality feedback loop as the dynamic equilibrium of the channel adjusts to its new conditions. Once a new, and perhaps less preferable dynamic stream equilibrium is established under the altered watershed processes, simply adding wood as habitat may not be the most appropriate way to recover fish populations. We contend that restoring dysfunctional processes will provide a better long-term solution for fisheries recovery than simply creating habitat within the existing system. To do this, one needs to consider the past watershed scale disturbances and develop plans to restore them to as close to their pre-disturbance conditions as possible. As a first step in this process, we suggest: (1) normalizing the watershed hydrology; (2) normalizing the sediment budgets in the system; and (3) fixing the broken system of natural wood recruitment and retention in the watershed. By restoring these processes to their natural conditions, one can create an environment where the stream system can reform a dynamic equilibrium consistent with its pre-disturbance conditions. In our talk we present a conceptual approach to identify, characterize, analyze, and mitigate watershed-scale disturbances to allow a watershed to develop a naturally sustaining, fluvial-geomorphic environment that will provide for long-term fisheries recovery.

How Big Can You Go with Your LWD Structure Before You Start Breaking Things? An Analysis of Structure Layout and Material Properties Comprising Simple LWD Structures

Rachel Shea, P.E., ***Michael Love & Associates, Inc.***

Many people wonder how far they can extend a log into a channel before it breaks, bends a rebar connection, or breaks the trees to which the structure is anchored. This talk will present the results of a site-specific case study that evaluates the stability of simple CDFW-style large-wood structures that include a long cantilevered into the channel and anchored to one or two anchor trees. Stability analyses presented will include evaluation of stable cantilever log lengths for various wood species, rebar bending failures, and anchor tree torsion and bending failures for various species and diameters of anchor trees. The presentation will conclude with tips for the design of stable large wood structures.

Going Big with Large Wood Structures in Low Gradient Alluvial Valleys: Design Approaches and Lessons Learned from the Ten Mile River Projects

Luke Walton, P.E., *Prunuske Chatham, Inc. (Presenter)*
and Co-author: ***Lauren Hammack,*** *Prunuske Chatham Inc.*

Many of California's coastal streams are entrenched in their alluvial valleys. Sediment derived from historic upland land clearing and resource management practices have aggraded the floodplains. This legacy sediment, coupled with simplified channel forms, minimal woody debris delivery, and dense riparian vegetation stabilizing the channel banks, severely limits high-quality juvenile salmonid rearing habitat and population recovery potential in these systems. Using examples from three phases of design and construction in the lower Ten Mile River, the potential for engineered log jams to initiate and maintain geomorphic processes that increase stream and valley habitat complexity will be explored. Multiple wood structure design approaches were used in these projects to affect hydraulic and geomorphic conditions. Design intent, construction methods, and lessons learned will be presented.

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Rachel Shea, P.E., *Michael Love & Associates, Inc. (Presenter),*
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List of presenters on Wednesday, April 20:

Aaron Hébert and Jonathan Owens, Adam Cummings, Charnna Gilmore, Chris Jordan, Damion Ciotti, Eli Asarian, Kate Lundquist and Chris Jordan, Emily Fairfax, Ph.D, Kate Lundquist, Katrina Harrison and Tommy Williams, Kevin Swift, Katrina Harrison and Tommy Williams, Nick Bouwes, Ph.D, Nick Bouwes, Ph.D., Sarah Beesley, M.S, Ted Grantham and Julie Zimmerman, Will Arcand, P.G., C.E.G.

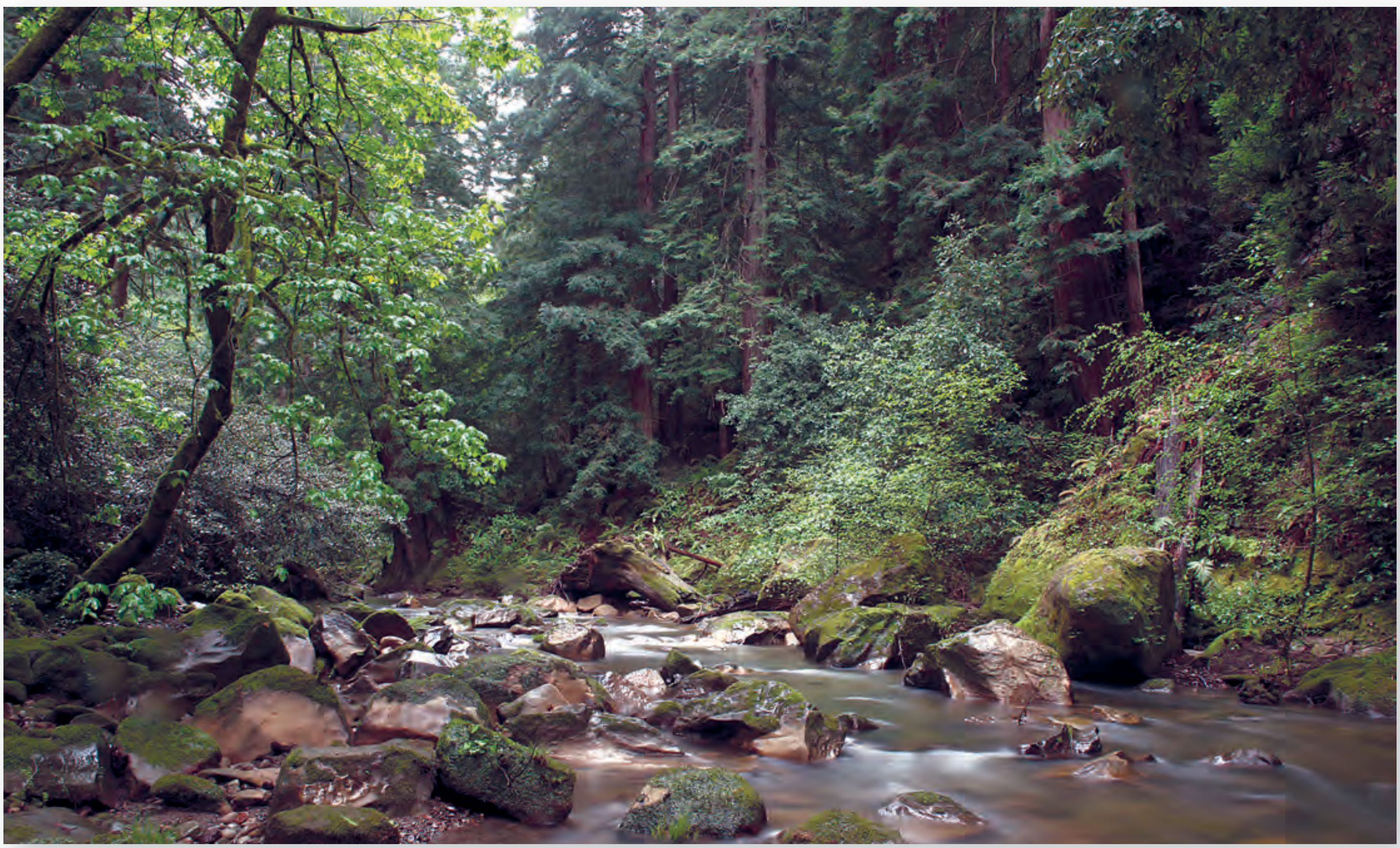
It Takes a Watershed: Fisheries Recovery in the Butano/Pescadero Watershed

Wednesday, April 20

Field Tour Coordinator: *San Mateo Resource Conservation District*

Tour Leaders: ***Amy Kaeser,*** *San Mateo RCD,* ***Jim Robins,*** *Alnus Ecological,* ***Julie Casagrande,*** *San Mateo County Parks,* ***Chris Hammersmark****, cbec Inc.,* ***Ryan Diller,*** *California State Parks,* ***Sean Cochran,*** *CDFW, and* ***Laura O'Leary,*** *Peninsula Open Space Trust*

The Pescadero-Butano Watershed is a critical independent watershed for CCC Coho, is home to myriad special status species, and contains the Pescadero Marsh Natural Reserve which has been a management flashpoint for 30+ yrs. The tour will focus on Butano Creek, the main tributary to Pescadero Creek and will enable participants to learn about solutions and partnerships necessary to address critical stressors of lagoon water quality, fish passage, habitat complexity, sediment transport dynamics, and instream flows. The tour will visit an array of representative projects from headwaters to ocean starting with the marquee Butano Reconnection project within the Marsh and ending in the redwood forests of Butano State Park.



California Environmental Flows Framework Workshop

Wednesday, April 20

Workshop Coordinators*: Ted Grantham,* *Dept. Environmental Science, Policy, and Management, University of California, Berkeley;* ***Julie Zimmerman,*** *The Nature Conservancy, and* ***Kris Taniguchi-Quan, Ph.D.,*** *Southern California Coastal Water Research Project*

The California Environmental Flows Framework (CEFF) is a management approach to efficiently develop environmental flow recommendations for California's rivers. CEFF is structured in three sections. First, statewide models are used to estimate ecological flow needs based on the natural ranges of functional flows for every stream reach in California. Second, these flow needs can then be revised at the watershed or local scales, taking into account non-flow impairments, specific ecological objectives, and available data from site-specific studies. The outcome of the first two sections of CEFF are ecological flow criteria—quantifiable metrics that describe ranges of flows that must be maintained within a stream and its margins to support the natural functions of healthy ecosystems. The third section outlines a process for addressing non-ecological flow needs and developing environmental flow recommendations that take human uses and other management objectives into consideration. This workshop will provide an overview of CEFF, introduce technical tools that were developed to support CEFF implementation, and highlight case study applications that are completed or underway. The workshop will include presentations and interactive elements and will be oriented towards practitioners working to assess and protect environmental flows in California's rivers and streams.

Rancho Cañada Restoration Project Tour

Wednesday, April 20

Tour Coordinators*: **Katrina Harrison,** McBain Associates,*
*and **Tommy Williams, Ph.D.,** NMFS, Southwest Fisheries Science Center*

The tour will focus on the lower portion of the Carmel River watershed where the Rancho Cañada Golf Course is being removed and restoration of the site for public access, parklands, and river restoration are being planned. Staff from the NMFS, Monterey Peninsula Regional Park District, Trout Unlimited, California Coastal Conservancy, McBain Associates, and others will provide an overview of the project and tour of the restoration site. On-site presentations will include various aspects of planning activities with a focus on restoration of stream channel and active floodplain including:

- Floodplain and rearing habitat design in an incised setting
- Modeling salmonid benefits for evaluating restoration design concepts
- Restoration near the urban interface
- Building coalitions for restoration
- Managing multiple benefits on public lands
- Educational opportunities for a range of constituents
- Consideration of basin-wide conditions and the role of lower floodplain restoration

Low-Tech Process-based Restoration with Beaver and Wood: Jump-Starting Structurally Starved Streams Workshop

Wednesday, April 20

Workshop Coordinators*: Eli Asarian, Riverbend Sciences, Kate Lundquist, Occidental Arts & Ecology Center and* **Chris Jordan, Ph.D.***, NOAA, NMFS, Northwest Fisheries Science Center*

The scale and severity of river impairment globally cannot be meaningfully addressed solely using traditional hard-engineering restoration approaches. This workshop will be an opportunity to share recent developments in the evolving science and practice of low-tech process-based restoration (LTPBR) of riverscapes. LTPBR is the practice of adding low unit-cost wood and beaver dams to riverscapes to mimic functions and initiate specific processes that improve river habitats. This workshop will provide an introduction to the LTPBR restoration approach and case-study examples from recent and ongoing LTPBR projects from the Western U.S. including California, Utah, Nevada, Oregon, and Washington. Presentation topics will include:

- Overview/introduction to the LTPBR restoration approach
- Effects of LTPBR on geomorphology, hydrology, hydraulics, habitat, water quality, salmonids and other organisms, and ecosystem drought and fire resiliency
- Updated case studies from restoration projects using beavers and wood
- Models and tools for prioritizing LTPBR site selection and evaluating outcomes
- Restoration construction techniques and implementation lessons learned
- Pathways for permitting LTPBR projects and restoring beavers in California

Presentations will be interspersed with panel/group discussions.

Low-Tech Process-based Restoration with Beaver and Wood: Jump-Starting Structurally Starved Streams Workshop

Wednesday, April 20

Introduction to Low-Tech Process-Based Restoration of Riverscapes Design Principles

Chris Jordan, Ph.D., *NOAA/NMFS/NWFSC (Presenter), and Co-authors:* ***Nick Bouwes, Scott Shahverdian,*** *and* ***Joe Wheaton,*** *Utah State University*

In this presentation, participants will be introduced to the principles underlying low-tech process-based restoration (LTPBR) of riverscapes. Participants will be introduced to cost-effective, low-risk techniques that can be implemented at large scales to meet riparian and instream habitat restoration goals including: partnering with beaver, beaver dam analogues (BDAs), post-assisted log structures (PALS), and other simple hand-built structures designed to facilitate process-based restoration of degraded riverscapes.

Structural Starvation: Design Examples of Low-Tech Process-Based Restoration Across a Diversity of Riverscape Forms.

Nick Bouwes, Ph.D., *Utah State University (Presenter), and Co-authors:* ***Sabra Purdy****, Anabranch Solutions, Inc.,* ***Stephen Bennett*** *and* ***Nick Weber,*** *Eco Logical Research, Inc.,* ***Chris Jordan, Ph.D.,*** *NOAA Fisheries, and* ***Joe Wheaton,*** *Utah State University*

Structural starvation is perhaps the most common form of process impairment in the riverscape settings appropriate for low-tech process-based restoration (LTPBR) methods. In this presentation, we will compare and contrast the design challenges presented by structural starvation in three very different bio-geomorphic settings: Bridge Creek (Lower John Day River, central Oregon, John Day Clarno Uplands EPA Ecoregion IV), Asotin Creek (Snake River, southeastern Washington, Lower Snake and Clearwater Canyons EPA Ecoregion IV), and Golden Trout Creek (Kern River, southern California, Southern Sierra Upper Montane Forest EPA Ecoregion IV). In each case, the source of potential structure is different (beaver dams, large wood, or wetland vegetation), as are the flow regimes and corresponding system dynamics. However, the basic principles and design methods for LTPBR apply well in each setting.

Four Criteria for Process-Based Restoration of Streams

Damion Ciotti, *U.S. Fish and Wildlife Service (Presenter), and Co-authors:*
Jared McKee*, U.S. Fish and Wildlife Service;* ***Karen Pope,*** *U.S. Forest Service;*
G. Mathias Kondolf, *University of California, Berkeley; and* ***Michael M. Pollock,*** *NOAA Fisheries*

Beaver biomimicry and other forms of low-tech process-based restoration (LTPBR) are most effective when implemented under a broad, process-based restoration approach that addresses impairments such as land management practices or infrastructure constraints on the stream. Four criteria or measurable attributes of a project are described that help practitioners evaluate if actions restore the self-healing capacity of the stream and increase the potential for LTPBR applications: the expansion of fluvial process space and connectivity lost because of human alterations, the use of natural energy (e.g. stream-flow or beaver activity) to do the work of restoration, the use of native materials that do not over-stabilize project elements, and the explicit incorporation of time and adaptive management into project design to place sites on recovery trajectories as opposed to attempts to "restore" sites via a single intervention. Applications include stream and infrastructure design and low-carbon construction. Examples in California's Sierra Nevada are presented.

Design Tools and Spatial Analysis to Support Low-Tech Process-Based Restoration of Riverscapes

Chris Jordan, Ph.D., *NOAA Fisheries (Presenter), and Co-authors:* ***Stephen Bennett*** *and* ***Nick Weber,*** *Eco Logical Research, Inc.;* ***Philip Bailey,*** *North Arrow Research, Inc.;* ***Nick Bouwes, Scott Shahverdian,*** *and* ***Joe Wheaton,*** *Utah State University*

Designing riverscape scale low-tech process-based restoration (LTPBR) is not a structure-by- structure engineering effort, but it does require extensive context-setting information in the form of floodplain delimitation, reach typing, and vegetation and flow potential mapping to establish an appropriate framework for the type, purpose and density of intervention actions. Mobile and desktop platform design tools are being developed to support planning, design, implementation, and project tracking. Several of these tools, plus novel analytical spatial data sets, will be reviewed as methods to support consistent design and implementation of LTPBR projects. In this presentation, we will preview a QGIS plugin that supports consistent planning, design, and assessment of LTPBR projects, and summarize the LTPBR implementation and monitoring protocol that supports a set of protocols and metrics for conveying designs and monitoring project outcomes. We will also describe the Riverscapes Consortium suite of context spatial data products, and introduce the LTPBR explorer website, in development, but meant to drive discovery of LTPBR projects, project partners, and locations.

Thinking Outside the Floodplain: A LiDAR-based Tool to Assess Stream and Floodplain Connectivity

Adam Cummings, M.S., *U.S. Forest Service, Pacific Southwest Research Station (Presenter), and Co-author:* ***Karen Pope, Ph.D.,*** *U.S. Forest Service, Pacific Southwest Research Station*

Put a group of restoration practitioners in a degraded meadow, and in short order you'll find them kicking dirt around an attention-grabbing gully or head-cut discussing options for fixing them. But these features often represent symptoms of altered flow regimes rather than causes. Any number of source problems may occur upstream of these scars, such as diversions, constrictions, and ditches that have been long since monumented into the landscape by roads, culverts, and other disturbances. The application of modern, freely-available data and tools can help get our heads out of the head-cuts. Here we describe a LiDAR-based streamflow analysis tool designed to expand the perspective and scope of restoration assessments and then focus attention on source problems that hold the impaired area in poor condition. We developed the tool using open-source and free software to unite high-resolution terrain maps with detailed streamflow analyses through a Google Earth platform. It allows for three-dimensional exploration of watershed features, color-coded by their elevational relationship to stream height. The user can easily pinpoint disturbances and disconnections in the stream network and locate the best places to rectify problems. Restoration of meadow and floodplain surfaces benefit from a watershed view of historical alterations so that we can remove these impediments to physical and biological processes that accelerate natural system recovery. An example of the tool's application is provided for the upper Deer Creek watershed, Tehama County, California.

Using Remote Sensing to Inform Beaver-Based Restoration: How to Get Started with Satellites and GIS Tools

Emily Fairfax, Ph.D., California State University Channel Islands

Beavers are a classic example of ecosystem engineers. The combination of their dam building, canal digging, and tree coppicing can rapidly transform even heavily degraded streams into robust, resilient riparian zones in a very short amount of time. Recent research has shown that these beaver-dammed riparian zones are particularly resilient to climate-exacerbated disturbances, such as floods, droughts, and wildfires. It's no surprise that environmental professionals are increasingly interested in partnering with beavers in river restoration and salmonid conservation projects. However, monitoring the effectiveness of these kinds of projects at the landscape scale, especially during events like fires and floods, can be challenging.

Relying solely on field methods in these environments presents a number of issues: it is time-consuming, resource-intensive, and often unsafe during disturbances. Additionally, collecting baseline data pre-restoration in the field is not always possible due to funding or time constraints. Without high-quality baseline data, it is harder to accurately assess the impact of different restoration actions. Using remote sensing methods to supplement field monitoring can avoid most of these issues. There is abundant free satellite data available, it can be accessed in a matter of minutes, and you can do it all from the safety of your computer desk. Furthermore, the archive of usable satellite data goes back decades - that critical baseline data has already been collected passively. Unfortunately, many people do not know how to get started with remote sensing or where to access useful data and tools.

In this presentation, I will demonstrate simple workflows for using publicly available Landsat and Sentinel-2 remote sensing data (false color 8,4,3; false color 12,11,4; and NDVI), evapotranspiration models (METRIC, OpenET), and aerial imagery (e.g. Google Earth Pro) to characterize the connectivity and productivity of riparian habitat at the landscape scale before, during, and after disturbances. These workflows provide valuable insight into the effectiveness of restoration projects at large spatial and temporal scales.

California's First Beaver Dam Analogues (BDAs) —What Have We Learned Since 2014

Charnna Gilmore, Scott River Watershed Council

Recent studies have highlighted the benefits of beaver pond habitat and how creating man-made beaver dam analogues (BDAs) can help provide critical habitat for endangered salmonids. For the past eight years, the Scott River Watershed Council (SRWC) has been working with BDAs and wood loading projects in the Scott River, a tributary to the Klamath River. SRWC's work focuses on finding opportunities to use low tech restoration as a tool to create process-based change to highly modified systems. SRWC has also successfully advocated for adaptive management in permitting pathways and continues to develop strategies to deal with the rapidly changing climate. This session will focus on these efforts and some of the lessons learned.

Use of Process-Based Restoration Techniques and Tribal Stewardship in a Coastal Tributary of the Klamath River

Sarah Beesley, M.S., *Yurok Tribal Fisheries Department (Presenter),*
and Co-Authors: ***Rocco Fiori, P.G.,*** *Fiori GeoSciences, and* ***Andrew Antonetti, B.S.,***
Jimmy Faukner, B.S., *and* ***Scott Silloway, B.S.,*** *Yurok Tribal Fisheries Department*

Since 2007, the Yurok Tribal Fisheries Department and our partner Fiori GeoSciences have been conducting process-based restoration in McGarvey Creek, a coastal tributary to the Klamath River. McGarvey Creek supports spawning runs of Chinook, Coho, steelhead, and coastal cutthroat trout (natal populations) and serves as vital rearing habitat to juvenile Coho from throughout the Klamath Basin (non-natal populations). Our approach in this watershed includes complementary use of constructed log jams, creation of off-channel wetlands, bioengineering, and installation/stewardship of beaver dam analogues (BDAs). To date, we have constructed four BDA sites in key locations (e.g. biological hot spots) to help support salmonid recovery and boost ecological function. Permitting and installation of these BDAs were possible because of strong working relationships with the landowner (Green Diamond Resource Company), state/federal/tribal resource agencies, and various basin partners. Extensive biological and physical monitoring of the McGarvey BDAs has been conducted to help assess restoration performance and guide our species recovery and watershed stewardship approach. Study findings indicate that the McGarvey BDAs: 1) provide high-quality juvenile rearing habitat; 2) do not appear to hinder adult or juvenile salmonid fish passage; 3) increase localized floodplain inundation frequency and duration; 4) can boost summer rearing capacity in perennial reaches and thus serve as placement sites for juvenile salmonids rescued from seasonally drying reaches of lower McGarvey Creek (and potentially other streams); 5) help retain fluvial transported wood; and 6) create/maintain complex, dynamic habitats even when one or more dams breach. Based on these findings, we intend to install additional BDAs and plan to expand process-based restoration into the upper reaches and explore the use of other “low-tech” approaches (e.g. hand-built log jams) throughout McGarvey Creek to help feed this structurally starved watershed.

Mimicking Beaver Dam Building and Fencing Cattle to Increase Carbon Sequestration and Raise Groundwater Levels in Childs Meadow, California

Kristen Wilson, Ph.D., *The Nature Conservancy, and* ***Sarah Yarnell, Ph.D.****, Center for Watershed Sciences, University of California, Davis (Co-Presenters), and Co-authors:* ***Ryan Burnett****, Point Blue Conservation Science,* ***Karen Pope, Ph.D.****, Pacific Southwest Research Station, U.S. Forest Service, and* ***Evan Wolf, Ph.D.,*** *Applied Ecohydrology Institute*

Numerous wet meadows in the Sierra Nevada and Cascades were drained over the past century to improve livestock grazing. At one such meadow near Lassen Volcanic National Park, we used a before-after-control-impact design to test the effects of fencing cattle out of the riparian area, planting willows, and constructing beaver dam analogues to improve habitat conditions for beaver (*Castor canadensis*). Fencing cattle out of the channel resulted in increased vegetation growth that stored 430 gCO2-Ceq m-2 per growing season, with a smaller effect on carbon storage from the beaver dam analogues (70 gCO2-Ceq m-2) reducing decompositional carbon loss. Fenced vegetation grew on average 40 cm taller and contained 1500 lbs/acre more residual dry above-ground biomass. Willow survival was slightly lower in the beaver dam analogue reach, but height was taller. Beaver dam analogues raised the groundwater elevation 0.3 m higher, 10-20 m laterally from the channel. While beavers did not move into the restoration demonstration site within the first five years post-restoration, we hypothesize that once willow densities increase over time, food availability may eventually lure the beavers into the site. The study demonstrates how process-based restoration focused on beaver-inspired ecosystem engineering can increase carbon storage and groundwater levels.

PBR The Hard Way—Fear, Hype, and the Reality of Your First 1000 Structures

Kevin Swift, *Swift Water Design*

Process-based restoration (PBR) is the new buzzword, so of course there's a bit of hype mixed in with the real potential, and a lot of fear and doubt. Hype is a hassle that drives unrealistic expectations, but isn't the real problem. Fear a project will cause harm, and doubt it will do good, together are the twisted sisters at the null point of restoration, the crippling paralysis driving species extinction as we science away, monitoring ecosystems while they die, afraid to intervene and defaulting to the no-action option.

Uncertainty, on the other hand, is a reality-based spectrum that acknowledges all possible outcomes from project success to failure, and should be embraced as a core principle of all restoration. This presentation is intended to demystify PBR by offering a wide-ranging look at the inner workings of a single company, over the course of building our first 1000 structures, to reduce that fear of the unknown and help improve adoption of PBR.

While using free system energy and on-site materials to repair degraded riverscapes is undoubtedly the most cost- and carbon- effective solution available, these magical BDAs don't just appear on the ground. They have to be hand-assembled, one at a time, using a potent combination of subtle design choices, delicate interpersonal dynamics, careful planning, brute force, suffering and sheer determination. It's not for the faint of heart or idly curious, but does deliver incomparable results, so this presentation provides an overview of some notable process-based restoration projects throughout the west, completed since June of 2018. We'll look at what it took to get them built, successes, and lessons learned from high-level planning considerations down to the detail level of managing disasters in the field. Additional topics include:

- Blitz Design—miles of design per day, with just a phone and a drone
- What's On Your Altar? - the sacrifice dimension of field work
- Ninja Builds—do more with less, faster, while having more fun
- Dogs, Waffles, and Christmas—employee retention and what people really want
- Endangered Species Underfoot—working in Cascades Frog habitat
- The Need For Speed—128 structures in 8 weeks, permits and all
- Faster—60 structures in 4 days, permits and all
- 24—a 24 hour build in a high severity burn area
- The Beerometer—a new metric for carbon burn on projects
- Dream Bigger—sneak preview of the Tasmam Koyom project

Update on California Department of Fish and Wildlife Efforts to Provide a Guidance Document for The Use of Low-Tech Process-Based Stream Habitat Restoration

Will Arcand, P.G., C.E.G., *California Department of Fish and Wildlife (Presenter), and Co-author:* ***Elijah Portugal, M.S.***, *California Department of Fish and Wildlife*

In 1991, the California Department of Fish and Wildlife (CDFW) published the first edition of the California Salmonid Stream Habitat Restoration Manual (Restoration Manual). The Restoration Manual was the culmination of efforts by authors Gary Flosi and Forrest Reynolds, and many others, to provide a comprehensive technical guidance document to stream restoration practitioners throughout the state. During the past 30 years, the Restoration Manual has been widely used by landowners, environmental consultants, resource conservation entities, non-governmental organizations, and regulatory agencies at all governmental levels. The Restoration Manual also provides guidance to CDFW staff during their review and implementation of restoration grants, during project consultations, and while composing Lake and Streambed Alteration Agreements. The Restoration Manual has been updated multiple times since 1991, and in 2015, CDFW's Fisheries Branch and Region 1 staff reinvigorated efforts to update the Restoration Manual to reflect evolving and improving planning, design, and construction methods, and to better reflect the current state of scientific understanding of rivers. During this process, additional chapters were developed to incorporate and support contemporary restoration treatments, such as low-tech process-based restoration (LTPBR). CDFW is in the process of finalizing three guidance documents that will be incorporated into the Restoration Manual. One such guidance document will focus on the use of LTPBR techniques and is the subject of this presentation. To support the completion of this document and to further investigate the efficacy of LTPBR projects in different physiographic regions in California, CDFW staff have identified two potential LTPBR pilot project locations—one in the Little Shasta River watershed, and one in the Eastern Sierra Nevada Mountains on the West Walker River. CDFW staff will present an update on the status of the LTPBR guidance document, and will discuss the process and progress of our pilot project program.

Introducing the California Process-based Restoration Network

Karen Pope, Ph.D., USDA Forest Service, Pacific Southwest Research Station

A diverse group of restoration practitioners, resource specialists, and scientists have recently initiated the California Process-based Restoration (PBR) Network. The Network will serve as a communication hub for people committed to applying stream restoration approaches that capitalize on the system's natural energy and materials to do the work. Focus will be on collaboration and information sharing to increase the application and acceptance of PBR approaches in California. We will address topics including outreach/training, project support, policy/permitting, community engagement, beaver restoration, and research. Please consider joining the Network!

Bring Back the Beaver Campaign Updates

Kate Lundquist, *Occidental Arts and Ecology Center WATER Institute (Presenter), and Co-author:* ***Brock Dolman,*** *Occidental Arts and Ecology Center WATER Institute*

Beaver (*Castor canadensis*) are believed to have historically occupied many watersheds across California. From the late 1700s to early 1900s, the fur trade decimated beaver, greatly altering watershed function across the state. The concurrent genocide of indigenous tribes followed by mining, land clearing, grazing activities and altered hydrology has left many California streams with significant bank erosion, diminished water quality/quantity, and widespread loss of riparian vegetation. The long list of rare, threatened and endangered species currently listed in California is evidence of the extraordinary negative impacts of these practices on biodiversity.

The scientific literature indicates that beaver habitat modifications can substantially alter the physical, chemical, and biological characteristics of river ecosystems. These changes can result in: higher water tables; reconnected and expanded floodplains; higher summer base flows; expanded wetlands; improved water quality; enhanced soils; carbon sequestration; increased forage; and greater habitat complexity and biodiversity. While once abundant, beavers' absence and slow recolonization to their former range across California is being hindered by intolerance and misinformation.

In 2012, the Occidental Arts & Ecology Center (OAEC) launched the "Bring Back the Beaver Campaign" to support resource managers in recognizing the value of beaver and process-based restoration to watershed restoration and listed species recovery efforts in California. Since then, OAEC has been collaboratively working from ridgeline to reef to conduct beaver restoration education, planning, implementation and policy change at local and state levels. In this talk OAEC will provide policy change updates and share recent successes from its work with landowners, communities, tribes, restoration practitioners, agencies, wetland managers, and NGOs to better integrate beaver and process-based restoration into California's resource conservation practices.

18 Years of Managing Mountain Bikes, Sediment, and Legacy Logging to Improve Salmonid Habitat

Wednesday, April 20

Field Tour Coordinators*: Aaron Hébert, Midpeninsula Regional Open Space District and Jonathan Owens, Balance Hydrologics*

Since 2001, the Mid-peninsula Regional Open Space District and Balance Hydrologics Inc. have been working to reduce and monitor sedimentation from 24 miles of roads and trails in a popular mountain biking open space preserve. Threatened salmonid species are present in the creek system downstream, which was historically impacted by forestry activities in the preserve location. Monitoring the effectiveness of road and trail improvements has been performed through V* sediment pool monitoring and stream- and sediment-gaging. Baseline conditions were measured from 2004 through 2007, and are being remeasured during 2018 and 2019.

The field tour will head to the San Gregorio watershed and the El Corte de Madera Creek Open Space Preserve. Participants will hike the roads, trails, and bridges that Midpen rebuilt to reduce sedimentation, enter the mainstem of El Corte de Madera Creek, and learn about stream gaging, sediment sampling, and the basic techniques of V* field data gathering that were used.

Topics will include discussions of logging legacy, large-wood jams, sediment rating curves, and natural vs. human-influenced sediment sources.

Thursday, April 21

Salmon Fishing, More than a Sport: How Salmon are Vital to Native American Culture, Health, and Prosperity

Brook Thompson, Native Scholar, Stanford University

Salmon populations along the Klamath River in Northern California are vital for indigenous peoples living along the rivers. We will be going over how salmon directly affects community, spiritual, physical, and mental health of those living on the Klamath. Investigating how the continued decline of salmon populations and degradation of river water quality, in addition to past trauma, has led to the current crisis. In addition to what takeaways we can learn from indigenous peoples' connection to water and fish to create a more coherent understanding of our connection with waterways.

Adapting to Increasing Drought Intensity: Recommendations for Reform in Policies and Practice

Jeffrey Mount, Ph.D., *Senior Fellow, Public Policy Institute of California*

Allocating water for multiple, often conflicting uses during times of increasing scarcity is the grand challenge of water management in California. This is made more difficult by on-going, rapid changes in climate that are magnifying conflicts between environmental objectives and traditional uses of water. Unfortunately, agency policies and the array of tools available to manage this—century-old water rights laws and half-century-old environmental laws—are insufficient to meet this challenge. Meanwhile, we continue to see decline in the many benefits we rely upon from the state's freshwater ecosystems, including native biodiversity. We need a new approach.

It is time to shift thinking about environmental management. Today, the environment is viewed as a constraint, rather than a priority in water management. As shown during the recent droughts, this tends to disproportionately increase the risk to the environment. In addition, despite years of talking about why we shouldn't do it, we remain focused narrowly on flow for individual life-history stages of species protected by state and federal Endangered Species Acts. Both approaches have not worked.

Here are five modest reforms in policy and practice to get away from our constraint-based, listed species-driven approach to management, with the broader goal of reversing the decline of native species and adapting to changing conditions.

Move toward ecosystem-based management, which focuses on ecosystem condition (structure and function) and integrates human uses of water and land into all phases of management. Messy, complex ecosystems function better.

Make the environment a partner in water management by granting it an ecosystem water budget that can be flexibly managed like a senior water right. This includes water set aside through forbearance agreements or allocations of a percentage of unimpaired inflow to reservoirs and a percentage of storage to manage it.

Set up independent ecosystem trustees to manage this budget, including the all-important planning that is essential for ecosystem-based management. This avoids conflicts of interest that bedevil current constraint-based management efforts.

Commit to ensuring that ecosystem water budgets are used most efficiently and effectively, taking advantage of flexible allocations. This means pairing functional flows or flow-shaping with major investments in structural habitat. One without the other is inefficient and insufficient.

Support restoration at the proper scale. This involves shifting away from low-hanging-fruit-restoration projects to much more strategic, ecosystem-based projects. The latter is harder, but over the course of decades likely to be more effective.

All these proposals are doable under current state and federal laws and can be achieved through regulation or through negotiated comprehensive agreements. However, it would be helpful if the legislature could direct risk-averse agencies to implement this policy change. California has made big changes in water policy before (e.g. the 2014 Sustainable Groundwater Management Act), and it needs to do the same to protect freshwater ecosystems and adapt to changing conditions.

Thursday, April 21

Answering the Question Most of us are Afraid to Ask in Southern Salmon Restoration: Why Bother?

Sean A. Hayes, Ph.D., *NOAA Fisheries Northeast Fisheries Science Center*

There is a question many are afraid to ask. Occasionally a trusted colleague pulls another aside, looking for some combination of hope and validation that their life's work has meaning. Climate change, invasive species, human population growth and a consumption-based economy—these variables all mean one thing—approaching restoration from the principle that salmon will return if we simply put a river back the way 'it was'- will eventually fail. So why bother?

Only after we accept there is no going back, can we go forward. But how? The mindset that restoration means 'go back', must shift to 'go forward' with new goals. The current goal is self-sustaining populations of native fish stocks. Thinking temporally, a native stock is composed of some collective of life histories that produced an evolutionary stable strategy for a time under a set of environmental conditions. In reality those conditions were never stable, and a stock that persisted was one that perpetually evolved, or failed, retreated, and came back as something different. Humanity has accelerated selective pressures to the point where species failure without intervention is increasing.

Here, we share our discussions of "why" and "how" salmon recovery moves forward and hope to learn yours. First "Why (bother)?" Salmon have been part of these ecosystems for thousands of years with deep connections to Indigenous peoples. Losing salmon is more than an ecological disaster, it is a justice issue. Moreover, southern stocks have adaptations that may increase the pace of adaptation to climate changes in northern stocks. Salmon have long fascinated ecologists as keystone species that define the ecosystem around them. That power extends well beyond the wild environment, to influence societal goals. No economist could justify all the efforts toward salmon restoration unless they somehow capture their social power. The average citizen can't grasp the consequences of our consumptive economy, and put little thought into the convenience of a faucet or a light switch. But if you tell them "there will be no salmon tomorrow" something changes. Suddenly ecosystem issues they could not care about for their own wellbeing, must be fixed to save salmon. This creates a political mandate, with scientists and managers sent forth to ensure coexistence. We propose the term "keystone management species" for this phenomenon where society will move rivers (which move mountains) to save something for a salmon, when they wouldn't save it for themselves.

Moving forward with 'how', we propose applying management solutions within the RAD (Resist, Accept, Direct) framework. Traditional efforts have been in the 'Resist' category. To move forward we must 'Accept' that many ecosystems which supported self-sustaining populations will cease to exist. This might require accepting perpetual intervention to maintain linkages to ecosystems and people. But there is the potential to 'Direct' by intentionally moving the ecosystem and the fish to some new state that achieves self-sustaining populations. Finally, within this framework, we encourage pursuing Traditional Ecological Knowledge. Thousands of years of success shouldn't be ignored and gives hope.

Protecting and Restoring California's Ocean Ecosystems

Margaret Spring, ***Chief Conservation and Science Officer, Monterey Bay Aquarium***

The health of our ocean and coast is under threat. A range of unsustainable practices on land and at sea have resulted in fishery declines, ocean pollution and habitat destruction—all exacerbated by climate change. Fortunately, we have tangible examples of how to reverse impacts, and at the state, national, and international levels there are efforts to tackle these problems.

California has led the way in addressing ocean threats, from climate to plastic, and the protection of salmonids is a part of this story. But many populations are still declining, especially along the southern extent of their North American range. Recent research has also raised the alarm about the impacts of microplastics on salmonids, along with many other ecosystem and wildlife impacts.

The Monterey Bay Aquarium and its technology partner, MBARI, are researching the risks facing West Coast salmonids. This includes automated eDNA methodologies to better measure abundance of salmonid populations within rivers, and studies of microplastic pollution in the ocean. We hope these efforts will help resource managers develop effective strategies to protect and conserve coastal ecosystems.

Approaches for Management and Restoration of Central California Coastal Lagoons

Thursday Afternoon Concurrent Sessions

Session Coordinators*: Dane Behrens,* *ESA; and* ***Jim Robins,* *Alnus Ecological***

Coastal lagoons are a vital part of the California coastline, acting as links in the sediment supply chain that form sandy beaches along the shoreline, and as critical habitat for native species. Because of their location, they are frontlines for climate change impacts from both the coastal side (sea-level rise) and from the upstream side (increased runoff variability). Climate change is anticipated to create extensive change to the long-term function and fate of these systems. At the same time, the historical backdrop includes a host of legacy impacts to the hydrograph and sediment supply, as well as development encroachment within the floodplain. While this is the reality for most of coastal California, there is a particular urgency in central California, where a small number of coastal lagoon systems have disproportionate importance as homes for threatened and endangered species, such as the California Central Coast Steelhead, California Central Coast Coho salmon, and tidewater goby.

This session will showcase novel approaches for restoration, monitoring, and long-term management that are being developed in central California. Speakers will include: restoration practitioners that will highlight recent efforts to improve habitats and add long-term resilience to climate change, local fisheries biologists that will discuss recent advances in monitoring methods and how they are being implemented in the field local resource agency staff that will discuss how long-term planning approaches are evolving to meet the challenge of climate change. This session will integrate with site tours of local sites, including Scotts Creek and Pescadero.

Considerations for Management of the Mouth: State of California's Bar-Built Estuaries

Kevin O'Connor, *Moss Landing Marine Labs (Presenter), and Co-authors:* ***John Largier, Ph.D.,*** *Bodega Marine Laboratory, and* ***Ross Clark,*** *City of Santa Cruz*

There are numerous small bar-built estuaries (lagoons) along the coast of California that provide important habitat function for endemic species including salmonids listed under the Endangered Species Act (ESA). At many of these estuaries there are ongoing conflicts among landowners, community stakeholders, agencies, and organizations regarding sandbar management and favorable habitat function. More than 25 of these bar-built estuaries are mechanically breached under state and federal permits. Agency staff struggle to determine if, when, and how breaching can occur and how permit conditions can best help to manage the resource and protect the various species and environmental services. The National Marine Fisheries Service (NMFS) and other federal and state agencies currently address these conflicts on a case-by-case basis in response to a proposed breaching action or in response to restoration proposals for individual systems. NMFS West Coast Region provided grant funding to develop considerations for regulatory agencies to improve management, restoration, and protection of coastal lagoons in California when breaching actions are needed. This pilot project has investigated the utility of existing data to document changes in environmental parameters and functions within systems under varying bar management regimes. The report provides an evaluation of how various breaching techniques may affect lagoon species and services and makes recommendations regarding selection of enhanced monitoring strategies that better document changes in the resulting condition. The analysis is intended to better inform future regulatory oversight and support a more consistent, state-wide, science-based approach to management of California lagoons.

Logging, Leather, Lime and, "Lost Boys"—Reducing Limiting Factors for Anadromous Salmonids in the San Lorenzo River Lagoon

***Chris Berry,** City of Santa Cruz (Presenter), and Co-authors:* ***Scott Ruble,** City of Santa Cruz;* ***Jeff Hagar,** Hagar Environmental Science;* ***Nicole Beck,** 2NDNATURE, LLC;* ***David Revell,** Integral Consulting Inc.; and* ***Bob Battalio,** Environmental Science Associates*

The San Lorenzo River watershed has a long history of suffering negative anthropogenic impacts as well as the distinction of formerly being one of the healthiest anadromous salmonid fisheries south of San Francisco. While significant water development from the watershed goes back to the mission days of the late 1700s, the post-Gold Rush era was characterized by substantial land use and water development activities that substantially impacted the watershed. During the latter half of the 20th century, the growth of upper watershed communities, legacy impacts of 19th century land uses and flood control activities in the lower watershed have also strongly influenced the watershed's ability to support Coho and steelhead populations due to channel simplification, water diversion, groundwater overdraft, riparian vegetation removal, streambed sedimentation, water quality degradation and related issues.

However, flood control planning for the lower San Lorenzo River and lagoon was among the first in the state to include requirements for retention of riparian vegetation and recommended instream flows for the protection of anadromous salmonid rearing and other beneficial uses of water. In recent years, the City of Santa Cruz (in partnership with the California Department of Wildlife and the National Marine Fisheries Service) has developed and implemented instream flows which are substantially higher than have been present historically and which directly benefit the lower San Lorenzo River and lagoon functions. Great effort has also gone into management of the sandbar at the mouth of the San Lorenzo River recently and plans are currently underway for installation of a water level control structure that will provide greater lagoon stability and enable further improvement of the habitat there. These management actions have been informed by a long-term water quality and fisheries monitoring program that is amongst the most robust of all California coastal lagoon monitoring programs.

Concurrent with this work, the city has also partnered with numerous stakeholders on a variety of activities widely ranging from houseless persons camp management to regional water supply planning. These activities aim toward improving the overall conditions of the watershed—understanding that a well-aligned, watershed-wide restoration effort is instrumental for the provision of conditions necessary for anadromous salmonid recovery success as well as protection of other beneficial uses of water. These efforts will not only benefit anadromous salmonid rearing in the San Lorenzo River lagoon, but also protect other important beneficial uses such as municipal water supply and recreation from headwater tributaries near Skyline, all the way to the San Lorenzo River lagoon where the river enters the Pacific Ocean at the Monterey Bay National Marine Sanctuary.

With a long-term commitment to fisheries conservation, including dedicated funding for monitoring and restoration ultimately being enabled by the City of Santa Cruz Anadromous Salmonid Habitat Conservation Plan, science-based management of the San Lorenzo River and its lagoon will be supported into the future—providing hope that the river may once again reclaim its position as one of the state's most important anadromous s almonid watersheds.

Lessons Learned from Eight Years of Lagoon Management of the San Lorenzo River, Santa Cruz, California: Using Sand to Balance Ecological Function and Social Demands

David Revell, Ph.D., *Integral Consulting (Presenter),*
and Co-authors: ***Scott Ruble*** *and* ***Chris Berry****, City of Santa Cruz*

The San Lorenzo River Lagoon lies at the mouth of the San Lorenzo River and the Pacific Ocean in Santa Cruz, California. As a bar-built estuary in the middle of an urban environment, it is a complex, dynamic system that has been heavily altered by human activities. The San Lorenzo River used to host a run of 25,000 salmon annually, and like many urban altered watersheds, have seen these numbers plummet. It is also the first place that surfing came from Hawaii to the Mainland.

The urban environment requires a multi-objective approach to balance community, flooding, water quality, marine safety, coastal recreation, the Boardwalk - a national historic landmark, and threatened and endangered species including the tidewater goby, steelhead, and several salmon species.

There is hope in this system. In 2014, the City of Santa Cruz began active management of the lagoon. In 2019, the first pink salmon since 1915 was documented. Beginning in 2012, the city began documenting water quality parameters in the lagoon and have generated a substantial data set to support management of the lagoon.

This presentation will discuss the myriad challenges that have changed and altered the lagoon, and the current functioning of the lagoon. We will share lessons learned from eight years of river-mouth management as well as share a proposed (and permitted) long-term solution for lagoon management. These lessons learned will help other communities better manage their bar-built estuary systems.

Butano Marsh Channel Reconnection and Resilience Project: Design, Implementation, and Preliminary Results

***Chris Hammersmark,** cbec Inc. and **Ryan Diller,** California State Parks (Co-presenters), and Co-authors: **Jai Singh,** cbec Inc., and **Jim Robins,** San Mateo RCD*

This multi-objective project addressed critical fish passage, water quality, and flood risk challenges affecting Butano Creek, Pescadero/Butano Marsh and the community of Pescadero in unincorporated San Mateo County, CA. Anthropogenic disturbances to the watershed significantly increased sediment delivery to Butano Creek and Marsh. Prior to project implementation, the creek channel was no longer discernible for over a half-mile length due to sediment accumulation and subsequent vegetation colonization that had filled the channel. The resulting condition was nearly impassable for salmonids, specifically endangered Central California Coast Coho Salmon and threatened Central California Coast Steelhead. Compounding these challenges were the regular development of high levels of anoxia in Butano Marsh which previously caused devastating annual fish kills in Pescadero Lagoon following natural breaching events. The loss of Butano Creek's conveyance capacity also contributed to chronic flooding of Pescadero Creek Road, following even moderate rain events, disconnecting the town from its main access route and emergency services.

While the issues of fish passage, water quality, and flooding have been the source of controversy and enmity across stakeholder groups for decades, the five years leading up to the project saw a tectonic shift in collaboration and cooperation amongst key stakeholders. While this shift can be attributed to myriad factors, several key mechanisms appeared most significant: (1) an RCD-led effort to identify solutions to flooding along Pescadero Creek Road; (2) scientific research on the mechanisms, drivers, and impact of anoxia on aquatic resources; and (3) a realization that the loss of a defined creek channel through Butano Marsh was a common variable contributing to water quality degradation, lack of escape habitat and fresh water inflows during poor water quality conditions, and chronic road flooding. Moreover, with significant flooding in the winter of 2017 and documentation of a massive fish kill in 2016, the planning paradigm shifted from a focus on the risks associated with action to the risks associated with inaction. This shift resulted in a unique opportunity for collaboration among disparate interests in developing a solution to these long-standing problems.

Project construction was completed in October 2019 and included excavation of accumulated sediment from the Butano Creek channel to reestablish fish passage and to reduce flooding of Pescadero Creek Road during low magnitude, frequently occurring events. This sediment was beneficially reused to selectively aggrade Butano Marsh, filling in relic ditches, borrow pits and other man-made low spots that generated anoxic conditions and allowed anoxic water to rapidly drain from the marsh into the lagoon following breaches. Preliminary field observations and monitoring data are beginning to the show that these actions have: restored salmonid access to upstream spawning habitat, enhanced refuge during periods of poor water quality and ameliorated the conditions that create anoxic water and drive fish kills. Specifically, Butano Creek now maintains sufficient dissolved oxygen concentrations within the upper freshwater stratum to support salmonids during breach events. Meanwhile the Butano Marsh still produces anoxia but the project has reduced the volume and rate at which the system drains into the downstream lagoon.

Pescadero Marsh: A Bar Built Estuary's Importance to Steelhead

Sean Cochran, *District Fisheries Biologist, California Department of Fish and Wildlife (Presenter), and Co-Author:* ***Patrick Samuel,*** *Bay Area Director, California Trout*

Pescadero lagoon has been regarded as a regionally significant and ecologically important resource along California's Central Coast. Like in many other nearby watersheds land use changes including agriculture and forestry have resulted in profound changes to the ecosystem and the lagoon's fish population. In our presentation, Sean will present seven contiguous years of results that California Department of Fish and Wildlife, California Department of Parks and Recreation, Caltrout and other partners have collaboratively collected on steelhead trout (*Oncorhynchus mykiss*) populations and water quality conditions in the lagoon. We will highlight how populations of lagoon rearing Central California Coast steelhead trout have fluctuated in the face of drought, fire, management, and restoration efforts to improve the lagoon's water quality and prevent the occurrence of catastrophic fish kills, which were common in past decades. We will also examine how lagoon water quality in particular affects steelhead growth and population estimates and will present insights on fish age and life history we gained from examination of scale samples collected during sampling.

Building on the lagoon sampling, Patrick will present findings from two years of tracking steelhead tagged with Passive Integrated Transponder (PIT) tags utilizing two PIT tag antenna arrays stationed upstream of the lagoon. This work was made possible through partnerships and continues the body of work in other nearby Central California Coast streams (e.g. Scott Creek) to document steelhead life history diversity. Our findings may offer clues as to why Pescadero remains a stronghold for steelhead south of the Golden Gate bridge.

Projecting Habitat Evolution in the Face of Sea Level Rise, a Case Study in Pescadero Marsh

***Matt Jamieson**, Integral Consulting (Presenter), and Co-authors: **David Revell**, Integral Consulting; **Ross Clark** and **Kevin O' Connor, Ph.D.**, Central Coast Wetlands Group; and **Jim Robins** and **Andrew Hall**, San Mateo County RCD*

The Pescadero Marsh is the largest estuary between the Monterey Bay and San Francisco Bay. It has had a wide variety of challenges ranging from agricultural and flood control alterations, to upstream watershed logging affecting sediment supply, various restoration efforts, and future sea level rise. Habitats in bar-built estuaries on the Central California Coast are not dependent solely on tides, but rather the duration of inundation during the full suite of inter and intra annual open and closed lagoon conditions.

This study applies a new approach to evaluating potential future habitat evolution based on recently collected water levels across the lagoon as well as a San Mateo County sea-level rise vulnerability assessment that considers different sea level rise scenarios. While most lagoon sea level rise assessments identify the acreage of wetlands that will get wet, this new approach applies recently collected water level data and topography with specific field collected habitat/ water level duration assemblage relationships across various parts of the Marsh. Using high resolution topographic data following the 2020 Butano Creek channel restoration this method projects habitat evolution into the future that considers 5 feet of sea level rise and provides recommendations for future studies and management actions that could improve the viability of the Pescadero Marsh.

Lightning Tales Where Wisdom Sails

Thursday Afternoon Concurrent Session

Session Coordinators*: Eli Asarian,* *Riverbend Sciences, and* *Sarah Phillips,* *Marin RCD*

This session will feature “lightning” (5-minutes or less) talks in which presenters share nuggets of inspiration and wisdom relevant to restoration. Here are some thought-provoking questions to help your brain start flowing:

- What’s the best advice anyone has ever given you that you find yourself applying to your work in the field of restoration?
- What›s your favorite book/article/lecture/quote that›s relevant to restoration, and how does it guide and/or inspire your work?
- Who has had the greatest impact on you and why?
- What have you found to be a hidden gem that needs more time in the limelight?
- What do you know now that you wish someone had told you years or decades ago?

Share a distilled and focused insight with the SRF community. It can be anything from a practical tip to a philosophical musing or heart-stirring experience to captivate the audience. Let’s focus on the positives and the possibilities. We welcome any and all to come share their gems of wisdom that have carried them through the days, months, years, or decades in their practice of restoration. Whether this is your first conference or you’re an old-timer, we want to hear from anyone who is willing to impart such valuable wisdom to our restoration community. We aspire for people to leave this session feeling replenished, motivated, energized, and connected.

Creating a Watershed Moment for a Watershed Approach to Fish Passage

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

The NOAA watershed approach is a conceptual framework to help guide fish passage for NOAA Fisheries’ trust resources. This conceptual framework relies on two guiding principles (or tenets) that provide NOAA Fisheries with a consistent framework to implement a watershed approach with external partners. These tenets are: 1) An iterative and adaptive process that is, 2) supported by a foundational understanding (or pillars) of the natural and human environment. Sounds simple, but creating a holistic approach (headwaters to ocean) is anything but. Overview and insight into the making of a watershed approach to inspire your own watershed moment.

RAD Thinking May Mitigate SBS

Brian Cluer, *NOAA Fisheries West Coast Region CCO*

During the course of my several decades as a student of landscapes, riverscapes, and salmon-scapes in particular, it has become increasingly apparent that the rivers we are trying to conserve and restore are a lot more impacted by past land uses than we (the royal we) are aware of. I make this claim through the lenses of a geomorphologist, and can only imagine how implausible or possibly hysterical that may sound to those not trained in reading landscapes. And of course, the pace and scale of ecosystem change is not slowing down. There is a formal term for progressively ‘forgetting’ what the environment was like; it is shifting baseline syndrome (SBS).

In my presentation, I will explain SBS by giving a couple of examples of how we completely misunderstood alluvial valleys and the streams flowing on them, and why that fundamentally changes our concept of restoration. I will conclude my lightning presentation by introducing RAD, an emerging concept in various fields of ecology that questions how effective it is to continue a traditional focus on resisting ecosystem change, by also considering whether accepting past and inevitable future change and directing it along some desirable pathway is more feasible, practical and appropriate under many circumstances.

Lessons Learned from 40 years of Watershed Restoration

Don Allan, *Mad River Alliance*

This talk will reflect on lessons learned throughout my career as a project manager and landscape contractor. Throughout my career I primarily worked for a non-profit organization on scores of projects that included everything from conducting road and watershed assessments to planning and implementing wetland and stream enhancement projects to building trails. The keys to developing and implementing successful projects varied from project to project depending on who the landowner(s) was, what the funding source(s) was, the goals and objectives of the project, and whether they fit the criteria of the funding program. My biggest project had a total budget of $10 million and took more than 15 years to get from the initial landowner agreements and grant applications to the final phase of implementation. I will use examples from that project to demonstrate the strategy that ultimately was successful in bringing that project to fruition.

How to Maximize your Grant Writing Efforts

Steve Madrone, *Humboldt County Supervisor*

In this competitive world we live in, with limited resources, how does one prioritize the work we do as Non-Profits and Tribes. There are so many grant opportunities and how do you decide which ones to go after. Time is money and with limited resources and staff how do you maximize your efforts and be successful at getting the proposals you submit funded. If you are only getting a fraction of the proposals you submit funded, then you are going to burn out staff and not have the funds to do the valuable work you do.

This Lightning talk will offer suggestions for how to prioritize proposals that are likely to be funded. I will share my thoughts and experience from over 40 years of successful grant writing with an overall success rate of over 80% funded.

Creek Incision Prevention/Fish Habitat Creation

Freddy Otte, *City of San Luis Obispo*

In the world with a changing climate, it is time to start looking at ways to prevent creeks from continually incising and disconnecting from historic floodplains. This disconnection is impacting our riparian forest here on the Central Coast and once the trees die, they fall into the creek and create flood control problems and potential to direct water at road banks next to the creek to compromise infrastructure. If we are forward looking with current restoration practices, we can prevent these problems from happening, keep more moisture in the floodplains by reconnecting and create more fish habitat. Rock weirs or roughened riffles can achieve multiple benefits and are a low-tech climate adaptation strategy.

A Few Nuanced Tips for Getting the Most Out of Large Wood Loading Projects

Thomas H. Leroy, *Engineering Geologist, Pacific Watershed Associates*

Large wood loading into streams is a popular approach to improving aquatic habitat for fisheries recovery, particularly in rivers that have been subjected to past anthropogenic disturbances. Typically, the large wood structures are installed to provide aquatic habitat at site specific locations. Although providing immediate habitat is prudent and appropriate in many locations, these types of individual structures often do not address the dysfunctionality of the processes that collectively, over time, provide the dynamic elements of a naturally self-sustaining fluvial geomorphic environment conducive to developing and maintaining aquatic habitat. The interaction of wood, sediment, and water in streams is what allows habitat to form. Here I provide a few tips on planning and constructing large non-engineered wood loading projects.

(1) Plan objectives specific to your watershed and stream reach- Don't cookbook wood loading for the sake of adding wood to meet numeric targets or for habitat, unless a detailed characterization of the watershed dictates that specific action.....

(2) Think beyond your individual structure- Plan objectives at the reach scale to better address the dysfunctionality of the riverine system processes .... ask yourself, how can my project help normalize watershed hydrology, redistribute substrate and large wood, and improve riparian services.....

(3) Use your streamside opportunity to improve riparian conditions/services- (a) align access routes to allow for shafts of sunlight to hit riffles and stream side areas to improve primary productivity; (b) leave large dead standing and dead downed wood within the riparian zone; (c) reduce riparian stand density and composition in overstocked forests with the goal of allowing 2 canopy layers and appropriate species diversity.....

(4) Construct your wood feature with racked and loose wood built into the jam and pre-rack the upstream portion of the jam with lots of different sized branches oriented in myriad directions- Don't rely on nature to rack wood into your jam, it can take a long time and may never happen....

(5) Don't get hung up on one construction technique, employ the one that is best suited to your site conditions and desired outcome- If your only tool is a hammer, every problem looks like a nail.......

Turning Forest Fuels into Instream Habitat to Benefit Long-Term Ecological Function

Brandt Gutermuth, *Trinity River Restoration Program: Bureau of Reclamation*

Fire frequently takes its toll in Northern California where we engage in river restoration along the Trinity River. Combining river and forest management efforts, for the benefit of human health and the environment, is a simple solution that, with the right planning, can work.

In the local urban wildland interface, we use fuel treatments (primarily thinning), to decrease fire risk and reduce the time it takes for old growth forest habitats to mature. Reducing fuel loading protects our communities, reduces the risk of catastrophic fires, and supports forest resiliency. What is more, removed trees provide the organic material and structure needed to maintain complex river habitat in areas where wood was long ago removed. By sharing our plans openly with land managers and the public, we have gained broad support for this step forward in resiliency and ecosystem function. Our reviewers find common ground in promoting landscape and community health instead of another fire.

Restoration Success While Negotiating with Disney Villains, Plus a Perspective on Time

Alison Willy, *SRF Board Member*

Do you remember rotary phones, party lines, IBM Selectric typewriters? No? They were not that long ago. So maybe, just maybe, it will take your restoration project a lifetime to get off the ground...or in the ground. Change is lightning-fast all around us, but sticky, viscous, change-resistant attitudes can make your project look like Sleeping Beauty or Snow White—asleep but not dead. So, what do you need to do to wake it up? Better yet, what do you need to put into practice to make sure your projects don't fall into a deep sleep due to unhappy compatriots or avoidable pitfalls?

Perfect is the Enemy of Good, A Pragmatic Restorationists Perspective

Mike Berry, *CDFW (retired)*

In my presentation, I will give examples of how striving for perfection has hindered different types of restoration projects that are good for anadromous salmonids, but not absolutely perfect. I will present examples of good fish passage projects that have languished for years because the less than perfect designs are preferred by landowners, but not acceptable to entities funding the projects. I will also give examples of flow requirements where a good compromise could be reached but some entities are holding out for perfection. In each of my examples, I will discuss the real consequence to wild anadromous salmonid population and recovery. My hope in presenting this topic is to revive interest in restoration projects that are beneficial to salmonids, but don't provide a perfect solution.

When Failure Leads to a Plethora of Successes

Sarah E. Phillips, *Marin RCD*

A good friend of mine who embodies the Trout Unlimited mission in every way, Erik Young, really helped me through two of the most intense, complicated, and challenging projects in my 12-year career. The projects included the first ever instream large woody debris installations into residential backyards in west Marin's ever-contentious San Geronimo Valley. Winston Churchill defines success as the ability of going from failure to failure without a loss of enthusiasm. There are many benefits to experiencing failure, even though you may not think so initially. In this talk, I will share how I was able to find successes amidst what at the time felt like a series of ongoing failures. In the field of restoration, it's easy to set the bar so high and equally easy to forget that we are doing the very best we can and to seek those little victories to motivate us to carry on!

How I Began to Listen to Traditional Environmental Knowledge (TEK)

Michael Belchik, *Senior Water Policy Analyst, Yurok Tribe*

It was 1995. I thought it would be a good idea to interview tribal elders about water, given my new job as tribal Senior Biologist. I went into a tribal elder's house, expecting a standard interview. Instead, the interview took a different direction entirely, and we ended up talking about fishing rights. "You want to make the Klamath some park where we just look at the fish. The fish need us to fish for them and to care for them. Just like they care for us." And this is how I began to learn about our role as stewards and our responsibility to the natural world. My lesson I'd like to impart to you restorationists, especially non-tribal folk, is to think about humans as an integral part of the ecosystem rather than something to be overcome. Restoration isn't how to eliminate human influence, it's about how to be good caretakers.

Thinking Like a Natural Historian: Nature Nerd Nuggets from the Professor of Wonderment

Brock Dolman, *Occidental Arts & Ecology Center WATER Institute*

Dr. Kenneth S. Norris was a Professor of Natural History at UC Santa Cruz from 1973 to 1990 and the creator of the UC Natural Reserve System in 1965. His legendary course The Natural History Field Quarter was, for most students, a worldview altering watershed moment which academically anchored the remainder of their professional and personal lives. Ken's rigorous and pragmatic pedagogy not only fed the head but more importantly challenged us to physically and emotionally embody the Natural World through direct participation with what he called Thinking Like a Mountain. Through humility and humor, Norris enticed and cajoled his students into becoming agents of reconnection and reciprocity with our more-than-human kin. This talk will elucidate a sampling of his most salient insights for all students of our life-laden planet and specifically for self-identified salmonid saviors.

What Makes a Good Mentor and Why is a Mentor Important

Ross Taylor, *Ross Taylor and Associates*

Like most professions, who you know is important to a successful career in watershed restoration or fisheries management. Finding a mentor early on is an excellent means in furthering one's education or professional career. Mentors may be sought out, provided or they may just organically occur. Mentors can provide guidance, inspiration, or act as a conduit for networking. Mentors may also provide initial job opportunities and assist in career advancement. The person most influential in my fisheries career was.................

Advice I Lived By...

Mary Power, Angelo Coast Range Reserve

What's the best advice anyone has ever given you that you find yourself applying to your work?

Before I headed down to Panama in 1978, I had a brief conversation with Robert Trivers at Harvard, and he said—"Follow individuals." This is great advice for anyone trying to enter the more than human world, and I first applied it to armored catfish in Panama. Later, my friend Art Stewart said "Mary, you've got to learn to think like an alga", propelling me into the strange miniature world of microbes that unfolds to affect basin-wide processes.

Who has had the greatest impact on you and why? My husband, Bill Dietrich—when I was peering at ecological processes that occurred over cm2 to m2, Bill made me see what I'd experienced but not really registered over scales of kilometers. Bill brought geomorphic and hydrologic context to my appreciation of food web dynamics.

Praise for Phil Pister's Species in a Bucket

Eli Asarian, Riverbend Sciences

Edwin Philip Pister has devoted much of his career and life to conservation of native desert fishes. As an intern at the White Mountain Research Station in Bishop, California in 1999, I had the opportunity to hear Phil tell the story of how he saved the Owens Pupfish. In 1969, the wetland holding the last remaining population of the Owens Pupfish was drying up, and Phil and his colleagues successfully relocated the fish to another spring, saving the species from extinction. During the rescue, Phil carried all remaining individuals of the species in two plastic buckets, treading carefully while pondering the weight of the moment. In this talk, I'll blend my recollections of Phil's lecture, and what it meant to me, with excerpts from his eloquent 1993 article "Species in a Bucket" in Natural History magazine (*https://www.nanfa.org/ac/species-in-a-bucket.pdf*) where he profoundly reflects on why we are here on Earth.

So You Want to be a Stream Scientist

Bill Trush, Ph.D., Cal Poly Humboldt River Institute

Following high school, I wanted to somehow fold art and tennis into an undergraduate biology degree at Penn State. Dr Robert Butler, my advisor, looked me straight in the eye in our first meeting. "Do you want to be a scientist? Well first, we must keep all your art classes. Second, we are going to teach you how to think." He taught me hypotheses are plausible causal explanations for observed phenomena. Not predictions. Dr. Luna Leopold was my Ph.D. advisor at UC Berkeley. His dad, Aldo, defined an ecosystem's health as its 'capacity for self-renewal.' To perpetuate self-renewal, adult salmonids must saturate their watersheds with fertilized eggs to the fullest extent each prevailing water year allows. Our job is to allow them that opportunity, and not to prescribe minimum baseflows that marginally allow riffle passage. Both mentors shaped who I am as an ecologist. Thank you so much.

A Different Perspective and Uncomfortable Conversations

Larry Notheis, *California Conservation Corps*

In my presentation, I will speak about how different perspectives and uncomfortable conversations have both helped me and led me to the greatest change and opportunity. I will share life lessons through a story or two as well as epiphanies that have come my way that have molded me into the restorationist I am. The education, mentorship, work/family/life struggles, and daily opportunities, that we need to make choices about, are the openings for greatness we sometime miss or with hindsight regret. I will talk about my over 39-year history in restoration from Guatemala to Australia, and from Northern Pakistan to Humboldt County. Many people and places have encouraged me to continue on this path and I would be grateful for the opportunity to share what I have learned with SRF, its constituents, and all the attendees in the workshop.

Reflections on a Quarter Century in Waders

Sarah Nossaman Pierce, Ph.D., *California Sea Grant*

Sarah has been dedicated to supporting salmonid recovery through habitat assessment and restoration, fish monitoring and specialized research for the past 25 years. After all that time roaming the streams of the Russian River watershed searching for imperiled salmonids and the answers to how we can help preserve these incredible species so critical to our ecosystem health, one would hope she's gathered some pearls of wisdom! Either way, she's delighted to meet with our amazing community of salmon warriors in-person to exchange stories and reflections, and hopefully share a gem or two.

There is No EGO in Ecosystem Restoration

Anna Halligan, *Trout Unlimited*

Some of the best advice that was ever given to me was to make sure to always give ample credit to all partners involved in a restoration project, regardless of how large or small the role. It's one of the simplest things to do, but can often be overlooked, and it does matter. This presentation will be focused on the importance of developing outreach messaging that ensures that everyone is acknowledged.

Teamwork Makes the Stream Work

Elise Ferrarese, *Trout Unlimited*

Working to recover endangered salmonid species can be overwhelming due to the scale of the problem, the myriad of issues facing these species and the habitats on which they depend, and the impacts of climate change. However, we can look to our peers in the restoration community for inspiration and support, and to improve the effectiveness of our work. Restoration of complex ecosystems and processes requires a distinct and varied set of skills and experiences that can only be tapped into through teamwork. Programs and projects that involve creative collaboration harness the strengths and expertise of the project team and produce better outcomes. Project teammates can also serve as a source of inspiration-everyone who has chosen this line of work has a unique background and an interesting story to tell

Effectively Engaging Elected Officials and Public Agencies to Support and Advocate for Restoration and Conservation Projects

Natalie Arroyo, *Eureka City Council, Redwood Community Action Agency, and Humboldt State University*

This presentation focuses on actionable ways to get support for projects from local and regional governments and organizations.

Cultivating Salmon-Saving People and Partnerships

Dave Kajtaniak, *CDFW*

The resiliency of Pacific Salmon knows no end—whether its surviving multiple years of drought conditions, varied ocean conditions, diminished stream habitat, loss of access, overharvest, etc; they are here and surviving. That is not to say they could use some help from people. In my career associated with the California Department of Fish and Wildlife I have been fortunate enough to work with over a hundred young professionals in the fisheries and watershed science field. Whether it is helping develop the next fisheries biologist, restoration specialist, watershed coordinator, or simply fostering ecosystem consciousness that one will share the rest of their lives, embracing this role has led to numerous positive connections and on-going partnerships . For it is through people and partnerships that we are going to make significant contributions in saving and restoring salmon populations.

Drought Response: Identifying the Science, Policies and Projects Needed to Protect Fisheries and Water Resources in a Drying Climate

Session Coordinators*: Matt Clifford, JD, Trout Unlimited; Monty Schmitt, The Nature Conservancy; and Redgie Collins, JD, California Trout*

The health of California's rivers and fisheries is suffering as a result of persistent severely dry years. These events are not one-offs, but rather a harbinger of our future with climate change. By failing to effectively leverage lessons learned from recent dry years, we continue to be caught unprepared, with management actions coming too late and on too limited a scale to protect streamflows for fish, wildlife, and drinking water supplies. To address this problem, we need a new approach. Plans need to be formulated in advance, so that when dry conditions develop we have implementable, science-based management measure ready to be put into action to protect streamflows.

We must act now to be ready for future dry years or we risk extinction of salmon populations and loss of reliable water supplies for people. This session will explore the policies, science, and water management practices that will enable us to protect the rivers that provide fish habitat and human water supplies in the face of a rapidly drying climate.

Drought Planning in the Western United States: A Review of Drought Plans in the Western States and Recommendations for California's Future Response

Dan Wilson, *NOAA California Coastal Office (Presenter),*
and Co-authors: ***Rick Rogers*** *and* ***Dereka Chargualaf,*** *NOAA California Coastal Office*

The West Coast has been experiencing severe and unprecedented drought conditions, which pose challenges for water supply, human health and safety, agriculture, and fisheries due to instream flows that are critically low. In order to address these challenges, Washington's Department of Ecology, Oregon's Water Resources Department, and Idaho's Department of Water Resources have established statewide Drought Plans which serve as frameworks to prepare for drought conditions and to conduct effective and timely responses to minimize the negative impacts of drought conditions. Drought Plans allow systematic coordination and communication among local, State, and Federal agencies; outline a strategy for monitoring and forecasting anticipated drought conditions; provide a set of emergency drought response tools, including emergency water rights permitting, transfers, and curtailments; and disburse funds to mitigate the negative impacts of drought conditions. Drought Plans also acknowledge the vulnerability of fish during drought conditions and aim to reduce the negative impact of low instream flows by providing response actions to protect wild fish populations and hatcheries in a timely manner. The recovery of California's salmon and steelhead populations listed under the Endangered Species Act (ESA) is challenged by the increasing frequency and intensity of drought. Their survival and recovery could be enhanced through effective and timely implementation of a Drought Plan, especially in coastal watersheds where individual water users aren't supplied by a public or private utility district. In this presentation, we review Drought Plans that are used in Washington, Oregon, and Idaho, and recommend elements of a Drought Plan in California that could increase survival and recovery of ESA listed salmon and steelhead populations during drought.

Exploring Monthly Natural Flow Predictions and Applications to Dry Year Planning to Protect Aquatic Ecosystems

Julie Zimmerman, *The Nature Conservancy (Presenter), and Co-authors:* ***Jennifer Carah*** *and* ***Kirk Klausmeyer,*** *The Nature Conservancy,* ***Gabriel Rossi, Ph.D.,*** *University of California, Berkeley, and* ***Mia Van Docto,*** *Trout Unlimited*

Predictions of the natural flow regime and indicators of unusually low flow during the dry season are helpful in developing approaches to manage streamflow during extraordinarily dry years. To develop predictions of natural flow, we utilized machine learning statistical models to predict natural monthly flows for all stream reaches in California from 1950 to 2015 (the Natural Flows Database) and recently updated the models and database to extend to 2021 (*https://rivers.codefornature.org/#/home*). Predicted monthly flow data can be used to evaluate when dry conditions may pose an extraordinary risk to aquatic ecosystems and in which streams, and to predict extraordinarily dry conditions up to a few months prior to the dry season. We compared the monthly natural flow predictions for a given year to the range of natural flow predictions across the period of record to determine if a critical dry period is expected to occur during the dry season. We determined that extraordinarily dry months earlier in the year (May or earlier) indicated that critical dry conditions are likely later in the dry season. Using the Natural Flows Database, we examined these patterns across the State for different water year types and regions. Such analyses can be used to predict when streamflow conditions are likely to pose an extraordinary risk to aquatic ecosystems and can inform drought planning and management.

Drought Response: An Overview, Lessons Learned, and Moving Forward

Erin Ragazzi, *Assistant Deputy Director, Division of Water Rights,*
State Water Resources Control Board

Within the past decade California has experienced two of its worst droughts (2014-2016 and 2021-????), and dry conditions and drought are expected to become more common throughout California. In response to these droughts, the State Water Resources Control Board has issued drought emergency regulations that provide for curtailment of the water rights to protect senior water rights and provide instream flows for fish, required enhanced water conservation measures, and created improved water supply and demand tools to address the drought conditions. This presentation will look at previous and ongoing drought efforts undertaken by the State Water Board, lessons learned, and discuss where to go from here to ensure we are better prepared to address water supply shortages moving forward.

An Ecological Drought Indicator Framework for California

Ted Grantham, Ph.D., *University of California, Berkeley (Presenter),*
and Co-author: ***Jeffrey Mount, Ph.D.***, *Public Policy Institute of California*

Regional drought indicators are used by water managers and decision makers to assess the risk of water scarcity and determine when curtailments in water deliveries and use may be necessary. However, these indicators typically rely on estimates of regional precipitation deficits and reservoir conditions, rather than measurements of water availability in the landscape and natural water bodies. Commonly used drought indicators also fail to account for water availability in antecedent seasons and years, which has a strong effect on the condition of freshwater ecosystems and aquatic species. As a result, the degree of stress that the environment may be experiencing is often underestimated by conventional drought indicators. We have developed an ecological drought indicator framework that more accurately reflects the impacts of regional drought on freshwater ecosystems in California. It includes three elements: a regional ecological drought index that relies on hydroclimatic data to estimate environmental water availability in the landscape; a hydrologic drought index that assesses stream flow conditions regionally and at individual gauging stations; and a vulnerability index that describes the sensitivity of freshwater ecosystems to drought impacts. The framework is informed by user-defined parameter weightings, which makes it possible to customize the indicator to different regions and ecosystem types, offering a flexible tool to monitor—and inform actions to limit—drought impacts to the environment.

Watershed-Scale Cooperative Solutions: Projects and Approaches to Increase Drought and Climate Resilience to Streamflows, Fish Habitat and Water Supply in Coastal Watersheds

***Mia van Docto**, Trout Unlimited, and **Monty Schmitt**, The Nature Conservancy and Marin Municipal Water District (Co-Presenters), and Co-author: **Linda MacElwee**, Mendocino County RCD*

2021 was the second driest year on record and experts predict that these kinds of drought conditions are increasingly likely as the climate warms. These and future dry years significantly reduce streamflow in the rivers and streams in unregulated coastal watersheds. Low stream flows, further reduced by water diversions and coupled with high temperatures degrade salmonid rearing habitat, particularly in the dry season. Reduced streamflows also impact the reliability of water supplies for farms and communities that depend on direct diversions to meet demands for water. In watersheds including the Russian and Shasta Rivers drought conditions have resulted in curtailment orders by the State Water Resources Control Board. Future dry years fueled by the impacts of climate change are likely to result in more surface water shortages and water right curtailments for water users (Hanak 2015). This presentation will explore projects and collaborative water management approaches that increase water supply reliability by reducing reliance on dry season diversions, improve instream flows for fish and reduce the impacts of future curtailment orders on water users by utilizing watershed cooperative solutions for compliance.

Drought Resiliency in the Klamath Basin: The Yurok Tribe's Strategies and Approach

Michael Belchik, *Senior Fisheries Biologist, Yurok Tribe Fisheries Program;*
and ***Thomas Starkey-Owens,*** *Environmental Specialist, Yurok Tribe Environmental Program (Co-Presenters)*

Members of the Yurok Tribe community are bearing witness to changes within the Klamath River Basin that are linked to extended periods of drought and climate change. Anticipated and observed impacts in Yurok country include rising air temperatures, heavier and unpredictable precipitation, increasing winter flows and flooding, decreasing snowpack, reduced late spring and summer flows, increasing intermittence of stream flow, increasing surface water temperatures, expanding harmful algae blooms and water-borne pathogens, a longer and higher intensity fire season, and more. The lack of adequate infrastructure and heavy reliance on aquatic resources puts the Yurok Tribe at significant risk of adverse tribal health resulting from drought and climate change. For these reasons, the Yurok Tribe have taken a pro-active approach to monitor, mitigate and act on the threats to natural resources and sensitive ecosystems they depend on for their livelihoods, culture, and overall wellbeing.

Case studies are discussed including the Yurok Tribe's Fisheries Program (YTFP) process-based instream restoration activities to increase ground water and floodplain recharge. Additional restoration goals aiming to improve climate resiliency are supported by the Yurok Tribe's long-term use of bioindicators to monitor water quality and quantity. The Yurok Tribe Environmental Program (YTEP) collects benthic macroinvertebrates (BMI) during summer months from study sites representing both perennial and intermittent sections of seven tributaries to the lower Klamath River. Samples have been collected over a 12-year period including critically dry and extremely wet years. Intermittent sites consistently exhibit lower BMI diversity and high proportions of collector-gatherer taxa relative to perennial sections of streams. Additionally, YTEP collects environmental DNA (eDNA) to monitor the presence of sensitive amphibian species in headwater streams. Water quantity in headwater wetland ponds is simultaneously monitored to study the persistence of species through extended periods of drought. Future project outcomes and impacts of climate change on ecologically critical perennial sections of streams is discussed.

LOTIC: Convolutional Neural Networks and Their Place in Monitoring Migratory Fishes

Keane Flynn, University of Nevada

In recent years, advancements in machine learning have led to models that have become highly accurate with minimal detection latency. These factors have allowed for much more practical applications of convolutional and deep neural networks in modern industry. One area of machine learning that has seen unprecedented accelerated evolution is in applications to object detection and image classification, largely due to advancements in graphics processing power. While much of migratory fisheries monitoring relies upon on-the-ground fieldwork and observations, population estimates can be made from underwater video footage from key migratory pathways, for both adult and juvenile populations. Leveraging underwater video in conjunction with these modernized neural networks allows for real time, automated video monitoring of migratory fishes. When combined with network connections to high-speed graphics processing computers or on-location, edge computing devices, computer vision software allows these neural networks to detect, track, and count all observable migratory fishes in real time. Creating open-source software for customizable field applications will liberate the need for arduous fieldwork and allow for a paradigm shift of prioritizing directing human effort towards analysis of fish population and their respective movements at the aforementioned in-situ video observation sites.

Automated Salmonid Counting Using Sonar Data

Justin Kay, *California Institute of Technology (Presenter),*
and Co-authors: ***Peter Kulits, Sara Beery, Suzanne Stathatos,*** *and* ***Pietro Perona,*** *California Institute of Technology,* ***Grant Van Horn****, Cornell University, and* ***Erik Young****, Trout Unlimited*

Accurately measuring and counting the number of salmon and steelhead migrating upstream to spawn is essential in monitoring threatened populations, assessing the efficacy of recovery strategies, guiding fishing season regulations, and supporting the management of commercial and recreational fisheries.

The success of these initiatives depends on accurate and fine-grained data collected in real-time on-site. While several different methods exist for counting freshwater fish, they often suffer from problems associated with mortality, measurement error, and high expense. Many key sites in Alaska, Washington, Oregon, and California are using multi-beam SONAR cameras to count and measure salmon returning to their natal streams. This method eliminates mortality and reduces measurement error. However, because the actual counting is done manually, requiring technicians to count fish by manually viewing in-stream SONAR video, it is expensive and can be slow. An automated system using visual recognition technology could accurately count and measure migrating salmonids around the clock and would lead to cost savings, improve counting accuracy, and reduce reporting times for river conservation and fisheries management initiatives, allowing these programs to scale to cover a broader range of locations and conservation goals.

The Computational Vision Lab at California Institute of Technology (Caltech), in partnership with Trout Unlimited and with partial support from Amazon Web Services (AWS), is developing an automated system for fish counting and measurement. The approach is using state-of-the-art Machine Learning (ML) and Computer Vision (CV) algorithms to analyze multibeam imaging sonar video collected from SoundMetrics ARIS and DIDSON cameras. The ultimate goal is to automatically detect, track, count, and measure migrating salmonids in real-time. We envision a system using on-site cameras and laptops with installed software designed to accurately estimate salmon and steelhead upstream migration, 24 hours per day in-season, transmitting this data in real-time to fishery management personnel for making rapid, detailed, and cost-effective management decisions.

Work on this project began in the Spring of 2019. A dataset of over 400,000 images has been collected and annotated for machine learning from SONAR cameras deployed on the Kenai, Elwha, and Nushagak rivers. An initial proof-of-concept algorithm has achieved promising results.

As of October 2021, we have deployed in the cloud a prototype algorithm and automated counting system for testing by stakeholders at NMFS and ADF&G who were able to upload and analyze a sampler of their videos. Initial feedback has been positive.

Future work will include: evaluating and improving generalization performance on new rivers and data sources; improving algorithms to reduce counting and measurement error; and deploying the algorithm on low-cost “edge” hardware on-site for real-time data analysis and reporting.

Pedigree Analysis of Hatchery Steelhead from the Mad River, California Provides Insight into Life-History Patterns and Informs Management

Andrew P. Kinziger, Ph.D, *Department of Fisheries Biology, Cal Poly Humboldt (Presenter), and Co-authors:* ***Steven R. Fong,*** *Department of Fisheries Biology, Cal Poly Humboldt; and* ***John Carlos Garza, Ph.D.,*** *Fisheries Ecology Division, NOAA Southwest Fisheries Science Center, and University of California, Santa Cruz*

We applied parentage-based tagging (PBT) methods to study steelhead returning to the Mad River Hatchery (MRH), which operates an integrated program that has received relatively little monitoring but supports one of the most important steelhead fisheries in California. We generated SNP genotypes at 96 loci for all adult steelhead broodstock spawned at MRH over a nine-year period (2009–17; N = 1,572) and identified 965 trios (mother, father, and offspring) using parentage analysis. Our analysis uncovered a large difference in the proportion of hatchery-origin broodstock individuals as estimated by pedigrees (0.87) and traditional adipose-fin clipping (0.58). This difference, which presumably resulted from failure to clip or identify a clip in 100% of hatchery-produced fish. Our analysis also revealed the complete age structure of six cohorts of hatchery broodstock and showed how differing age composition and survival can lead to substantial differences in age composition of broodstock in different years for MRH steelhead. Pedigree-based estimates of narrow-sense heritability for spawn date were 0.242 to 0.470, indicating moderate to high heritability, and highlighting the opportunity for a strong response to selection on this trait imposed by hatchery spawning. The application of PBT provided critical information for understanding life history variation and the efficacy of management actions for Mad River Hatchery steelhead, and provides a framework for minimizing domestication selection and associated reductions in fitness for naturally spawning fish in this integrated population.

Comparison of Standard and Environmental DNA Methods for Estimating Chinook Salmon Smolt Abundance on the Klamath River

Doyle Coyne, MS, Cal Poly Humboldt, Kinziger Lab

Evaluating abundance and out-migration timing of juvenile salmonids is critical to conservation and management efforts. Current methods of evaluation are costly and difficult, making their employment at more than a few sites in a basin infeasible. Environmental DNA (eDNA) offers a more efficient method that may be used to increase the accuracy and resolution of sampling efforts. I compared the relationship between flow corrected eDNA estimates (eDNA rate) and traditional estimates of abundance from a rotary screw trap. A model including flow corrected eDNA (stream flow x DNA concentration) and temperature explained 76% of the variation in weekly abundance. These results suggest that eDNA may potentially be used to estimate weekly abundance of out-migrating Chinook salmon smolts.

Comparison of Environmental DNA and Snorkel Surveys for Monitoring Fish Distributions in Rivers

Jason Shaffer, M.S. Student, *Cal Poly Humboldt (Presenter),*
and Co-authors: ***Andrew P. Kinziger, Ph.D.,*** *Cal Poly Humboldt;* ***Eric P. Bjorkstedt, Ph.D.,***
NOAA Fisheries and Cal Poly Humboldt; and ***Andre Buchheister, Ph.D.,*** *Cal Poly Humboldt*

Monitoring programs designed to assess the spatial distribution of aquatic species using traditional methods require significant effort to attain estimates of species distributions at broad spatial scales. Environmental DNA (eDNA) surveys have been shown to be less labor-intensive and have higher detection probabilities than traditional survey methods, especially when targeting rare or episodic species. However, the application of eDNA in basin-wide monitoring programs is still uncommon. Here we conducted concurrent eDNA collections and snorkel observations at 136 pools distributed across 32 survey reaches in the Smith River Basin, California, to compare the method-specific detection probabilities and occupancy estimates for juvenile Coho salmon (Oncorhynchus kisutch) and Chinook salmon (Oncorhynchus tshawytscha). Field surveys consisted of triplicate water samples paired with double observer snorkel dives. Water samples were later tested for presence/absence of the target species using digital droplet PCR. The two approaches were compared using multi-method occupancy models with several habitat covariates. For Coho salmon, the estimated detection probabilities were similar for both methods indicating that under ideal snorkeling conditions, eDNA and snorkeling have the similar detection probabilities. Preliminary analyses indicated some difference in detection probabilities of Chinook salmon by method; however additional testing of samples for Chinook eDNA will be done using a better genetic assay to improve results for this species. Our findings indicate that eDNA monitoring can complement existing snorkel survey methods to assess basin-scale fish distribution and changes through space and time.

Environmental DNA, Snorkel Counts, and the Ratio Estimator: an Approach for Rapidly Estimating Total Juvenile Coho Salmon in a Small Stream

***Dylan Jon Keel**, Cal Poly Humboldt (Presenter), and Co-authors: **Gavin Brian Bandy, Jacqueline Marie Bridegum, Braden Alexander Herman, Jason Tyler Shaffer,** and **Andrew Kinziger, Ph.D.**, Cal Poly Humboldt*

Accurate and cost-effective methods for the estimation of stream-fish abundance and distribution are critical for conservation and management. The application of environmental DNA in water samples represents a novel, noninvasive, and cost-effective approach for monitoring aquatic species, but it is not readily apparent how eDNA concentrations can be translated to estimates of species abundance. We present a sampling design, following Hankin and Reeves (1988), where total fish numbers and total habitat area are estimated by collecting a large number of water samples for eDNA analysis and at a subset of habitat units both water samples and visual observations are conducted for calibration purposes. We estimated the total number of Coho salmon (*Oncorhynchus kisutch*) juveniles in pools within a 7.7 km reach of the Little River, Humboldt County, California. Four water samples for eDNA analysis were collected at 47 pools and a smaller subset of sampled pools were systematically selected for visual counts of the target species (Ns= 11). We used eDNA concentrations of the target species as an auxiliary variable that could be quickly applied at many sites, and visual count data from triple-pass, dual-observer bounded counts as a ratio estimator to calibrate the auxiliary variable. We will share our methods, results, lessons learned, and sampling optimization calculations. The use of eDNA as an auxiliary variable for the rapid assessment of salmonid abundance in small streams presents an opportunity to decrease costs, reduce reliance on assumption and parameter-heavy predictive models, and provide a non-invasive alternative to traditional monitoring.

Considering Life-History Variation in Salmonid Restoration

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

Salmonid fishes are characterized by high levels of variation in life-history traits related to migration and reproduction. In some cases, the variation is so great that fish with alternate strategies even have different names, such as steelhead/rainbow trout, spring-run/fall-run salmon, sockeye/kokanee. In California, salmon and steelhead display a full array of variation in such life-history traits including the presence, location, age and timing of migratory behaviors, and related variation in reproductive behavior. Much of this variation has a genetic basis, so may not be very flexible and is also subject to selection. Restoration projects often alter habitat conditions in ways that change the availability or quality of resources available to fish on a temporal or spatial basis, with potentially profound consequences for fitness of associated salmon and steelhead populations.

Understanding how life-history variation of salmon and steelhead is coupled with habitat use and how specific changes in the physical and biological habitat can affect salmonid populations is a key to implementing successful restoration projects.

This session will bring together biologists studying the patterns and underlying bases of life-history variation in salmon and steelhead, restoration practitioners working on projects that consider this variation and policy makers that plan, prioritize and permit such projects. The session goal is to highlight the importance of explicitly considering variation in migratory and reproductive traits in salmonid restoration projects.

Is it Just a Matter of Time? Allowing for Changing Phenology in Salmon Restoration and Management

Michael D. Tillotson, Ph.D., *ICF, (Presenter), and Co-authors:* ***Heidy K. Barnett,*** *West Fork Environmental;* ***Mary Bhuthimethee,*** *Seattle Public Utilities;* ***Michele Koehler,*** *Seattle Public Utilities; and* ***Thomas P. Quinn,*** *University of Washington*

The timing of breeding migration and reproduction links generations and substantially influences individual fitness. In salmonid fishes, such phenological events (seasonal return to freshwater and spawning) vary among populations but are consistent among years, indicating local adaptation in these traits to prevailing environmental conditions. Changing reproductive phenology has been observed in many populations of Atlantic and Pacific salmon and is often attributed to adaptive responses to climate change. Indeed, rising temperatures may impose strong selection on the timing of migration and breeding if thermal thresholds are exceeded progressively earlier, or if increased incubation temperatures drive advances in hatching and emergence. The sockeye salmon spawning in the Cedar River near Seattle, Washington, USA, have displayed dramatic changes in spawning timing over the past 50 years, trending later through the early 1990s, and becoming earlier thereafter. We explored these patterns and drivers of their drivers using generalized linear models and mathematical simulations to identify possible environmental correlates of the changes and test the alternative hypothesis that hatchery propagation caused inadvertent selection on timing. The trend toward later spawning prior to 1993 was partially explained by environmental changes, but the rapid advance in spawning since was not. Instead, since its initiation in 1991, the hatchery has, on average, selected for earlier spawning, and, depending on trait heritability, could have advanced spawning by 1–3 weeks over this period. Recent observations of low reproductive success among early spawners and relatively low survival of early emerging juveniles suggests that artificial and natural selection are acting in opposite directions. The fitness costs of early spawning may be exacerbated by future warming; thus, the artificially advanced phenology could reduce the population's productivity. The implications of these salmon management and restoration are many. From the perspective of hatchery management, they suggest a need to minimize selection on phenology and allow for expected changes in migration timing in response to warming waters and altered hydrology. From the perspective of habitat restoration these findings emphasize the necessity of considering the interaction of phenology and habitat use, both in the present and under future conditions.

A Multigenerational Pedigree Analysis Reveals the Potential for Selection on Steelhead Life-history Traits

Anne K. Beulke, *Graduate Student, University of California, Santa Cruz, (Presenter); and Co-authors:* ***Alicia Abadía-Cardoso, Ph.D.,*** *Universidad Autónoma de Baja California,* ***Devon E. Pearse, Ph.D.;*** *Southwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration;* ***Laura C. Goetz, Graduate Student,*** *University of California, Santa Cruz;* ***Neil Thompson, Ph.D.,*** *Agricultural Research Service, U.S. Department of Agriculture;* ***Eric C. Anderson, Ph.D.,*** *Southwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration; and* ***John Carlos Garza, Ph.D.,*** *University of California, Santa Cruz and Southwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration*

We used a multigenerational pedigree to estimate the potential for selection on steelhead (*Oncorhynchus mykiss*) life-history traits from hatchery-reared winter-run steelhead from two sites on the Russian River in Northern California. With samples from approximately 18,000 fish over a 14 year period, we used genetic data and the parentage-based tagging technique to form a multigenerational pedigree by assigning parent pairs for over 13,000 fish. This huge pedigree allowed us to estimate the heritability of spawn timing and age at maturity in these anadromous fish. We also assessed the population's age structure, the impact of inbreeding on offspring survival, the variance in family sizes, and the rate of migration between sites. We found the Russian River population has a strong presence of age-2 fish that only spend one year at sea. This is unusual for steelhead and may be the result of artificial selection from hatchery practices over time. Both age at maturity and spawn timing were found to be highly heritable. The heritability of age at maturity varies between the sexes with a higher heritability in females. Spawn timing was found to be highly heritable in both sexes, supporting previous findings. Spawn timing was also found to be correlated with age, and younger, age-2 fish spawned later in the season. These findings of substantial heritability of age at maturity and timing of reproduction in these protected steelhead emphasizes the high opportunity for selection on these critically important traits, due to a variety of anthropogenic factors, including hatchery practices and ecosystem modifications. In addition, the correlation of spawn timing and age at maturity suggests selection on one of these traits could lead to selection on the other trait as well. This highlights the importance of restoration actions that enable habitat access for the full spawning season to allow spawning access for all ages of fish across the full range of spawning dates.

Counting the Parts to Understand the Whole: Rethinking Monitoring of Steelhead in California's Central Valley

Tyler J. Pilger, *FISHBIO (Presenter), and Co-authors:* ***Jackman Eschenroeder, Matthew Peterson,*** *FISHBIO,* ***Michael Hellmair, Doug Demko,*** *and* ***Andrea Fuller,*** *FISHBIO*

Steelhead (*Oncorhynchus mykiss* expressing an anadromous life history) in the Sacramento and San Joaquin rivers and their tributaries in California's Central Valley (CCV) belong to a Distinct Population Segment (DPS) that is listed as threatened under the U.S. Endangered Species Act. Although contemporary management and recovery plans include numerous planned and ongoing efforts seeking to aid in DPS recovery—such as gravel augmentation, manipulation of spring flows, and restoration of rearing and spawning habitat—a paucity of data precludes the possibility of evaluating the impact of these actions on populations of Steelhead in CCV streams. Knowledge gaps relating to historic and current abundance, population-specific ratios of resident and anadromous life history expression, and the influence of hatchery-reared fish remain largely unaddressed. This is in part due to aspects of Steelhead biology that make them difficult to monitor, including the multitude of factors that contribute to the expression of anadromy, polymorphic populations, and migration periods that coincide with challenging field conditions. However, these gaps in understanding are also partly the result of an institutional focus on Chinook Salmon (*Oncorhynchus tshawytscha*) and a pervasive notion that actions benefiting Chinook populations will also benefit Steelhead populations. To evaluate these gaps and to suggest approaches for assessing DPS recovery actions, we review available data and existing monitoring efforts, and consider the actions necessary to inform the development of targeted *O. mykiss* monitoring programs. Current management and recovery goals focus on abundance estimates of Steelhead only, yet current monitoring is insufficient for reliable estimates. We argue that a reallocation of monitoring resources to better understand the interaction between resident *O. mykiss* and Steelhead would provide better data to estimate vital rates needed to evaluate impacts of recovery actions.

Landscape and Life-History Variation in Southern California Steelhead Recovery Planning

Mark H. Capelli, *Recovery Coordinator, South-Central/Southern California Steelhead Recovery Planning Domain, National Marine Fisheries Service*

Steelhead are the most widely distributed of the five Pacific salmon (*Oncorhynchus spp.*) and occupy the widest diversity of climates and landscapes, from the mixed-conifer rainforests of the Pacific Northwest to the semi-arid chaparral of Baja, California. This diversity of landscapes and selective pressures is reflected in the both the genotypic and phenotypic variation exhibited by steelhead across this landscape, and within individual populations. This variability has been recognized in a general way since early researchers such as David Star Jordon recognized the resident an anadromous forms of *O. mykiss* (formerly *S. gairdnerii gairdnerii* Richardson, 1836) and Leo Shapovalov and Alan C Taft's pioneering study of two steelhead populations along the Central Coast of California. More recent research has continued to explore and discover variations in run-timing, habitat preferences, micro-behavioral traits, environmental tolerances and the relation between the anadromous and resident forms exhibited by this species. The recovery strategy developed by the National Marine Fisheries Services (NMFS) for the endangered Distinct Population Segment (DPS) of southern California steelhead reflects the importance of this variation and its continued evolution in ensuring the long-term viability of the federally listed species. The division of the Southern California Steelhead DPS into five distinctive Biogeographic Population Groups (BPGs) reflects the landscape and climate diversity of the Southern California Steelhead Recovery Planning Area (extending from the Santa Maria River in the north to the Tijuana River in the south). Within the five BPGs a suite of core recovery populations occupy both large arid inland and short marine dominated coastal watersheds that present differing selective pressures to which these populations are subjected and to which they have adapted over evolutionary time. These selective pressures include rainfall and run-off patterns, sediment regimes, stream morphology, the distribution of tributaries and refugia habitats, and bar-built estuary dynamics. NMFS's viability recovery criteria for the Southern California Steelhead DPS expressly includes life-history diversity criteria that reflects the basic life-history variation naturally exhibited by the species: fluvial anadromous, lagoon anadromous and freshwater resident, with a minimum number of populations within each of the five BPGs, thus capturing the full range of variation within the Southern California Steelhead Recovery Planning Area. NMFS population-level viability criteria (annual run-size) for southern California steelhead was originally expressed solely in terms the anadromous fraction (100%) of each core recovery population. However, with the recent explication of the genetic mechanism by which steelhead and resident forms of *O. mykiss* can sustain each other, it may be possible to relax this anadromous fraction criterion; though what this new value could be requires additional data and analysis. A better understanding of O. mykiss variation will therefore continue to inform recovery planning for the endangered Southern California Steelhead DPS.

Evaluating Estuary Residency and Restoration Potential for Chinook Salmon in Redwood Creek via a Life Cycle Model

Emily K. Chen, *UC Berkeley and Cal Poly Humboldt (Presenter), and Co-authors:* ***Nicholas A. Som,*** *U.S. Fish and Wildlife Service;* ***John Deibner-Hanson,*** *Stillwater Sciences and USGS California Cooperative Research Unit;* ***David G. Anderson,*** *National Park Service (retired); and* ***Mark J. Henderson, Ph.D.,*** *USGS California Cooperative Research Unit and Cal Poly Humboldt*

Understanding the spatial and temporal habitat use of a species is a necessary step for restoration decision making. Variation in downstream migration and habitat use of Chinook salmon complicate predicting and comparing the influence of various restoration options on total recruitment. In Redwood Creek, Humboldt County, California, we compiled life cycle monitoring data into a stage-structured model to evaluate the potential influence of restoration activities on total recruitment. We considered how juvenile migration and estuarine use in the population varies with environmental conditions and fish abundance. We evaluated the sensitivity of the population trajectory to increases in life cycle parameters potentially enhanced by upslope or estuary restoration. Under current conditions, the expected proportion of the Chinook salmon population to rear in the estuary of this watershed during the summer ranged from 3 to 52 percent. These estuary rearing fish were eight times less likely to survive than fish that migrate to the ocean in the spring or early summer before estuary closure. Because estuary residents experienced low survival in the estuary and in the ocean, improvements to both estuary survival and growth are needed to increase the total survival of estuary residents. The population's trajectory was most responsive to enhancing spawning productivity (egg and fry survival), suggesting upstream restoration should prioritize enhancing the quality of spawning habitat and juvenile rearing capacity over spawning habitat capacity. Life cycle monitoring data are critical to developing stage-structured models that inform restoration decision making and predict outcomes at scales relevant to conservation.

Habitat Restoration to Support Life History Diversity for Coho Salmon in Small Coastal Streams

***Darren Ward, Ph.D.**, Cal Poly Humboldt (Presenter), and Co-authors: **Colin Anderson, Joshua Cahill, Katherine Stonecypher, Madison Halloran,** and **Grace Ghrist,** Cal Poly Humboldt; and **Seth Ricker,** California Department of Fish and Wildlife*

Coho salmon juveniles express diverse life histories distinguished by their use of different habitats at different ages. Data from our long-term Coho salmon population monitoring program in Humboldt Bay tributaries suggest that small-scale variation in habitat conditions experienced early in life is associated with larger-scale, long-term divergence in habitat use and life history later in life. For example, juveniles that spend their first summer in a small tributary are likely to remain in the stream for the winter, while juveniles that spend their first summer a short distance downstream in the main stem are likely to disperse long distances to winter rearing habitat in the estuary or an adjacent watershed. These differences in winter habitat use lead to differences in growth rate and body size, with potential implications for the age and timing of smolt migration and eventually adult life history. Habitat-dependent life history expression means that habitat alteration and habitat restoration activities can directly promote or erode life history diversity in the population over short time scales, with consequences for population stability.

Seascape Ecology: Growth, Survival, and Foraging in the California Current

Friday Morning Concurrent Sessions

Session Coordinators*: Cynthia Le Doux-Bloom, Ph.D., Cal Poly Humboldt, Department of Fisheries Biology; and* ***Nate Mantua, Ph.D.,*** *NOAA, Southwest Fisheries Science Center*

Although many factors may be responsible for the declines in anadromous salmonid populations, this circumstance is commonly linked to the oceanic and estuarine conditions present during the smolt life cycle phase, which remains unstudied compared to riverine life phases. Upon saltwater entry, salmonids display a wide range of growth and survival rates and display a variety of movement and migratory behaviors, both tied to ocean and estuary productivity which influence the foraging conditions these individuals encounter across space and time.

These sessions will feature innovative and novel studies focused on understanding the ocean and estuary life cycle phase of Pacific salmonids, including: (1). An Overview of Seascape Ecology and Current Events; (2). Movement and Migration; (3). Survival and Growth; and (4). Foraging Conditions influenced by the California Current.

Twenty-Two Years of Seascape and Salmon Studies on the Pacific West Coast

Nate Mantua, Ph.D., *NOAA Fisheries (Presenter), and Co-authors:* ***Brian Wells, David D. Huff, Brian J. Burke, Richard D. Brodeur, Jarrod A. Santora, John C. Field, Kate Richerson, Kurt L. Fresh, Michelle M. McClure, William H. Satterthwaite, Chris J. Harvey, Forbes Darby, Su J. Kim, Richard W. Zabel,*** *and* ***Steve Lindley,*** *NOAA Fisheries*

Twenty-two years have passed since the initiation of National Oceanic and Atmospheric Administration's (NOAA's) research program aimed at advancing understanding of estuary and ocean ecology of U.S. West Coast Pacific salmon (*Oncorhynchus spp*.). In this review and prospectus, we summarize key findings from this program and describe a plan for better orienting it toward Ecosystem Based Management (EBM). Twenty-two years ago, NOAA Fisheries West Coast Science Centers proposed a coordinated plan for ocean research on Pacific salmon (*Oncorhynchus spp.*) to elucidate the drivers of variation in salmon abundance. The research plan was designed to inform hatchery practices, to provide forecasts to inform harvest rules, and to consider ocean climate variability when evaluating restoration and recovery plans and actions. Each of the projects carried out under the ocean research plan focused on ecosystem components and how they affected salmon physiology/vital rates and salmon population dynamics. Successful outcomes include descriptions of coastwide and local-scale distributions and distributional relationships to small-scale oceanographic features. Studies have also examined seasonal and interannual variations in diet composition, immature salmon growth rates and condition, diseases and parasites, salmon predators, environmental covariates of salmon presence or abundance, and correlates of marine survival. Our EBM approach will provide managers with information to improve resilience of West Coast salmon populations and the fishing and biotic communities that depend on them. Our path forward involves increasing our understanding of ecosystem processes in order to improve the dependability of scenario testing under novel conditions. We have developed a conceptual model for how salmon are influenced by climate, predators, prey, fisheries, and human activities. Knowledge gaps that we identified from our conceptual model include limited understanding of salmon distributions, behavior, maturation dynamics, and population dynamics; and salmon interactions with predators, competitors, and prey during winter. We consider emerging risks and vulnerabilities facing salmon and propose analysis frameworks for evaluating them. Increased marine predator populations coupled with climate change pose a significant risk to West Coast salmon and require new strategies and actions to mitigate their negative impacts on salmon and salmon-dependent fishing and ecosystem components. We propose research to support the development of new decision-support tools for evaluating tradeoffs associated with alternative management strategies. Research is expected to develop decision-support tools and information to inform salmon and ecosystem management, and ultimately form a central part of the adaptive management system needed to improve resilience of salmon populations and salmon-dependent fisheries and ecosystem components.

Salinity Tolerance and Smoltification Differences Between Winter, Fall, and Spring-run Chinook salmon (*Oncorhynchus tshawytscha*) Brood Stocks

Leah Mellinger, *University of California, Davis (Presenter), and Co-authors:* ***Dennis Cocherell, Nann Fangue, Ph.D., Brian Sardella, Ph.D.,*** *and* ***Richard Connon, Ph.D.,*** *University of California, Davis*

Chinook salmon *(Oncorhynchus tshawytscha*) in California are unique in the fact that they have several distinct runs: Spring-run, Fall-run (including late-Fall) and Winter-run (Yoshima et al. 1998; Thompson et al. 2012). Just as Chinook salmon adults enter the rivers at different times depending on the runs, it is conceivable that juveniles will enter the ocean at different times and sizes (Clarke & Shelbourn 1985). What is not fully understood are the mechanisms behind the trigger for juvenile outmigration and smoltification as well as whether different runs can smolt at different sizes. The aim of this study is to simulate a stepwise salinity exposure (0 ppt to 12 ppt, 12 ppt to 22 ppt, and then 22 ppt to 32 ppt) to assess salinity tolerance differences between Livingston winter-run, Trinity spring-run, and Iron Gate fall-run juvenile Chinook salmon at different size classes (65 mm, 95 mm, and 125 mm fork length). Physiological responses were measured by quantifying mRNA expression of smoltification and mineral homeostasis on specific areas of DNA. Mortality and body condition has also been assessed for the duration of the study.

Climate-driven Variability in Zooplankton in Coastal Waters off Northern California: a Potential Ecosystem Indicator for Klamath River Chinook Salmon

Eric P. Bjorkstedt, Ph.D., *NOAA Fisheries SWFSC Fisheries Ecology Division, Department of Fisheries Biology, Humboldt State University (Presenter), and Co-authors:* ***Roxanne R. Robertson*** *and* ***Blair M. Winnacott,*** *Department of Fisheries Biology, Cal Poly Humboldt, CIMEAS at Cal Poly Humboldt.*

Sampling along the Trinidad Head Line has been conducted since late 2007 at approximately monthly intervals throughout the year to provide information on the state of the coastal plankton ecosystem off northern California in the context of hydrographic variability and climate forcing. This sampling design resolves seasonal patterns, cross-shelf structure, and climate responses in the composition of several assemblages (e.g., krill, copepods, larval fish) and has yielded important insights to factors. In general, seasonal patterns in assemblage composition reflect combined effects of variability in reproductive output and advection-driven cross-shelf distributions and climate events—especially warming events—drive changes in assemblage structure as a consequence of large scale advection. Climate forcing also appears to drive variability in the size structure of the numerically dominant krill species Euphausia pacifica. Adult krill are substantially smaller during warm periods than during cooler, more productive periods, and this pattern appears to reflect disruption of seasonal growth that would normally coincide with the onset of sustained upwelling. Collectively, these time series provide strong evidence of changes in the plankton community off northern California in response to climate forcing, including shifts with potentially important implications for productivity throughout the broader ecosystem. Preliminary analysis indicates that ecosystem indicators based on these observations provide insight to variability in marine survival in fall-run Chinook salmon from the Klamath River.

California Current Seascape Influences Juvenile Salmon Foraging Ecology at Multiple Scales

Megan C. Sabal, Ph.D., *Oregon State University (Presenter), and Co-authors:* ***Elliott L. Hazen, Steven J. Bograd*** *and* ***Isaac D. Schroeder,*** *Environmental Research Division, NOAA Fisheries;* ***R. Bruce MacFarlane, Arnold J. Ammann, Jeffrey A. Harding,*** *and* ***Brian K. Wells,*** *Southwest Fisheries Science Center, NOAA Fisheries;* ***Sean A. Hayes,*** *Northeast Fisheries Science Center, NOAA Fisheries;* ***Kylie L. Scales,*** *University of the Sunshine Coast; and* ***Peter I. Miller,*** *Remote Sensing Group, Plymouth Marine Laboratory*

Juvenile salmon *Oncorhynchus spp.* experience variable mortality rates during their first few months in the ocean and high growth during this period is critical to minimize size-selective predation. Examining links between the physical environment and foraging ecology is important to understand mechanisms that drive growth. These mechanisms are complex and include interactions among the physical environment, forage availability, bioenergetics, and salmon foraging behavior. Our objectives were to explore how seascape features (biological and physical) influence juvenile Chinook salmon *O. tshawytscha* foraging at annual and feeding-event scales in the California Current Ecosystem. We demonstrate that forage abundance was the most influential determinant of mean salmon stomach fullness at the annual scale, while at the feeding-event scale, fullness increased with greater cumulative upwelling during the 10 days prior and at closer distances to thermal fronts. Upwelling promotes nutrient enrichment and productivity, while fronts concentrate organisms likely resulting in available prey to salmon and increased stomach fullness. Salmon were also more likely to consume krill when there was high prior upwelling and switched to non-krill invertebrates (i.e., amphipods, decapods, copepods) in weaker upwelling conditions. As salmon size increased from 72 mm to 250 mm, salmon were more likely to consume fish, equal amounts of krill, and fewer non-krill invertebrates. Broad seascape processes determined overall prey availability and fullness in a given year, while fine- and meso- scale processes influenced local accessibility of prey to individual salmon. Therefore, processes occurring at multiple scales will influence how marine organisms respond to changing environments.

The Pelagic Juvenile Rockfish Survey in your Backyard: Linking Forage Variability to Salmon in the California Current

John Field, Ph.D., *(Presenter), and Co-authors:* ***Jarrod Santora, Ph.D.,*** *NOAA Fisheries, SWFSC,* ***Tanya Rogers, Keith Sakuma, Rebecca Miller,*** *and* ***Brian Wells,*** *Institute of Marine Sciences, Fisheries Collaborative Program, University of California, Santa Cruz*

Since 1983, the National Marine Fisheries Service (NMFS) has conducted an annual midwater trawl survey for pelagic young-of-the-year rockfish in the coastal waters of Central California, with the survey expanding in geographic range and scope in 2001 to include nearly all coastal waters of the U.S. West Coast. The survey informs recruitment estimates of rockfish (Sebastes spp) and other groundfish in stock assessments and supports a wide range of fisheries and ecosystem oceanography studies throughout the California Current. In this talk we focus on the role of the survey data with respect to informing forage availability and productivity for predators, particularly seabirds and salmon in the central California region. We will also summarize recent trends in coastal and epipelagic forage species diversity and abundance with respect to the ongoing anchovy population boom and other oceanographic and ecosystem insights (such as habitat compression) from four decades of continuous data collection.

Thiamine Deficiency in California Salmon: The Ocean is Impacting Freshwater Productivity

Rachel Johnson, Ph.D., *NOAA Fisheries, SWFSC (Presenter), and Co-authors:* ***Carson Jeffres, Ph.D.,*** *University of California Davis, Center for Watershed Sciences;* ***Bruce Finney, Ph.D.,*** *Idaho State University;* ***Steve Litvin, Ph.D.,*** *Monterey Bay Aquarium Institute;* ***John Field, Ph.D., Steve Lindley, Ph.D., Nate Mantua, Ph.D.,*** *NOAA Fisheries, Southwest Fisheries Science Center;* ***Brett Kormos,*** *California Department of Fish and Wildlife;* ***Iliana Ruiz-Cooley, Ph.D.,*** *Moss Landing Marine Laboratory;* ***Jacques Rinchard, Ph.D.,*** *State University of New York, Brockport;* ***Donald Tillitt, Ph.D.,*** *U.S. Geological Survey, Columbia Environmental Research Center; and* ***Dale Honeyfield, Ph.D.,*** *Retired United States Geological Survey, Northern Appalachian Research Branch*

Understanding how factors in one aquatic habitat influence an organism's growth, survival, and reproductive success at later life stages is one of the greatest challenges in the conservation and management of migratory fishes. Thiamine Deficiency Complex (TDC) is a nutritional deficiency of thiamine (vitamin B1) recently linked with high mortalities of early life stages of Chinook salmon in California's Central Valley (CCV). TDC is caused by female Chinook salmon not acquiring enough thiamine from their ocean diets to provide needed nutrition in their eggs that their young require for proper development. Here, we use $\delta^{13}C$ and δ 15N in salmon muscle tissue and in sequential eye lens layers to test the hypothesis that females with low egg thiamine levels fed on a narrow diet of anchovies. Anchovies are known to produce thiaminase (an enzyme that destroys thiamine in consumers) and prey species high in thiaminase were identified as the primary explanation for the onset of TDC in Great Lakes and Baltic Sea salmonids. Anchovy abundance was found to be anomalously high in 2019-2021 with salmon gut content results showing anchovies to be dominant prey. Our work to-date has revealed low levels (3.1 ± 1.5nmol/g) of egg thiamine in winter run Chinook salmon prior to spawning, resulting in an estimated 44% thiamine-dependent mortality in 2021. Stable isotopes of $\delta^{13}C$ and δ 15N measured in eye lens laminae provide a chronology of ocean diets prior to spawning that will be linked to egg thiamine concentrations. Marine isoscopes for the California Current Ecosystem will allow us to assess associations between salmon prey and thiamine levels in salmon eggs. Thiamine deficiency is an emerging stressor to California salmon and understanding these aquatic linkages will be critical in assessing causes, impacts, and potential mitigation opportunities.

Beyond Physical Habitat: The Importance of Prey Availability

Friday Morning Concurrent Sessions

Session Coordinator*: Robert Lusardi, Ph.D.,* *UC Davis Center for Watershed Sciences and California Trout Coldwater Fish Scientist*

This session will delve into understanding how prey availability may influence the growth and fitness of salmonids and will identify productive ecosystems or habitats that may assist in the recovery of imperiled populations. We will also explore ecosystems, including highly managed ecosystems, that have the ability to improve productivity or prey availability at broader spatial scales and in an overall effort to improve habitat heterogeneity across the landscape.

Putting Fish and Fish Food in the Framework: Using Drift-Foraging Bioenergetics to Make Flow Recommendations

Suzanne Kelson, Ph.D., *University of Nevada, Reno and McBain Associates (Presenter), and Co-authors:* ***Tim Caldwell, Ph.D.,*** *McBain Associates;* ***Sudeep Chandra, Ph.D.*** *and* ***Tara McKinnon,*** *University of Nevada, Reno;* ***Scott McBain,*** *McBain Associates; and* ***Natalie Stauffer-Olsen, Ph.D.*** *and* ***Rene Henery, Ph.D.,*** *Trout Unlimited*

Understanding the ecological effects of modified streamflows in regulated streams remains a challenge for restoration. Streamflows predictably modify physical habitat for fish through hydraulics (depth and velocity), but the connections between habitat, prey availability, and streamflows in creating suitable conditions for fish are often more complex. We used a fish bioenergetics model, as a tool that synthesizes both food and physical habitat resources, to develop streamflow recommendations in a heavily regulated stream, the Upper Shasta River, California. To develop a framework for using bioenergetics, we first demonstrated how alternative flow regimes, above and below the major water diversion in this stream, influence ecological productivity in terms of benthic and drifting macroinvertebrate resources, fish foraging behaviors, and modeled drift-feeding trout energetics. We found that daily flux of drifting invertebrates was greatly reduced below the diversion (98% reduction in August and September), even though the densities of benthic invertebrates were similar between the sites in (mean ± std. dev of 936 ± 714 individuals/m2 above vs 1094 ± 1243 individuals/m2 below the diversion). The reduction of drift flux below the diversion created unfavorable conditions for drift-feeding rainbow trout at the end of summer. Underwater video footage suggested that trout shifted from drift to benthic/search foraging behavior weeks earlier below the diversion compared to above. Similarly, net rate of energetic intake (NREI), which was modeled using Bioenergetics HSC, a freely available software, was reduced by over 80% below the diversion compared to above at the end of the summer. Next, we developed a framework for creating flow recommendations using outputs from drift-feeding bioenergetic models. To do this, we developed a long-term record (63 years) of unimpaired flows and modeled NREI at our site below the diversion for the late spring and summer months (May—September) for different flow scenarios. Flow scenarios included unimpaired flows and percent-of-flow diversions. We modeled NREI at monthly timesteps across all 63 years that would result from implementing the flow scenarios and compared them to the unimpaired conditions. We then identified the highest percent-of-flow diversion that produced NREI values that were not significantly different from unimpaired conditions. Our analyses suggested a higher allowable percent-of-flow diversion in the spring and early summer compared to late summer. Overall, we demonstrate that trout bioenergetic modeling is a tool that can be used to make flow recommendations by synthesizing both physical (depth and velocity) and ecological (food resources) variables to create a more complete picture of how flows influence life for fish underwater.

The Effects of Prey Density and Water Velocity on Capture Success of a Juvenile Salmonid

Kwanmok Kim, Ph.D., Post-doctoral researcher, *University of California, Santa Cruz and NOAA affiliate (Presenter),* ***Peter Dudley, Ph.D.,*** *Project Scientist and PI, University of California, Santa Cruz and NOAA affiliate; and* ***John Piccolo****, Department of Environmental and Life Sciences, Karlstad University*

Many drift feeding studies of juvenile salmonids have assumed a linear relationship between prey density and capture success rate. However, the capture success rate may decrease as prey density increases, as fish may encounter more prey than it can process. Moreover, when water velocity changes, the density effects may also change as it affects the prey delivery rate. For example, even with low prey density, high water velocity would not allow the fish to respond to the next prey and hence, decrease the capture success rate. This may lead to both underestimating and overestimation of prey capture success in drift feeding models. Thus, testing the effects of density coupled with the effects of water velocity on capture success becomes important for drift feeding models. In this study, we hypothesized that the prey capture success does not increase linearly in relation to prey density.

To test the hypotheses, we developed a mechanistic model that simulates the juvenile steelhead Oncorhynchus mykiss irideus foraging behavior from a study that conducted a lab experiment to test the effects of water velocity on capture success (Piccolo et al. 2008). We acquired precise 3D coordinates of the fish location (focal, attack, and return point) for successful prey captures. We used this information to predict the next focal and return points using the Generalized Linear Mixed Models (GLMM). Moreover, we used the GLMM to find important factors that lead to an attack e.g., fish size, distance to the prey (horizontal and vertical), the time between prey, and water velocity. We also calculated the detection range of the fish by fitting an ellipsoid to its maximum detection distance (horizontal, vertical, and longitudinal). Our model simulates the movement of the fish in a 2D plane and calculates the remaining time to respond to the incoming prey and determines whether to attack. Successful capture is when the fish has a longer time to respond to the prey than the amount of time prey takes to pass the fish.

We validated our model with results from Piccolo et al. 2008 which was on average 3.1% lower in capture success than that of Piccolo et al. 2008. We then tested the effects of density and water velocity on capture success. For the preliminary study, we ran 500 simulations of prey capture experiments with six times the prey density (M6PD) than that of the Piccolo et al. (2008) (M1PD) which is within the range of prey encounter rate in Sacramento River, California. The capture success was 35.9% lower than that of the M1PD model (60.7%) in 29cm/s water velocity. In 61cm/s water velocity, the M6PD capture success of our model was 41.3% lower than that of the M1PD (12.1%). This indicates that regardless of higher prey densities, the capture success may vary depending on the water velocity. We will further include precise depth data to increase the accuracy of the detection range and test the effects of various prey densities coupled with various water velocities on capture success.

Salmonids Return to Montezuma Wetlands after 150 Years: Fish Use and Productivity Trends in a Sediment Beneficial Reuse Restoration Site

Cassie Pinnell *and* ***Chris Jasper,*** *Vollmar Natural Lands Consulting (Co-presenters) and Co-authors:* ***Elsie Platzer,*** *Center for Watershed Science at UC Davis;*
John R. Durand, Ph.D., *CWS, University of California, Davis;*
and ***Doug Lipton, Ph.D.,*** *Lipton Environmental Group*

Salmonids face unprecedented challenges when outmigrating through the San Francisco Estuary (SFE). The current status of the SFE seldom reflects historic wetland habitat and associated ecosystem processes which were present prior to the insurmountable changes the SFE has experienced throughout the modern era. Reduction of physical habitat from wetland conversion and the degradation of existing habitats from human induced changes to abiotic and biotic processes have fundamentally altered the quality of estuarine habitat present in the SFE. In an attempt to re-establish lost ecosystem processes, there have been a variety of efforts restore peripheral habitats along the SFE salmonid migratory corridor. These restorations have had varying approaches and varying levels of success as a result. Success of a tidal restoration has many factors, especially regarding its benefits towards salmonid rearing during outmigration.

The Montezuma Wetlands Restoration Project located in Suisun Marsh, California has restored 550 acres of tidal marsh habitat which were converted to grazing and farmlands nearly 150 years ago. This restoration has used novel techniques of importing dredge sediment from the SFE bays to reverse land subsidence and create an engineered marsh with a progression of primary slough channels, secondary slough channels, intertidal marsh plain, and a fluvial hollow with intertidal habitats. In order to study the progress of the Montezuma Wetlands Restoration in supporting beneficial ecosystem processes and native fishes, the Suisun Marsh Fish Study (SMFS) (Center for Watershed Sciences, University of California, Davis), began monthly sampling the restoration after it was breached in October 2020.The SMFS was started in 1978 and is a long-running, monthly monitoring effort that examines water quality and abundance of invertebrates and fishes with the goal of understanding annual and long-term changes in trends of fishes, invertebrates, and water quality in Suisun Marsh.

Preliminary findings of SMFS study imply that the Montezuma Wetlands provides seasonal benefits in elevated Chlorophyll-a and zooplankton which may aid in juvenile salmon migration and the rearing of other native estuarine species. Here we examine the initial trends of this data, discuss the restoration design features that likely facilitate elevated Chlorophyll-a and zooplankton, and explore potential future sampling methods to understand how salmonids and native fishes are utilizing and benefiting from the Montezuma Wetlands Restoration project.

Does "Wilding" Juvenile Chinook Salmon on Agricultural Floodplains Boost Survivorship in California's Central Valley?

Rachelle Tallman, *Graduate Student, University of California, Davis (Presenter)*
and Co-authors: ***Carson Jeffres, Ph.D.; Robert Lusardi, Ph.D.; Dennis Cocherell, Nann Fangue, Alexandra Wampler, Jordan Colby****, and* ***Andrew Rypel***

In California's Central Valley, there is growing interest to incorporate innovative techniques into salmon conservation and management. Previous studies found high growth rates in juvenile Chinook salmon (*Oncorhynchus tshawytscha*) reared on natural and agricultural floodplains compared to salmon reared in the main river channel. Natural resource agencies are interested in understanding if faster growth rates translate to higher out-migration survivorship.

We developed a study utilizing miniaturized acoustic telemetry transmitters to test whether wilding juvenile Chinook salmon on winter-flooded rice fields resulted in increased survivorship to the ocean. Juvenile fall-run Chinook salmon were acquired from Coleman National Fish Hatchery during the winter of 2020. 1000 salmon were split among 72 experimental cages in winter-flooded rice fields. An additional 1000 fish were reared in tanks under laboratory conditions. 966 fish in total were implanted with acoustic transmitters. All fish were released at the same river location and monitored using an acoustic receiver array. Our preliminary results suggest that higher growth rates resulted in earlier migration timings with higher survivorship. Although it is an emerging technique, wilding juvenile salmon on agricultural floodplains may represent an essential conservation strategy for enhancing the life cycles of hatchery and wild fishes. These techniques could be used by management agencies interested in applying adaptive management strategies to salmon conservation.

How do BDAs Change Stream Food Webs: What Stable Isotopes Can Teach Us About Food Webs in Beaver Dam Analogs

Brandi Goss*, Master's student, UC Davis (Presenter), and Co-Author:* ***Robert Lusardi, Ph.D.****, Assistant Adjunct Faculty, UC Davis*

Several Beaver Dam Analogs (BDAs) have been installed in the Scott Valley over the last decade. Current research indicates that BDAs may serve as thermal refugia for cold-water fish in the face of climate change. Natural beaver dams are known to provide important habitat diversity that has been shown to enhance prey for foraging fishes. As a result, BDAs may be an important habitat that may assist in the recovery of imperiled Coho salmon. However, currently there are no studies that examine how food webs and trophic pathways to higher order consumers, such as Coho salmon, shift with the construction of BDAs. As such, we are using naturally occurring stable isotopes (13C and 15N) to compare food webs between BDA and traditional stream habitat. We collected and analyzed numerous food web constituents, including plants, seston, coarse and fine particulate organic matter, macroinvertebrates, and Coho fin clips in BDA and traditional stream habitat on Sugar Creek. We reconstructed those food webs using the IsoWeb program to better understand changes in trophic pathways to juvenile Coho salmon. Interestingly, the communities of primary producers and macroinvertebrates are quite different between the two habitat types. Thus, the trophic pathways identified using the 13C and 15N isotopic signatures in the Coho fin clips are also different between the two habitat types. This may indicate increased regional stability in aquatic food webs. With recent research indicating the importance of food availability for thermal resilience in Coho salmon, this increased food web stability and more consistent food availability for fish provides additional support for BDAs being an important habitat feature to consider in restoration and conservation efforts for Coho salmon.

Response of Coho Salmon Populations to Restoration Actions in the Context of Climate Change and a Multi-Year Drought in Northern California

***Michael M. Pollock, Ph.D.**, NOAA Fisheries (Presenter), and Co-authors: **Erich Yokel, Betsy Stapleton, Charnna Gilmore**, Scott River Watershed Council; **Shari Witmore**, NOAA Fisheries; and **Monica Tontym**, Cal Poly Humboldt*

Streamflow in the Klamath River basin in northern California and southern Oregon has been greatly impacted by drought and climate change. Altered hydrologic conditions have generally had negative effects on salmon populations, inclusive of ESA-listed Coho salmon, which has suffered precipitous population declines in California. The Scott River is a major tributary to the Klamath River. It harbors one of the largest remaining Coho salmon populations in California and is largely free of hatchery influence. In the past decade local conservation groups have partnered with state and federal agencies to engage in a suite of restorative actions designed to mitigate some of the effects of drought and climate change and create habitat in which this wild Coho salmon population and other species can thrive. Herein we present the results of an ongoing 10-year+ effort to restore habitat and monitor the response of Coho salmon to these restoration overtures during this period of extreme drought. We summarize the response of fishes and other biological and physical changes and discuss lessons learned that have enabled us to build more climate-resilient salmon habitat in the future.

Managing Non-Native Predatory Fish in California's Salmon Bearing Streams

Friday Morning Concurrent Sessions

Session Coordinators: ***Philip Georgakakos, Ph.D.***, *UC Berkeley;* ***Gabriel Rossi, Ph.D.***, *UC Berkeley, and* ***Abel Brumo***, *Stillwater Sciences*

Ordering and prioritizing recovery actions for California's endangered salmon and steelhead is a dizzying challenge. Instream flow, habitat alteration, genetic bottlenecks, and hatchery management each have a claim as a priority for our attention and recovery dollars. In this pantheon of insults to native salmonids, the effects of invasive predatory fish are sometimes assumed to be an unavoidable and unmanageable reality of California's modern landscape. However, non-native predatory fish are affecting the survival, distribution, abundance, and life history patterns of native salmonids. And the impacts of many non-native predatory fish are increasing with climate change. Here we seek to look deeper at the types of interactions between non-native predatory fish and native salmon in California, their ecological implications for salmon recovery, and management tools to reduce the effects of non-native predatory fish on native salmonids.

River ecosystems contain mosaics of linked food webs. Therefore, managers must carefully consider both the immediate and cascading effects of actions which remove predators or alter predator-prey dynamics. But given the critical state of our salmon populations it is necessary to make these considerations now, and carefully weigh the benefits and risks of different approaches. This session will include talks on the ecology of interactions between non-native predatory fish and Pacific salmon, the success and failures of methods to manage non-native predatory fish in salmon-bearing streams, and novel and traditional management strategies for the future. The session will conclude with a round table discussion on how to proceed with the management of non-native predatory fish in California's salmon-bearing streams.

Landscape-Scale and Habitat-Level Drivers of Fish Predation in the Sacramento-San Joaquin Delta

Cyril Michel, *UC Santa Cruz and NOAA-SWFSC (Presenter), and Co-authors:* ***T. Reid Nelson,*** *George Mason University;* ***Nicholas Demetras, Brendan Lehman****, and* ***Meagan Gary,*** *UC Santa Cruz and NOAA-SWFSC;* ***Chris Loomis,*** *CDFW; Mark Henderson, USGS CA Cooperative Fish and Wildlife Research Unit; and* ***Joseph Smith*** *and* ***David Huff,*** *NOAA-NWFSC*

Predation risk on juvenile fishes is being driven by factors acting at disparate scales, ranging from the habitat-level to the landscape-level. Identifying these different drivers of predation risk is essential for prioritizing management actions to reduce predation risk and ultimately improve survival for imperiled fish populations. Over the past five years, the Southwest Fisheries Science Center, in collaboration with other agency and academic partners, has undertaken several field campaigns to better understand these drivers. Specifically, we will present findings on what the landscape-scale drivers of predation risk are in the Sacramento-San Joaquin Delta, but also, results from more focused efforts at understanding how habitat features such as artificial illumination, submerged aquatic vegetation, and water diversion structures influence predator-prey dynamics and predation risk. Finally, we will discuss potential management actions informed by this work and future directions for research.

Spring Temperature Predicts Upstream Migration Timing of Invasive Sacramento Pikeminnow in a Salmon-Bearing River

Philip B. Georgakakos, Ph.D., *University of California, Berkeley (Presenter), and Co-authors:* ***David N. Dralle, Ph.D.,*** *USDA Forest Service Pacific Southwest Research Station;* *and* ***Mary E. Power, Ph.D.,*** *Professor, University of California, Berkeley, Department of Integrative Biology*

Invasive species introductions and our changing climate threaten salmon populations and the ecological communities they are embedded in across the globe, particularly when these stresses coincide. We document an invasive piscine predator, the Sacramento pikeminnow (*Ptychocheilus grandis*), migrating within its introduced range, the South Fork Eel River. Through a combination of snorkel surveys and temperature monitoring in 2015-2019 we show upstream migration by pikeminnow during spring and early summer occurred earlier in years when river water was warmer. Pikeminnow were more likely to occur in pools where their most numerous prey, North Coast Range Roach (*Hesperoleucus venustus*) were abundant and dense, suggesting that feeding motivates seasonal pikeminnow migration. We developed a statistical temperature model to forecast the timing and extent of upstream migration by pikeminnow under various combinations of discharge and air temperature. This model was calibrated with our field observations and showed that river temperature decreased with river flow and increased downstream and with air temperature. In years with low flow and high air temperature, we predict pikeminnow will move upstream earlier, move further upstream, and overlap in their summer range with rearing salmonids and other native fishes for a longer period of time. Understanding the conditions which limit co-occurrence of pikeminnow with threatened salmonids can identify shifting refuge habitat and can guide habitat restoration efforts to aid the recovery of these native fishes. Additionally, insight into the phenology of life history events, like migration, exposes invasive pikeminnow to control tactics that take advantage of their behavior. We suggest that capturing individuals as they move upstream or decreasing water withdrawals during the summer to keep river temperatures cool, reducing co-occurrence of pikeminnow and rearing salmonids, could minimize the negative impact of pikeminnow on these and other native fishes. Invasive pikeminnow will likely have larger impacts with climate warming and increasing drought severity. Detailed knowledge of life history and phenology for pikeminnow and other invasive predators will focus efforts to manage environments and control invasives for the benefit of salmon and other native species.

Shade Affects Magnitude and Tactics of Juvenile Chinook Salmon Antipredator Behavior in the Migration Corridor

Megan C. Sabal, Ph.D., *Oregon State University (Presenter), and Co-authors:* ***Michelle L. Workman,*** *East Bay Municipal Utility District,* ***Joseph E. Merz****, Cramer Fish Sciences;, and* ***Eric P. Palkovacs,*** *University of California, Santa Cruz*

Environmental conditions strongly affect antipredator behaviors; however, it is less known how migrating prey adjust antipredator behavior in migration corridors, in part because active migrants are difficult to observe and study. Migrants are vulnerable and encounter many predators in the corridor and their propensity to travel towards their destination ties antipredator behavior with movement. We evaluated how environmental risk cues in the migration corridor including in-water habitat structure (present, absent) and overhead shade (sun, shade) and salmon origin (hatchery, wild) affected how juvenile Chinook salmon (*Oncorhynchus tshawytscha*) reacted to a live predator. We measured how salmon react to predation risk as the difference in time to swim downstream through a 9.1-m long field enclosure with or without a live predatory largemouth bass (*Micropterus salmoides*). Shade significantly modified the reaction to the predator and it did so in two ways. First, the magnitude of antipredator behavior was larger in shade compared to direct sun, which suggests salmon perceived shade to be a riskier environment than sun. Second, the escape tactic also varied; salmon slowed down to be cautious in shade and sped up in sun. Structure did not significantly affect behavior and hatchery and wild salmon behaved similarly. Our study suggests that environmental risk cues can shape the magnitude and tactics of how migrants react to predation risk and illustrates how these responses relate to movement with potential to scale up and affect migration patterns.

Tracking (and Trying to Stop) the Invasion of Sacramento Pikeminnow in the North Fork Eel River

Zane Ruddy, *Bureau of Land Management, Arcata Field Office*

Over the past 40 years non-native Sacramento pikeminnow have invaded all accessible tributaries in the Eel River basin containing suitable habitat. The North Fork Eel River, the Eel River's fourth largest tributary, was believed to be spared from the invasion due to a natural barrier (named Split Rock) that occurs low in the watershed. However, a robust four-year monitoring effort led by the Bureau of Land Management has concluded this is no longer the case. The Sacramento pikeminnow's attempt to establish a population in the North Fork Eel River is actively underway. Sacramento pikeminnow are known to prey on native steelhead and compete with them for habitat and food resources; therefore, a successful invasion in the North Fork Eel River could result in a significant drop in steelhead production in a watershed where survival is already difficult.

On the bright side, the invasion was detected early, the population is at a relatively low abundance with a restricted distribution, and two meaningful suppression efforts have been possible. Our results indicate there is a growing population of Sacramento pikeminnow juveniles made up of multiple age classes (4 to 12-inches) currently numbering in the hundreds and adult fish have been puzzlingly absent. In this talk I will share the results of our surveys, describe our attempts to suppress the Sacramento pikeminnow population, explore (and solicit from the audience) some ideas that may explain the dynamics of the invasion, and share some noteworthy observations of other aquatic species in the watershed.

Pikeminnow Suppression: A Big Success in a Small Watershed

Ken Jarrett, *Stillwater Sciences (Presenter),*
and Co-authors: ***Ethan Bell*** *and* ***Matt McKechnie,*** *Stillwater Sciences*

Chorro Creek is a tributary to Morro Bay, California that supports federally listed steelhead (anadromous *Onchorhynchus mykiss*). Chorro Creek has high intrinsic potential to support steelhead with cool water, access to a productive estuary, and intact riparian habitat. However, invasive and highly piscivorous Sacramento pikeminnow (*Ptychocheilus grandis*), along with fish passage barriers in the watershed, are currently limiting steelhead production. Unlike many other watersheds where pikeminnow management efforts occur (e.g., Sacramento pikeminnow suppression efforts in the Eel River and Northern Pikeminnow in the Columbia River), the small size of the Chorro Creek watershed and limited pikeminnow distribution offer a unique opportunity to substantially suppress the pikeminnow population with comparably little effort. Results of relatively limited suppression efforts and associated population monitoring conducted from 2017-2020 demonstrate a high potential for a successful suppression program that benefits steelhead: portions of the creek that have been treated are now dominated by steelhead. Following four years of targeted control efforts consisting of backpack electrofishing and angling, pikeminnow abundance has decreased from 190 fish per 100 meters in the first year to less than 10 fish per meters in the fourth year, while juvenile steelhead abundance has increased from 13 fish per 100 meters to over 40 fish per 100 meters during the same period. Although pikeminnow haven't been eradicated from the Chorro Creek watershed, the population has been reduced substantially and the native steelhead population is expanding. Lessons learned in this small watershed may provide insight into larger suppression and management efforts for non-native predatory fish throughout the state.

Informing Management Strategies for Non-Native Salmonid Predators through Applied Ecological Studies: Lessons Learned from the Stanislaus River

Matthew Peterson, M.S., FISHBIO (Presenter),
and Co-authors: Tyler Pilger, Ph.D., Jason Guignard, and Andrea Fuller, FISHBIO

Non-native predatory fish are widespread and abundant throughout the California waterways that serve as the migration corridors for native salmonids. However, the trophic interactions between predatory fishes and salmonids are not homogenous along the entire length of the migration corridor. In response to the Water Infrastructure Improvements for the Nation (WIIN) Act (2016), we collaborated with NOAA Fisheries and California Department of Fish and Wildlife to develop and implement a suite of predator-related studies on the Stanislaus River. These studies were used to elucidate the ecology and trophic dynamics of native and non-native predatory fishes with the goal of identifying potential management strategies to mitigate predation related loss. From 2018 through 2021, we used boat electrofishing to sample fish and collect information on native and non-native predator populations over 64 kilometers of Chinook salmon migration corridor. Biological samples were collected and included scales for aging and stomach contents to characterize diets. We also employed multiple methods to estimate abundances of each predator species, including mark-recapture. The results to date indicate that the impact of predation on juvenile Chinook salmon in the Stanislaus River is significant. Non-native predators, striped bass and black bass, accounted for the vast majority (>98%) of observed consumption of juvenile salmon, which occurred over the seasonal extent of sampling (February to June). Sacramento pikeminnow (native) consumed juvenile Chinook salmon infrequently. Predation was observed during all sampling events in low and high discharge levels and at water temperatures as cool as 9.8ºC. Black bass as small as 90 mm consumed juvenile Chinook salmon fry. Predation at the site level appeared to be widespread in space and not concentrated, though one reach had higher-than-average predation rates. No evidence of hotspots associated with artificial structures was found, however, the random selection of units a priori may have missed such locations. The overall impact of predation was greatest for striped bass, but abundance estimates indicate that black bass outnumber striped bass by about 2.5 to 1. Although population vital rates are lacking, size-at-age data suggest in-river recruitment of black bass is stronger during dry years. While recruitment of striped bass does not occur in the Stanislaus River, annual immigration by a migratory contingent does. Our intensive studies of the predator-prey ecology on the Stanislaus River can inform the development of feasible and tailored management strategies to minimize predation pressure on native fishes. For the Stanislaus River, managers should consider approaches tailored to the ecology of both striped bass and black bass (e.g., limiting recruitment of black bass and reducing immigration of striped bass). In addition, other actions may need to be implemented concurrently, such as decreasing conditions that promote native and non-native species interactions (e.g., targeted pulse flows or mitigating contact points) and continued improvements to spawning and rearing habitats to increase the production, condition, and diversity of native fishes.

Hydrologic Management for the Anthropocene

Friday Morning Concurrent Sessions

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

A climate emergency is upon us. Salmon and their watersheds face extremes in flow and water temperature due to more frequent drought, extreme heat, flooding, wildfire, and reduced snowpack. Novel, science-based strategies are needed to maintain a place for cold water fish in our landscapes. This session is an opportunity to disseminate basic and applied scientific knowledge that will help to advance management practices for the betterment of salmon-supporting watersheds. This is a venue for practitioners from a variety of roles to report on their efforts. Approaches to enhance instream flow, improve water quality, and augment beneficial environmental conditions are encouraged to participate.

A Hydrospatial Approach to Measure Habitat Availability for Tidal Wetland Fishes

David E. Ayers, Ph.D. Student, *University of California, Davis (Presenter), and Co-authors:* ***Andrew Stevens,*** *Oceanographer, USGS,* ***Jesse R. Schroeder,*** *Research Technician, and* ***Andrew L. Rypel,*** *Associate Professor, University of California, Davis*

Tidal wetlands are dynamic ecosystems but metrics describing habitat characteristics are often quantified at static intervals. This paradigm is insufficient for facilitating conservation of diverse fishes whose life cycles rely on tidally variable drivers. Given the high costs of restoration activities, grave conservation needs of native and endemic fishes, and rising sea levels—practitioners need actionable information for creating optimal rather than nominal tidal wetland habitats. We present a hydro-spatial tool to overcome this challenge by integrating high-frequency tidal elevation data and high-resolution digital elevation models to quantify water volume and area of inundated tidal wetlands over a range of tidal and fluvial conditions. This process generates wetland-specific summaries of habitat availability across space, time, and established depth thresholds of tidal wetland fishes. More specifically our approach generates acre-hour (area summed over time) estimates of four distinct habitat categories including: insufficient depth, shallow habitat, deep habitat, and pelagic habitat. Additionally, we integrate fish dispersal (movement capacity) thresholds to explicitly account for habitat accessibility over space and time. We applied this methodology to two tidal wetlands in the Sacramento-San Joaquin Delta (Delta) which bookend the physical configurations (ecotypes) achievable through restoration activities. These sites, located in the northern Delta, are Little Holland Tract, a shallow flooded polder, and Liberty Island Conservation Bank, a dendritic wetland channel. Preliminary results suggest these study sites vary significantly in availability and connectivity of shallow rearing habitat for fishes. Our hydro-spatial tool is intended to help elucidate the habitat features which support imperiled fishes in tidal wetlands within the Delta.

California's Stream Gaging Plan, Priorities for Future Gaging, and Analysis Tools

Valerie Zimmer, *State Water Resources Control Board and* ***Todd Carlin,*** *Department of Fish and Wildlife (Co-presenters), and Co-authors:* ***Teresa Conner*** *and* ***Les Grade,*** *Department of Water Resources;* ***Dan Schultz,*** *State Water Resources Control Board;* ***Lucy Andrews,*** *University of California, Berkeley; and* ***Mike Fuller*** *and* ***Bill Short,*** *California Geological Survey*

The State Water Resources Control Board and the Department of Water Resources, in consultation with California Department of Fish and Wildlife and Department of Conservation, are developing a stream gaging prioritization plan, pursuant to Senate Bill 19 (Dodd, 2019), to address data gaps and support gage reactivation and deployment of new gages. Almost three-quarters of California watersheds do not have a federally or state-operated streamflow gage. The existing gage network is insufficient to address key management needs for water supply, flood, ecosystem, and water quality. The decommissioning and lack of gages in priority watersheds cause significant data gaps that hamper effective management of water resources, especially during periods of drought.

The stream gaging plan identifies gaps in the stream gaging network, prioritizes watersheds based on management criteria, and addresses data management and funding issues. Future gaging recommendations come from an intensive data review and a collaboration with UC Berkeley on development of an R-code based gage gap and prioritization tool. While the plan will support future gaging efforts, the tool will allow decision makers, water managers, and the public explore the input datasets and gage gap analysis. This presentation will discuss the plan highlights, the gage gap analysis, and prioritization results.

EcoFIP: An Enhanced Method for Evaluating Large-scale, Multi-objective Floodplain Restoration Opportunities

Michael Founds, M.S. and Luke Tillmann, M.S., cbec Eco Engineering, (Co-Presenters), and Co-Author: Chris Bowles, Ph.D., P.E., cbec Eco Engineering

The physical opportunities for multi-benefit floodplain restoration are being evaluated using a suite of eco-hydraulic modeling tools along a pilot study reach of the Upper San Joaquin River. This pilot study seeks to update and improve the Floodplain Restoration Opportunity Analysis (FROA), which was a key component of DWR's 2012 Central Valley Flood Protection Plan (CVFPP) and the 2016 CVFPP Conservation Strategy. The FROA analysis provided a systematic approach to rapidly identify habitat restoration opportunities for topographic modification or levee setbacks on floodplains for select ecological flows. This pilot study is evaluating how a refined set of modeling tools could be used to assess floodplain inundation, salmonid habitat suitability, and floodplain recharge for current and future flow regimes with the goal of identifying potential multi-objective floodplain restoration sites that provide high-quality salmonid habitat and maximize recharge on floodplains. The floodplain recharge quantification will support efforts to link Flood-Managed Aquifer Recharge (Flood-MAR) with restoration planning. EcoFIP (Ecological Floodplain Inundation Potential) is a methodology that acts as the first screening stage of the improved FROA to determine potentially suitable floodplain restoration projects and estimate their benefits. A key model output of EcoFIP will be the acre-days of inundated area, acre-days of suitable salmonid habitat, and potential recharge volumes summarized over a range of water years. The tools developed in this pilot study can evaluate habitat at any scale of interest (e.g., site boundary, parcel, or river reach). This makes it possible to evaluate the ecological characteristics of any boundary of interest for various historical or potential flow regimes. The pilot study model outputs will be used to identify and prioritize potential project boundaries or parcels of land along the upper reaches of the San Joaquin between the Friant Dam and Chowchilla Bifurcation Structure with physical opportunities for floodplain restoration project implementation. The pilot study will provide an updated framework for the FROA analysis with the potential for broader future applications throughout Central Valley rivers and their tributaries.

Notes from the Underground: the Hydrological Underpinnings of Watershed Response to Drought Across California

David Dralle, Ph.D., Research Hydrologist, U.S. Forest Service

Droughts are increasing in severity and frequency, yet the patterns of forest mortality and streamflow reduction are not entirely explained by above-ground factors, like plant density or snowpack. In this talk, we will dig deeply to explore the ways that subsurface water storage regulates tree and stream behavior in drought. In California, strong seasonality forces plants to dig deep for moisture, well beyond thin mountain soils into the fractured weathered bedrock beneath. How does water storage capacity in soil and bedrock layers impact forest drought resilience? When snow melts, how does its journey through the subsurface affect streamflow generation? To address these questions, we synthesize insights gained from multi-year, field intensive monitoring campaigns at sites across the state, and demonstrate how new tools from remote sensing and hydrological modeling can help us to extend these insights to less-well-instrumented forests.

Thermal Stratification of River Pools—Field and Numerical Modeling Study

Todd H. Buxton, Ph.D., *Trinity River Restoration Program, U.S. Bureau of Reclamation, (Presenter), and Co-authors:* ***Yong G. Lai, Ph.D.*** *and* ***Ben Abban, Ph.D.,*** *Technical Service Center, U.S. Bureau of Reclamation, Denver, CO*

Thermal gradients in rivers provide salmonids the diversity of temperatures they require for their freshwater lifecycle and pools are common areas for temperature gradients to form through vertical thermal stratification of the water. The warm water on the surface of a stratified pool can provide temperatures that optimize juvenile fish growth and the cold water at the pool bottom provides holding habitat for adults before spawning. We used field studies and numerical modeling to investigate thermal stratification of two pools with depths that adult spring Chinook target for holding on the Trinity River, California. The field data, including pool bathymetry, temperature and 3-dimensional (3D) velocity gradients, water depths, and discharges, were used to develop a 3D computational fluid dynamics (CFD) model of temperature to investigate conditions under which thermal stratification is formed and destroyed and replaced by homogenous temperatures in the pools. Diurnal temperature variation, thermal turbulent diffusion, and unstable convective mixing are found to dominate the pool's stratification. It is also shown that a unique critical flow exists for the maintenance of stratification when river flow is below the critical value or destroyed above it. The 3D CFD model reproduced the measured field data and can be used to determine the critical flow in a pool and the relative importance of different thermal processes that promote temperature diversity in it. The 3D model can also be used to evaluate the potential for temperature stratification in flows impacted by drought, design restoration projects to form pool bathymetries that promote stratification, and to develop flow schedules on regulated streams that maintain cold water in pools without depleting reservoir storage and later flow releases under a changing climate.

A Hydrologic Baseline for Quantifying Groundwater Contribution to Flows Supporting Critical Salmonid Rearing—Accretion in the San Lorenzo River System, Santa Cruz County, California

Barry Hecht, *Senior Principal, CHg, CEG (Presenter), and Co-authors:* ***Jason Parke,*** *Hydrologist,* ***Chelsea Neill, PG,*** *Balance Hydrologics,* ***John Ricker,*** *County Water Resources Director, and* ***Sierra Ryan,*** *County Water Resources Manager*

We collectively pioneered a monitoring approach to document flows and conditions in key streams supporting critical salmonids, while simultaneously meeting basic water-resource and water-rights' needs, including assessment of groundwater/surface water interactions, under the Sustainable Groundwater Management Act.

- The approach involves concurrent measurements of five non-biotic metrics:
- Streamflow discharge (cfs), measured with double precision
- Water temperature (deg C)
- Salinity (measured as specific conductance, umhos/cm)
- Nitrate concentrations (mg/L-N)
- Location, extent, and water temperature within pools deeper than 7 feet.

Measurements were made concurrently at pre-selected points approximately 400 to 1,000 meters apart during measurement walks down the stream channel once each during the late spring months and during the late summer months, detailing the source of flows during both the beginning and the latter stages of the summer months, a season thought to limit many remnant salmonid populations. These metrics can depict the key within-basin influences on the flow to the streams during the periods of most rapid smolt growth periods in May and June and the periods of metabolic stress later in the summer. We then tested these measurements during three consecutive water years—2017 (very wet), 2018 (dry) and 2019 (moderately wet). All told, measurements were made at about 40 regular points during each of 7 runs over the three years. Additional walks were made along two 1.5-mile reaches of Bean Creek, where geologic or hydrologic conditions were unusually complex. Five or six stream gages were operated during the six dry-season months, providing continuous flow data, quantifying effects of heat spells, rainstorms, diversion shutoffs, and other within-season events or influences potentially affecting fish populations and age structures.

The chosen metrics distinguishing inflows from alluvial, shallow, and deep aquifer systems, the nutrient status of the streams, effects of land use and wastewater management, plus annual climatic variability and response of bed conditions to episodic events such as storms, droughts, or wildland fires. Metrics can (and probably should) be tailored individual watershed based on local biological and planning considerations. In the San Lorenzo watershed, the authors have done 40+ years of measurements such that they were familiar with flow, salinity, nutrient, temperature, and bed-condition variations which might be most informative or allow comparison with past data, while also serving as a rigorous baseline for current conditions

Results showed important seasonal and year-to-year variations longitudinally along the main channels supporting salmonids. Measurements were made at pre-selected locations, such as at geologic contacts where ledges direct groundwater into the streams, or just above or below confluences of tributaries or springs, or at likely habitat bottlenecks.

Often, reach-by-reach management can guide planning for remnant or recovering populations, allowing managers and interested parties to see what has been changing and to address it.

In the case of the San Lorenzo River system, multi-metric accretion monitoring can be conducted in conjunction with groundwater (SGMA) and water-rights monitoring, with results also serving regional water-quality monitoring needs.

Opportunities for Collaboration: Tools and Initiatives for Increasing our Collective Impact

Session Coordinator*: Analise Rivero,* *Policy Associate, Cal Trout*

With heightened impacts from climate change being felt across the state and increasing competition for state attention and resources, it is more important than ever for our field to breakdown silos in order to achieve our common goals. This session will explore opportunities for collaboration amongst water professionals in order to increase our collective efficacy and impact. Topics covered will include:

- Collaborative tools
- Ongoing initiatives & agency efforts
- Legislation & state budget: how to advocate effectively together
- Lessons learned from prior efforts

Moving from Coordination to Collaboration for Transformational Change

Kellyx Nelson, ***San Mateo Resource Conservation District***

Good designs and engineering are critical to successful salmonid restoration, as are adequate funding, regulatory feasibility, and sound science. Equally important, and often overlooked, is the value of collaboration: to accomplish recovery at scale, to tackle projects because they are a priority rather than because they are the lowest hanging fruit, to make strategic investments with limited funds; to create shared investment for those times when something goes wrong; to create durable improvements. What is the difference between coordinating and collaborating? With so many demands on our time, and as we are spread thin, how can we justify the time spent on collaboration? Are there tangible outcomes? We will explore some of these questions and more as we consider various collaborations, their purposes and outcomes.

Redwood Creek Estuary Stakeholders Group, Using Strong Collaborative Process to Build Relationships and Trust

Mary Burke, California Trout, and Leslie Wolff, NOAA Fisheries (Co-presenters)

Strong collaborative process is built from relationship and trust. Collaboration is how we increase our collective impact to achieve process-based watershed restoration. Authentic relationship building leads to trust and trust leads to being open to discussions and agreement seeking on sensitive issues and topics. Practices that support collaborative processes are definition of values and interests, documenting areas of agreement, contingent agreements, and group decision-making.

In this case, the Redwood Creek Estuary (RCE) Stakeholder Group was convened to restore the estuary for multiple benefits, including recovery of ESA listed salmon and steelhead, and to improve agricultural function on adjacent lands. The U.S. Army Corps of Engineers (ACE) built the Redwood Creek Federal Flood Control Project in the 1960s, with levees on both sides of the estuary extending upstream for 3.4 miles, protecting the town of Orick, CA and adjacent grazing properties. The levees have dramatically reduced estuarine, tributary and floodplain function and habitat value, and the levees have led to extreme outboard and backwater flooding resulting in destruction of private grazing land, spruce sedge forests, and the critical estuarine habitat that supports recovery of listed salmon and steelhead. Private, public, and tribal interests intersect in a new opportunity to reach consensus for process-based estuarine restoration.

The concept of "contingent agreements" forms the basis of our RCE Stakeholder Group relationships and builds the trust needed to reach consensus and find win-win solutions. Our process incorporated definition of value-based interests for each stakeholder, mutual discovery through hydraulic modeling. Early attention was given to areas of agreement, while acknowledging the need for future refinement of design ideas and alternatives. A commitment to use contingent agreements rather than incentives or leverage have kept RCE Stakeholder Group trust, communication, and respect at high levels, and allow us to align with group agreements. The RCE Stakeholder Group's early and sustained use of collaborative process and contingent agreements built the trust and relationships needed to withstand ongoing collaboration to find durable agreements.

Public/Private Partnerships and Coalitions —Leveraging Skills and Avoiding Procurement Conflict

Lisa Hulette, MPA, MBA, WRA, Inc.

Partnerships and coalitions have created the most rewarding work and enduring professional relationships in my career. If the past few years have taught us anything, it's that going it alone is lonely and siloed work can lack enthusiasm and creativity. With state and federal grant money becoming increasingly focused on climate adaptation and resiliency, the time is now to bring together collective expertise and resources to quite literally change the world.

Climate change affects people, property, economy, and ecosystems in a way that no one entity can make the kind of meaningful change to address a multitude of issues. Public- private partnerships and multi-stakeholder coalitions can bring about more resources and power than the individual entity can accomplish alone. Key advantages include access to funding, people, and technology; transfer of risk; and business development opportunities. However, there are risks and lessons to be learned. Federal grants and subsequent procurement policies are critical to understand during the proposal process. Breakdown of partnerships during project implementation potentially leading to project failure.

During this session, I will provide an overview of the exciting world of procurement, case studies of successful coalitions, and some tools to help you decide if your project would benefit from a formal partnership or coalition.

High-resolution Water Budget Hydrology to Support Collaborative Water Management for Salmonid Recovery, Mill Creek Watershed, Navarro River, California

Christopher Woltemade, Ph.D., *Shippensburg University and Prunuske Chatham, Inc. (Presenter), and Co-authors:* ***Monty Schmitt*** *and* ***Jen Carah,*** *The Nature Conservancy*

The Navarro River watershed in northern California provides critical habitat for Coho salmon and steelhead trout, but low dry-season streamflow limits habitat quality due to poor hydrologic connectivity, warm water temperatures, and low dissolved oxygen. Mill Creek is a Navarro River tributary that drains 31.5 km2 and is important for the recovery of Coho and steelhead populations. The Nature Conservancy, Trout Unlimited, Mendocino County RCD, Prunuske Chatham, Inc., and other partners have focused on Mill Creek to demonstrate the potential for Collaborative Water Management (CWM) strategies to improve streamflow and water quality in support of fishery restoration.

CWM incentivizes individual water users to collectively implement projects and management actions that reduce summer diversions and increase infiltration to improve streamflow for fish, wildlife and water supply reliability. CWM is community-based, voluntary, stakeholder-driven, and uses existing strategies, tools, and policies to develop solutions that meet landowner needs. By reducing reliance on dry season water supplies, CWM increases the resiliency of salmonid habitat and water supplies against impacts of future droughts and climate change. CWM is rooted in science, with data-driven methods to identify water management solutions. This includes flow monitoring, wet/dry mapping, use of flow objectives, assessing impacts of groundwater extraction, and development of hydrologic water budgets.

A water budget modeling tool developed for Mill Creek CWM planning assesses high-resolution hydrologic conditions at a sub-watershed scale. Monthly calculations track flows of water between precipitation, soil moisture, groundwater, evaporation, transpiration, and streamflow. The water budget supports assessing impacts of water consumption for residential and commercial use, irrigation of conventional crops and cannabis, and frost protection. The model considers water sourced from groundwater, storage ponds and tanks, and direct stream diversions. The water budget was applied to evaluate four strategies to improve dry-season stream flow: (1) reduced dry-season diversions from streams, (2) strategic releases of water from ponds, (3) infiltration and groundwater recharge enhancement, and (4) reduced impacts of groundwater withdrawals.

Flow objectives were established for each stream reach and included minimum flows at all times and a dry-season average flow coupled with a minimum flow target. The potential contribution of each management strategy to meeting these flow objectives was evaluated. Specific management approaches best suited to each sub-watershed were identified and will inform engagement with the community to advance flow restoration in Mill Creek. Reducing dry-season sourcing of water for conventional crop irrigation would be an effective strategy in some areas, while in other areas the most effective strategies may be enhanced groundwater recharge or reducing dry-season sourcing of water for cannabis irrigation or residential and commercial use.

Results indicate that flow objectives could be met much of the time via a portfolio of targeted water management strategies. Strategic release of water from storage could supplement those strategies when flow objectives cannot otherwise be met. Given the sensitivity of California salmonids to minor changes in dry season streamflow, the calculated flow benefits would significantly improve salmonid habitat. CWM is a promising approach that is being further developed for several other North Coast watersheds.

Regional Collaborations to Solve the Eel River's Aged and Outdated Hydropower Infrastructure at the Potter Valley Project

Darren Mierau, *North Coast Director, Cal Trout (Presenter), and Co-authors:* ***Redgie Collins,*** *Staff Attorney, California Trout, and* ***Curtis Knight,*** *Executive Director, California Trout*

While strict regulatory processes are generally available to address complex hydropower and water supply infrastructure issues, they do not necessarily provide the most expeditious or "outside the box" pathways to solving these complex regional issues. They are at best, the baseline default pathway.

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 century is at a critical infrastructure cross-roads. In a somewhat unprecedented step and seeking to "collaborate from within", five stakeholder groups stepped forward in 2019-20 to obtain the FERC license to the Project and lead the project toward Congressman Huffman's "Two-Basin Solution". However, despite successfully navigating the FERC process for two years and completing a robust set of Feasibility Studies, the Partners were unable to obtain funds to complete an estimated $18 million in FERC-required studies.

By April 2022 at the latest, when the PG&E FERC license is set to expire, the Project will likely default back to PG&E who will then be directed by FERC into the Surrender and Decommissioning process. The Partners and their associated conservation and water supply interests must then seek to "collaborate from without", working together to guide PG&E toward a successful and acceptable decommissioning plan. 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. At stake are the threatened fall-run Chinook salmon and winter- and summer-run Steelhead populations in the Eel River, and the continued existence of a trans-basin water supply to Lake Mendocino and Russian River water users.

What could go wrong?

Establishing a Respected Ecological Workforce

Mark Cederborg, *CEO, Hanford, and* ***Jim Robins,*** *Principal, Alnus Ecological (Co-presenters), and Co-author:* ***Sally Bolger,*** *Director, Ecological Workforce Initiative*

It is at the ground level of restoration projects where the impacts to resources occur and where the regulatory requirements are implemented, yet there currently is no publicly available training for those workers. A coalition of restoration industry leaders, employers, workforce development partners, training providers, and educators are establishing an Ecological Workforce Training Program and industry-recognized Certificate for ecological trade work. The Ecological Workforce Initiative is a collaborative effort with the goal of increasing the impact of restoration activities by improving project outcomes, establishing a respected identity for Ecological Workers separate from general civil construction trade workers, and building recognition that investments in ecological restoration are investments in our human communities as well.

Educating laborers, equipment operators, and other trade workers about the purposes of restoration, the conditions within which they work, the types of permits that may be encountered, and the reasons why the regulations must be adhered to is critical to the project success and support for future restoration efforts. The extent to which workers are trained in this specialty is primarily based on on-the-job training, which varies dramatically between employers. Lack of qualifications standards can lead to damage to resources and unsatisfactory project outcomes. Without properly trained crews able to work in sensitive environments, construction activities intended to restore or enhance resources can instead result in environmental degradation, species mortality, and destruction of cultural artifacts.

As public concern about climate change builds and public funding increases, the danger that unqualified laborers will be hired to implement restoration projects grows. The not-for-profit Ecological Workforce Training Program, which was piloted in June and July 2021, is a combination of specially developed classroom curriculum supplemented by worksite-based restoration training and is designed to be integrated into a wide-variety of education and job-specific training programs. The Program delivers environmental compliance-focused curriculum at no cost to on-the-ground laborers and equipment operators, giving them the skills and knowledge needed to work appropriately in ecologically sensitive habitats, including a basic understanding of the permitting requirements and restrictions, habitat types, and species of concern.

Creation of a respected training program will foster recognition of Environmental Restoration as an economic driver for our communities and identify an Ecological Workforce separate from, and with more specialized skills than, traditional civil construction laborers. It is also a powerful means of addressing the long-standing barriers to employment in restoration work faced by many in our underserved communities by expeditiously training laborers of all levels into well paid and fulfilling jobs with excellent wages and benefits, without the need for higher-education or high-level English proficiency.

Establishing a recognized and respected Ecological Workforce will highlight the economic impact of restoration projects, so that public funding for these projects is seen not only as ecological benefit but also as direct economic benefit to workers and their families, resulting in more funding for restoration projects, better health of our environment, and a continually expanding job market for workers.

An Ecosystem Model Framework to Predict Historical and Future Ocean Conditions Impacting Juvenile Salmon off Central California

Jerome Fiechter, *Ocean Sciences Department, University of California (Presenter), and Co-authors:* ***Michael Jacox,*** *NOAA Southwest Fisheries Science Center, Monterey, CA, NOAA Physical Sciences Laboratory, Boulder, CO, and* ***Brian Wells,*** *NOAA Southwest Fisheries Science Center, Santa Cruz, CA*

This presentation reviews recent advances in marine ecosystem modeling with an emphasis on bridging variability at scales ranging from climate to regional and, ultimately, to those associated with the behavior, growth and survival of juvenile salmon following ocean entry. The framework includes an individual-based model (IBM) for juvenile salmon coupled to a regional ocean circulation model and a Nutrient-Phytoplankton-Zooplankton (NPZ) model, and the results illustrate how historical variability and future climate conditions can be integrated into high-resolution numerical simulations of the central California Current ecosystem. Growth potential following ocean entry is used as an example to contrast locations where local variability is dominated by environmental processes and prey distribution with locations where model uncertainty limits prediction robustness.

Can We Use an Ocean Productivity Model to Estimate Juvenile Salmon Early Ocean Survival?

Mark Henderson, Ph.D., *U.S. Geological Survey, California Cooperative Fish and Wildlife Research Unit, Department of Fisheries Biology, Cal Poly Humboldt (Presenter), and Co-authors:* ***Jerome Fiechter,*** *Department of Ocean Sciences, University of California, Santa Cruz,* ***David D. Huff,*** *Estuary and Ocean Ecology Program, Fish Ecology Division, Northwest Fisheries Science Center, NOAA, Hammond, OR, and* ***Brian K. Wells, Ph.D.,*** *SWFSC, Fisheries Ecology Division, National Marine Fisheries Service, NOAA, Santa Cruz, CA*

Early ocean survival of Chinook salmon, *Oncorhynchus tshawytscha*, varies greatly inter-annually and may be the period during which later spawning abundance and fishery recruitment are set. Therefore, identifying environmental drivers related to early survival may inform better models for management and sustainability of salmon in a variable environment. With this in mind, we used a cohort reconstruction for the fall run of California's Central Valley Chinook salmon population, combined with a biogeochemical oceanographic model, to investigate how spatial variability in ocean production after early ocean entry can influence the strength of a cohort. Our main objectives were to: (1) identify regions of high temporal variability in growth potential over a 23-year time series, (2) determine if the spatial distribution of growth potential was correlated with observed oceanographic conditions, and (3) determine if these spatial patterns in growth potential could be used to estimate juvenile salmon survival. For the period from 1988-2010, juvenile salmon growth potential on the central California continental shelf was described by three spatial patterns. These three patterns were most correlated with upwelling, detrended sea level anomalies, and the strength of onshore/offshore currents, respectively. Using the annual strength of these three patterns, as well as the overall growth potential throughout central California coastal waters, in a generalized linear model we explained 82% of the variation in juvenile salmon survival estimates. We attributed the relationship between growth potential and survival to variability in environmental conditions experienced by juvenile salmon during their first year at-sea, as well as potential shifts in predation pressure following out-migration into coastal waters.

Juvenile Chinook Salmon Growth and Survival After Ocean Entry off Central California: Top-down and Bottom-up Effects in an Individual-based Model

Kelly Vasbinder, Ph.D., *University of California, Santa Cruz (Presenter), and Co-authors:* ***Jerome Fiechter, Ph.D.,*** *University of California, Santa Cruz,* ***Brian Wells, Ph.D.;*** *SWFSC Fisheries Ecology Division and NWFSC Fish Ecology Division;* ***James J. Anderson, Ph.D.,*** *School of Aquatic and Fishery Sciences, University of Washington;* ***Jarrod Santorra, Ph.D.,*** *SWFSC Fisheries Ecology Division and University of California, Santa Cruz;* ***Nate Mantua, Ph.D.,*** *Program Lead, Landscape and Seascape Ecology, SWFSC Fisheries Ecology Division; S****teve Lindley, Ph.D.,*** *SWFSC Fisheries Ecology Division Director; and* ***David Huff, Ph.D.,*** *Estuary and Ocean Ecology Program Manager, NWFSC*

The time from ocean entry to the end of the first year is an important period for determining the survival of fall-run juvenile Chinook salmon. An ecosystem modeling approach is ideal for exploring the impact of spatial and temporal variability in predation pressure on juvenile salmon survival during the months following ocean entry. Our ecosystem model incorporates a ROMS sub-model for hydrodynamics, a Nutrients-Phytoplankton-Zooplankton (NPZ) sub-model for generating prey fields, and an individual based model (IBM) for juvenile Chinook salmon. The salmon IBM consists of a series of modules representing growth, mortality, behavioral movement, and predation interactions. In this project, we expand the mortality sub-model to include predation in the form of a central place feeder, with the potential for other predator types to be included in future versions. We calculate predation mortality through the use of predator and prey size distributions and their interaction probability. Temperature and krill fields from the ROMS and NPZ sub-models are used in the IBM for calculating juvenile salmon growth and inform behavioral movement. Interactions with predators depend on the size of the juvenile salmon, whereby individuals that grow past the size of the predator's prey distribution will escape predation. This size-dependent approach to predation mortality means that factors impacting the growth of salmon shortly after ocean entry can also impact predator-prey dynamics. We use a 21-year time series from 1990-2010 to explore interannual variability in growth and survival of juvenile Chinook salmon off central California under different predation scenarios. Our results illustrate the effect of predation on population-level characteristics and lay the foundation for establishing ecosystem indictors of juvenile Chinook survival at sea off central California.

Integrating Coded-Wire Tags and Genetic Stock Identification in State-Space Models to Characterize Marine Distributions of California's Chinook Salmon

Alexander Jensen, Ph.D., University of Washington

Improved understanding of Chinook salmon behavior and distribution in the marine environment can provide ecological insights and benefit fishery management efforts for stocks of conservation concern. California's Chinook salmon stocks include spring-, fall-, and winter-run fish from the Central Valley, spring- and fall-run fish from the Upper Klamath and Trinity River, and fall-run fish from smaller coastal river systems. Three of these groups are listed as threatened or endangered: Central Valley spring-run, California coastal, and Sacramento River winter-run. Recent studies used historical coded-wire tag (CWT) recoveries and Bayesian state-space models to characterize marine distributions of fall-run stocks only, primarily due to availability of tag data. Genetic stock identification (GSI), in which sampled fish are assigned to representative groups using genetic markers, is a valuable tool in fisheries management that has experienced increased usage and performance since the 1990's. Because GSI allows identification of all sampled fish, instead of only those fish included in tagging efforts, GSI data opens up new possibilities for studying the distribution of rarer spring- and winter-run socks in the ocean. The increased scope of GSI is offset by trade-offs in accuracy, as fish are rarely assigned to groups with complete confidence.

We propose combining both CWT and GSI data in an expanded Bayesian state-space model to estimate the spatiotemporal dynamics of California's spring-, fall-, and winter-run Chinook salmon stocks in the ocean. By combining CWT and GSI data, the model represents a novel integration of often competing data streams with complementary trade-offs. Model-estimated life history parameters will include the seasonal distributions and abundances of California's Chinook salmon stocks across ocean regions. Proposed GSI datasets include samples collected from Pacific hake bycatch, recreational harvest, and commercial landings from California, Oregon, and Washington. We expect modeling results will generate new insights into the marine distribution of California's spring- and winter-run stocks, strengthen past findings for more abundant fall-run stocks, and reveal potential differences in ocean distribution between tagged and untagged stock components. Furthermore, we hope results from this work will support future expansions of model scope to include additional Chinook salmon stocks across the West Coast and explore climate influences on life history.

Ocean Distribution of West Coast Chinook Salmon Inferred from Coded-Wire-Tags and Genetic Data

Will Satterthwaite, Ph.D., *NOAA SWFSC (Presenter), and Co-authors:* ***Alex Jensen, Ph.D.,*** *University of Washington,and* ***Ole Shelton, Ph.D.****, NOAA NWFSC*

Information on the ocean distribution of West Coast Chinook salmon comes primarily from recoveries of coded-wire-tagged (CWT) fish, and more recently genetic sampling as well, in commercial and recreational ocean fisheries. Nearly 40 years' worth of CWT data are available at this point, recovered in comprehensive sampling from Alaska to California. CWT reveal fish age along with other information about juvenile fish at the time of tagging. However, CWT are largely limited to hatchery-origin fish. Genetic stock identification (GSI) can provide information on natural-origin fish, but individual stocks and populations are not always resolvable at the desired level, and age information requires additional work on scales or otoliths, which is often not done.

Some of the earliest analyses of total CWT recoveries by area established that in general, Chinook from common freshwater regions have similar oceanic distributions, with stocks of more northerly origin often found further to the north in the ocean as well. Fall versus spring run stocks from the Columbia Basin appear to have substantial differences in their distributions whereas fall versus spring run stocks from California and the Oregon Coast appear more similar. Refined models for California stocks accounting for seasonality and fishing effort revealed seasonal changes in distributions, including increased density near source rivers as the spawning season approached, as well as some variation across years in fine-scale distribution, possibly tracking ocean temperatures. For California stocks of particular conservation concern, both CWT and GSI data suggest that Sacramento Winter Chinook are highly concentrated south of Point Arena and that Central Valley spring Chinook are distributed similarly to Central Valley fall Chinook. GSI data suggests broad similarity in the distributions of California Coastal and Klamath Chinook, with some divergence toward respective source rivers around August.

A recently developed state-space model reflects the most direct attempt to date at inferring area-specific ocean abundance of individual Chinook stocks and what factors might drive variation in distribution over time. Application of this model framework to CWT recovered from fall run Chinook coastwide has confirmed that ocean distribution depends strongly on region of origin, varies seasonally, and varies across years in ways that seem at least partially explained by ocean temperatures. Efforts are ongoing to extend this model to spring-run and natural-origin stocks by developing a unified statistical framework that can be applied simultaneously to CWT and GSI data while incorporating data from additional fisheries, such as salmon bycatch in groundfish trawl fisheries.

How Physical Habitat and Prey Abundance Interact to Shape the Growth Opportunities of Salmonids: Examples from Bristol Bay to the Klamath Basin

Jonny Armstrong, Ph.D., Oregon State University,
Department of Fisheries, Wildlife, and Conservation Science

Studies across a diversity of ecosystems and salmonid life stages have shown that larger fish generally have higher survival. This suggests that conservation should focus more explicitly on increasing growth opportunities. Fish energy budgets are typically most sensitive to consumption rates, so the best way to increase growth will often be to increase foraging rates. Researchers are increasingly considering metrics of food abundance or productivity as biotic habitat variables to complement existing abiotic metrics. However, our ability to interpret and utilize prey availability indices will likely be proportional to our understanding of fish foraging ecology. In this talk I will synthesize studies that reveal how prey abundance interacts with physical habitat conditions and fish behavior to determine the growth rates of fish. I will highlight three topics: (1) size thresholds for prey consumption and their potential to generate positive feedbacks between temperature and growth, (2) how phenological diversity of prey resources (derived from habitat heterogeneity) can prolong quality foraging opportunities for mobile fish, and (3) how ephemerally suitable habitats can fuel growth even if their abiotic conditions are lethal for much of the year.

Making a Living in a Seasonal Lagoon: Interactions Among Water Temperature, Prey Availability, and Juvenile Salmonid Growth

Rosealea M. Bond, *University of California, Santa Cruz, NMFS Southwest Fisheries Science Center (Presenter), and Co-authors:* ***Cynthia Kern, Ann-Marie K. Osterback, Alexander Hay, Joshua Meko,*** *and* ***Jeff Perez,*** *University of California, Santa Cruz, NMFS Southwest Fisheries Science Center; and* ***Joseph D. Kiernan,*** *NMFS Southwest Fisheries Science Center*

Estuaries are among the most productive habitats worldwide and serve a variety of critical functions in the early life history of anadromous Pacific salmon. In California, many estuaries transition to seasonal lagoons during the dry season when sandbars disconnect streams from the ocean. Juvenile rearing in lagoons may confer significant fitness advantages compared to rearing in upstream riverine habitat due to relatively abundant prey resources and high growth potential. However, key water quality parameters such as temperature and dissolved oxygen concentration can periodically approach or exceed the physiological tolerances of juvenile salmonids during the closure period. It remains unclear how juvenile salmonids weigh the tradeoff between access to increased prey and potential metabolic costs associated with the lagoon, particularly during the warm summer months. Previous research conducted in the Scott Creek watershed (Santa Cruz Co.) has demonstrated that juvenile steelhead (anadromous *Oncorhynchus mykiss*) and Coho salmon (*O. kisutch*) benefit from lagoon rearing despite periods of extreme environmental conditions and diminished habitat suitability. We hypothesize that oversummer persistence of juvenile salmonids may be facilitated by abundant prey biomass in the lagoon and recurrent movement into refuge areas when abiotic and (or) ecological conditions were unfavorable. In this presentation we will expand upon previous work by examining estuary/lagoon trophic dynamics and the degree to which enhanced food resources may allow juveniles to occupy and persist in habitats that are physiologically suboptimal.

Puddle Power and the Pivot to Process: A Landscape-scale Recipe to Allow the Sacramento Valley to Make Salmon Again

Jacob Katz, Ph.D., *California Trout (Presenter), and Co-authors:* ***Jacob Montgomery,*** *CalTrout, and* ***Carson Jeffres, Ph.D.,*** *University of California, Davis*

Central Valley native fish stocks continue to slide towards extinction despite decades of conservation effort and billions of dollars of investment leading many to believe that endangered fish populations may be an inevitable consequence of human development. This presentation will summarize a decade of work unequivocally demonstrating that collapsing aquatic ecosystems and endangered fish populations are, in fact, a direct result of infrastructure and land use practices put into effect long before we understood how they interrupted natural river valley processes and ecosystem functions.

We will focus on the hydrologic conditions typifying ephemerally inundated floodplains—shallow depths, warmer water, longer water residence times and predominantly detrital carbon sources compared to deeper, colder, swifter water and a predominantly algal-based carbon source in adjacent river channels—which appear to facilitate the dramatically higher rates of food web and salmonid biomass production observed in off-channel habitats compared to stream channels.

The Sacramento Valley has been highly altered, resulting in loss of hydrologic connectivity between river and formerly inundated floodplains and degraded fish habitat quality in two major ways:

1. Levee construction reduced fish access to floodplain: Levee construction during the late 19th and early 20th century reduced the frequency of hydrologic connection between river and floodplain by ~95%.

2. Pervasive landscape-scale alteration to wetland topography severely degraded floodplain habitat quality: Prior to levee construction Sacramento Valley floodplains regularly flooded for months at a time. In the few places where floodplains still regularly inundate, such as Sutter and Yolo Bypasses, wetland land surfaces have been extensively graded to expedite drainage of floodwaters. By their very design, the bypasses expedite the drainage of wetlands and limit inundation duration and short circuit the aquatic food webs which once fueled fish abundance.

This talk will outline a portfolio of solutions that reimagine water infrastructure and operation in ways that reactivate natural floodplain functions at the landscape scale needed to illicit population level response and set native fish populations on a trajectory towards recovery.

Coupling Habitat and Prey Supply with Juvenile Chinook Salmon Growth and Production in the San Joaquin River Restoration Project

Steve Blumenshine, *CSU-Fresno, California Water Institute,*
and ***Amy Hernandez****, CSU-Fresno, Dept. of Biology (Co-presenters)*

Salmon and river restoration projects could and should focus on juvenile fish production as an integrative variable to predict restoration success under varying hydrologic and habitat conditions. The restoration of Chinook salmon to the San Joaquin River in California's Central Valley is challenged by an unpredictable and diminishing water supply as well as the return and survival of Spring Run broodstock. We couple empirical approaches of habitat production potential, i.e. water temperature and invertebrate prey assemblages with simulation tools including fish bioenergetics, habitat simulation models, stable isotope mixing models, and drone imaging to develop approaches to best assess restoration goals and probability of success. Our empirical habitat assessment also includes the abundant macrophyte habitat in the San Joaquin River which is typically overlooked in habitat assessment models despite nearly 10x the invertebrate abundance compared to adjacent drift and benthic invertebrate abundances. Over recent years we are particularly interested in applying these approaches to scenarios of varying water regimes (flows) and the abundance of energy to juvenile salmon as invertebrate biomass and production.

Defining a Basin-Scale Restoration Framework to Recover an Endangered Species. An Optimization-Simulation Approach Using a Life Cycle Model

Francisco Bellido-Leiva, F.J., *Department of Civil & Environmental Engineering and Center for Watershed Sciences, University of California, Davis (Presenter), and Co-authors:* ***Rob Lusardi, Ph.D.,*** *Center for Watershed Sciences and Department of Wildlife, Fish, and Conservation Biology, University of California, Davis; and* ***Jay R. Lund****, Department of Civil & Environmental Engineering and Department of Wildlife, Fish, and Conservation Biology, University of California, Davis*

Efforts to restore freshwater habitats and improve the function of aquatic ecosystems have increased substantially over the last two decades. Such actions require considerable resource investments, while the success of such restoration efforts on target species are often fraught with uncertainty. More formal optimization frameworks may help coordinate and structure complex watershed-scale efforts, prioritize conservation actions before investments, and improve the likelihood of significant ecological benefits. This study focuses on the federally endangered and endemic Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*) and develops an optimization framework that seeks optimal restoration portfolios to maximize returning adult abundance under alternative investment scenarios. Each winter-run Chinook restoration strategy improves a combination of habitat availability, rearing conditions, residence time and/or survival. Their impact on population dynamics was simulated using an expanded Winter-run Habitat-based Population Model (WRHAP), denoted as WRHAP-SEA. Additional sub-models incorporate hatchery operations, reintroduction programs, and ocean-stage survival based on smolt development in the Sacramento River watershed. Optimized portfolios of recovery actions present promising results related to adult returns, population spatial structure, diversity, and growth rate, all of which could reduce winter-run Chinook risk of extinction. For instance: (i) Battle Creek reintroduced population greatly reduces winter-run Chinook vulnerability to catastrophic events, such as critical droughts; (ii) diverse restoration portfolios, obtained through increasing budgets, greatly reduced the ratio of hatchery supplementation. Viability assessment of defined portfolios showed the prominence of frequent and sustained floodplain activation (assuring enough juvenile residence time), as average positive population growth was not achieved until their implementation. This effort demonstrates the value of population reintroductions, off-channel habitat restoration, and floodplain connection enhancement as viable recovery actions for winter-run Chinook. The defined framework aids in exploring relationships between an ample set of restoration strategies at the watershed-scale and identifies optimal portfolios to assist water/environmental management and decision-making for species recovery.

Foodscapes as Reference States: Reconnecting Salmon with the Productive Capacity of Their Watershed

Gabriel Rossi, Ph.D., *University of California, Berkeley (Presenter), and Co-authors:* ***J. Ryan Bellmore,*** *U.S. Forest Service;* ***Sean Naman,*** *Fisheries and Oceans Canada; and* ***Mary Power,*** *University of California, Berkeley*

What baseline is the ultimate goal for salmon or watershed recovery? Identifying these baselines, or reference states, has been a perennial challenge in salmon and watershed recovery efforts. Reference states based on population targets and physical habitat suitability metrics have been criticized as approaches that fail to protect multiple ecological processes, favor heavily managed solutions, and tend towards unnaturally static conditions. Historical baselines are often vague or intractable to define. In recent years, process-based restoration has been held up as a model that addresses these concerns by aiming to "reestablish normative rates and magnitudes of physical and ecological processes that sustain river and floodplain ecosystems." However, in practice, process-based restoration has primarily emphasized reestablishment of physical (channel/riparian) processes, assuming—often incorrectly—that ecological processes necessarily will follow. A more explicit focus on ecological reference states, such as the spatiotemporal dynamics of food webs that sustain salmon, is needed.

Defining a "reference foodscape" can help us to apply process-based restoration that explicitly considers bioenergetic and spatiotemporal food web dynamics. The foodscape describes the spatial and temporal mosaic of growth potential that mobile consumers use throughout a watershed. Growth potential varies across the watershed as a function of food abundance, food availability, and metabolic costs. Each of these factors have been impaired in human altered watersheds and each must be considered in restoration efforts. The first step is to estimate a reference foodscape–the baseline, unimpaired phenology of growth potentials across river networks, and the multitudes of life histories they may have supported. Second, we define the altered, or realized foodscape and the current life histories it supports. By superimposing these two models we can identify and prioritize the mismatches between baseline growth potential and todays realized growth potential. We can also ask "what causes those mismatches?" The answer to these questions may reveal new insights to salmon ecology and more importantly help us target the most effect recovery actions to restore their populations and resilience.

Creating Opportunities for Community Involvement to Address Common Urban Stream Management Issues

Friday Afternoon Concurrent Sessions

Session Coordinator*: Jessica Hall,* *California Urban Streams Partnership*

This session will focus on addressing community involvement in some of the most pressing issues facing urban streams, highlighting why community engagement in urban areas is crucial to successful long-term restoration and management. Speakers will focus on engaging diverse communities in stream stewardship, including homeless populations, landowners, the urban and rural divide, and under-served urban populations. How can we forge and maintain collaborative relationships to steward our shared resources? How can we learn from our past mistakes in urban stream management to create more inclusive and comprehensive collaborations? We will examine how urban stream management can benefit both human populations and stream ecosystems through holistic flood management, steelhead recovery, trash management and more.

Engage, Educate, and Empower: Motivating Communities to Get on Board with Restoration in Their Backyards

Sarah Phillips, *Marin Resource Conservation District*

Getting residents on board with restoration can prove challenging, especially in urbanized watersheds. There are many hurdles a watershed faces while navigating through an urbanized landscape, including the people. Yet it is people that can make a difference. Luckily, there is a multitude of ways to engage the communities around you in order to see the change we need to see in our impacted waterways. This presentation will cover a series of strategies used by Marin Resource Conservation District's Urban Streams Program Manager, Sarah Phillips, who carries out such efforts throughout Marin County's watersheds, including both rural and urban watersheds as the two require differing messages and at times, varying approaches. It all starts with making a personal connection followed by education then finding the motivation that will entice the community to join in with ways to improve the watershed that they live in. In some cases, It is a matter of providing incentives and in other cases, it can be as simple as taking people out to observe juvenile salmonids up close and personal so that their hearts swell to the point of caring, and inspiring them to change behavior and improve habitat conditions in whatever ways possible. It is monumental to teach communities about salmonids and the crisis their populations face today and even more monumental to provide the people with the tools they need so they don't feel hopeless but instead become empowered to do their part. This presentation will take a hard look at the successes and lessons learned since the Urban Stream Program was initiated in September 2014, so that others may gain knowledge on key elements that have worked and have not. Lastly, this presentation will also touch on ways in which the practice of facilitation and mediation may prove very crucial when used at the right time in the right place.

Addressing Property Owner Fears of Creeks

Jessica Hall, *Project Manager, California Urban Streams Partnership*

The California Urban Streams Partnership works to address stream management needs to protect the environment in urban and rural private properties throughout Contra Costa Country through the Streamside Management Program for Landowners (SMPL). SMPL has made it simple for homeowners to understand solutions, permitting requirements and best ecological practices available to address their property-creek issues. Property owners who fear that they have problems relating to stream bank stability, stormwater and flooding are referred to CUSP by the County Public Works Department, towns, and cities in the county. In addition to providing site assessments, CUSP in partnership with the Contra Costa County RCD has provided on-site stream restoration assistance to property owners.

Contra Costa County has a population of approximately one million, and 40% of the county is public space while 60% is held privately. The County acreage is contained within an urban growth limit boundary containing 43% of the acreage. Many of the streams are habitats for anadromous fish and other species of concern. Within this context, CUSP works to help residents understand how to be stewards of their watersheds, while solving conflicts between property and stream boundaries.

Due to the lack of knowledge and fear of stream management, many property owners revert to environmental damaging riprap, concrete, gabions, and channelization. SMPL provides landowners with information to face their fears around streams to manage their streams with environmentally sensitive strategies that achieve the results they need.

Currently, CUSP has visited and consulted with 71 property owners between 2018 - 2021. We will discuss the common reasons property owners ask for assistance through SMPL, and what practices are used to address common issues. Many common requests for assistance are due to erosion (71%), stormwater and flooding (50%), invasive plants and vegetation management (43.7%), fire management (42%), tree falls (27.54%) and fear of unknown hazards (100%). An interesting outcome of recording urban stream management problems is finding a pattern of in-channel weirs or grade control structures causing significant damage to properties involving 17% of our cases.

Additionally, we will explore how this program helps participants understand stream-related regulations, as well as more about streams systems and watersheds. This education has empowered SMPL participants to accomplish installation of inexpensive remedies to address their property concerns and enhance their creeks, all while dispelling their fear and stress about stream environments.

CUSP has partnered with the County Public Works Department to make the SMPL program possible, while the workload is reduced for the County staff. Additionally, SMPL operates in compliance with the California Department of Fish and Wildlife and the San Francisco Bay Regional Water Quality Control Board by pre-emptively educating property owners on how to avoid regulatory issues through mismanagement.

Coalition and Community-based Endangered Steelhead Recovery in Southern California

Sandra Jacobson, Ph.D., *California Trout, Director—South Coast Region (Presenter), and Co-author:* ***Russell Marlow,*** *California Trout, Program Manager—South Coast Region*

Due to the complexity of threats that face endangered salmonids and the precariously few populations left particularly in Southern California, a coalition approach is needed to engage a wide range of partners in the recovery process. This opens the door for community participation in a way that can effectively align agency and community goals. CalTrout leads two steelhead coalitions in Southern California, one based in San Diego, the other in Ventura. These coalitions engage the community at multiple levels—with the strategy to integrate fisheries conservation and recovery efforts for steelhead into existing regional conservation efforts in the South Coast Region through actions that are consistent with Recovery Plan objectives. The coalition operates according to a strategic plan. This focuses effort to ensure maximum efficiency and positioning for funding, and to ensure a pragmatic and economically feasible approach to accomplish the goals. Examples of projects underway will be presented that remediate large and complex fish passage barriers on high priority rivers, remove non-native species to benefit native fish, and improve irrigation efficiency to benefit tribal communities water resources, local agricultural technical capabilities while supporting native trout habitat. Overall, these projects chart a new path to integrate natural processes into urban landscapes—creating resource management solutions that support wildlife and communities.

Community-Involved Creek Restoration in the Walnut Creek Watershed

Heather Rosmarin, *Co-Founder, Friends of Pleasant Hill Creeks, Former Member of the Contra Costa County Fish and Wildlife Committee (Presenter), and Co-author:* ***Bob Simmons,*** *President, Walnut Creek Watershed Council, Former Mayor of the City of Walnut Creek*

The Walnut Creek Watershed is a 146 square-mile watershed located in Contra Costa County, California. The watershed includes 309 miles of creek channels and multiple urban areas. In October 2021, Chinook salmon were observed in Walnut Creek and one of its main tributaries, Grayson Creek. The Walnut Creek Watershed Council (WCWC), a California Public Benefit Non-Profit Corporation, and grassroots "Friends of the Creeks" groups engage with community volunteers and landowners as well as with city and county agencies to advance watershed education, protection, and restoration programs. This presentation will focus on how WCWC and allied community groups have engaged community volunteers and private and public land owners in restoration activities including: trash cleanups and assessments, invasive species removal with a focus on Arundo donax, water quality monitoring, wildlife surveys, riparian restoration, and land-use planning in an urban creek context. Successes include: removal of thousands of items of trash from waterways, mapping and removing Arundo donax from public and private creek banks, influencing creek-side development to be more wildlife- and watershed-friendly, implementing native riparian re-planting restoration projects with mitigation funds and other donated funds, and documenting more than 100 species of birds in one of the watershed's urban creek systems.

Planting a Dream: A Community Designed Urban Park Connects People and Nature

***Chelsea Neill**, PG, Balance Hydrologics (Presenter), and Co-authors: **Montana Marshall, PE**, Balance Hydrologics; and **Rachel Saunders** and **Beth Febus**, Big Sur Land Trust*

The Carr Lake basin is a 480-acre historic lakebed situated within the center of the City of Salinas, California. Historically, one of seven lakes in the Salinas Valley, Carr Lake was characterized by extensive wetland and freshwater marsh environments prior to the 1900s. European settlers began reclaiming the chain of lakes and surrounding floodplains for use as agricultural lands over 100 years ago. Carr Lake has been farmed since the land was reclaimed for agriculture and serves as flood storage capacity for the surrounding City of Salinas.

In January 2017, Big Sur Land Trust (BSLT), a nationally accredited land trust, acquired approximately 73.1 acres of lakebed property. BSLT initiated a robust community engagement process working with residents to envision a new multi-benefit community park for the site. The project is currently in the design phase and includes: 1) a new neighborhood park with a variety of amenities that will benefit local residents and 2) restoration of the land to thriving riparian, freshwater marsh, and upland habitat and offering trails to access the natural environment. The neighborhood park will include picnic areas, basketball courts, a play area, a dog park, and a community center/classroom.

The restoration area includes sections of Gabilan and Hospital Creeks. The design is based on an analysis of historical and existing conditions and includes design elements to achieve project objectives. Gabilan Creek is listed as critical steelhead trout (*Oncorhynchus mykiss*) habitat. The existing ditched channels and surrounding agricultural land provide very little habitat due to limited vegetation, channel variation, substrate, and temperature. Design of the restoration area involves rerouting Hospital and Gabilan Creeks out of the existing man-made ditches and into restored ecosystems that mimic historical conditions and create wildlife habitat. Gabilan Creek is designed to be a dynamic, multi-thread stream, which will flow across an inset floodplain. Hospital Creek is designed to be similar to a freshwater marsh ecosystem with backwater channels. Components of Hospital Creek include a treatment wetland to address water quality issues within the watershed, and a seasonal wetland to mimic the historical conditions of Carr Lake, which had variable extents of open water dependent upon seasonal rainfall patterns. The restoration project is designed to enhance habitat for fish and wildlife and generally improve water quality, while also creating much needed park and open space area for the residents of Salinas.

The robust community engagement process has included involvement from residents through specific outreach activities and a series of public meetings and events. The community input has been a critical component of the design process. As part of the on-going community involvement, BSLT hosts regular planting days at the ¼ acre native plant garden on site. The project has also engaged local CSUMB students in community events and the existing conditions at the site have been the focus of class projects to help inform the restoration design. In September 2021, the Salinas City Council adopted the CEQA document for the project. It is anticipated that park construction could begin as early as 2023.

Engaging Community to Protect the Pinole Creek Watershed: Assessment of Trash Impacts to Promote a Thriving Ecosystem

Ann Moriarty, *Board Member, Friends of Pinole Creek Watershed and Community Members (Presenter), and Co-authors:* ***Lisa Anich,*** *Watershed Coordinator, Contra Costa Resource Conservation District;* ***Win Cowger, Ph.D.,*** *Research Scientist, Moore Institute for Plastic Pollution Research;* ***Itzel Gomez,*** *Program Manager, Earth Team,* ***Todd Harwell, Ph.D.,*** *Postdoctoral Scholar, Center for Community and Citizen Science, University of California, Davis School of Education; and* ***Norma Martinez-Rubin, MPH, MBA,*** *Councilmember, City of Pinole*

This presentation will describe how, through the collaboration of community-led, nonprofit, and government organizations, a litter assessment project was planned and implemented to meet the shared goal of protecting an urban watershed. Examples of outreach activities to engage city residents and students along with a few lessons in much needed leadership team adaptability will be shared.

Pinole Creek flows 15 miles from the Briones foothills to San Pablo Bay. It is one of the few remaining free-flowing creeks in the East Bay and runs through agricultural ranching land maintained by East Bay Municipal Utility District (EBMUD), and into the City of Pinole passing houses, schools, shopping areas, and parks.

Pinole Creek maintains a population of steelhead/rainbow trout (*Onchorynchus mykiss*) which is part of the federally threatened Central California Coast Steelhead population. The last remaining physical obstacle to steelhead migration was addressed in 2016 with the completion of the Interstate-80 Fish Passage. However, the health of the watershed is threatened by a disheartening amount of trash including litter, household waste, and larger items such as furniture and vehicle tires.

Contra Costa County and the cities of Pinole and Hercules have made efforts to address the trash issue by introducing storm drain capture devices, complying to statewide permits and policies, and organizing a number of cleanup events. Friends of Pinole Creek Watershed (FoPCW), a well-established local volunteer-run group that has a long history of collaboration with community members and groups, has long worked with the City of Pinole.

In the fall of 2020, FoPCW partnered with the City of Pinole, Contra Costa Resource Conservation District, and Earth Team, a local non-profit that empowers youth to become lifelong environmental stewards, to initiate a community science project with the support and guidance of Thriving Earth Exchange, a division of the American Geophysical Union. This project aims to engage community members to protect the Pinole Creek Watershed through volunteer assessment, monitoring, and cleanup efforts to inform a data-driven, evidence-based creek ordinance for the City of Pinole.

Our data collection and analysis process is guided by the assistance of a consulting scientist to ensure scientific rigor. Assessment methods are drawn from the Trash Monitoring Playbook, a standardized statewide monitoring protocol for river trash. We are assessing randomly selected sites along the main stem of Pinole Creek so that our results will be representative of the trash problem in the entire creek. We have engaged community members throughout the watershed to volunteer with us to collect the data.

Outreach efforts to the Pinole community have resulted in a wide range of volunteers, including 6th graders at a local elementary school, Earth Team high school interns, and adults of all ages. The high schoolers and adults have engaged in on-site training and have become adept at the protocol, and are now asking questions and making thoughtful policy suggestions as they consider how to encourage a thriving ecosystem that welcomes steelhead. Even more, they are becoming passionate advocates of the creek.

Mountain Meadows: Restoring Functions in Headwater Catchments under Changing Climate and Wildfire Regimes

Friday Afternoon Concurrent Sessions

Session Coordinators*: **Jay Stallman**, Stillwater Sciences, and **Gabrielle Bohlman**, U.S. Forest Service*

The importance of mountain meadows for hydrologic function, ecological diversity, and climate resilience has become increasingly recognized over the past few decades, especially within the context of recent catastrophic wildfires and severe drought throughout California. This session will focus on restoration and management of mountain meadow systems with emphasis on current tools and approaches, linkages between hydrogeomorphic processes and aquatic habitat responses, and the role of mountain meadows in landscape-scale fire resilience and post-fire recovery.

Restoring Ecological Function to California's Montane Meadows

Karen Pope, Ph.D., *U.S. Forest Service Pacific Southwest Research Station (Presenter), and Co-author:* ***Adam Cummings, MS,*** *U.S. Forest Service Pacific Southwest Research Station*

The pace and scale of meadow restoration is increasing across the mountains of the western USA. And for good reason: intensive land uses have transformed numerous wet meadows from complex, biodiversity hotspots into simple, incised channels through disconnected floodplains. These habitats store less water and carbon and have reduced habitat quality. I will summarize the state of California's mountain meadows, discuss restoration practices, and highlight the value of applying process-based restoration approaches. Process-based approaches address source problems, capitalize on natural energy and materials, are scalable, and are adaptively managed over time to recover self-sustaining and dynamic processes.

Effects of Twenty Years of Climate Warming and Livestock Grazing on High-Elevation Meadows in the Golden Trout Wilderness

Devyn Orr, Ph.D., *Research Ecologist, USDA ARS, (Presenter), and Co-authors:*
Hugh Safford, Ph.D., *USDA Forest Service, and* ***Kayla Goldstein-Miller, BS,*** *USDA ARS*

The California golden trout (*Oncorhynchus mykiss aguabonita*)—a vulnerable subspecies of the rainbow trout endemic to California—is currently restricted to a few streams within high-elevation meadows in the southern Sierra Nevada Mountain Range. To protect this species, the Golden Trout Wilderness (GTW) area was established in 1978 in the upper watersheds of the Kern and South Fork Kern River. Despite this protection, climate warming and cattle grazing continue to pose a potential threat to this critical habitat area. Grazing can have a deleterious effect on meadow vegetation, which is essential for stabilizing the river channel and banks, as well as ameliorating the expected water temperature increases linked to global warming. Warming can also affect a myriad of habitat components, including plant community structure and composition, soil moisture and groundwater, and stream hydrology. To assess long-term trends in meadow and riparian vegetation in response to grazing and warming, we resurveyed 38 meadow monitoring points from 1999 to 2021 across the four grazing allotments in the GTW (Monache, Mulkey, Templeton, and Whitney), two of which have been ungrazed since 2001 (Templeton and Whitney). Preliminary results indicate significant differences in meadow vegetation phenology, ground cover, rooting depth, and depth to ground water among grazed and ungrazed sites. Additionally, meadow plant community trajectories have diverged significantly through time. Collectively, our results strongly demonstrate the negative impacts of cattle grazing in this high elevation meadow system, particularly under warming and drying conditions. These results will be used to guide policy makers about the long-term consequences of livestock grazing on golden trout habitat and will directly inform planned restoration efforts in the GTW to improve freshwater habitat conditions and meadow resilience to further perturbations in the Anthropocene.

LTPBR in Sierra Nevada Meadow Systems: A Case Study from the Golden Trout Wilderness

Sabra Purdy, *Trout Unlimited/Anabranch Solutions*

Restoration techniques and approaches have evolved rapidly over the past few decades but the body of research remains fairly small and there is no consensus on the best way to approach meadow restoration. Traditional, form-based engineering and earth moving approaches have been the most widely applied but results can be mixed with high levels of risk and high costs. This approach is not compatible with sites within designated wilderness and often does not address key structure and habitat needs. The scale and scope of meadows in the West that have been degraded and in need of treatment in order to restore function and resiliency is immense. More effective, less costly, and less impactful approaches to treatment are desperately needed. In partnership with the USDA Forest Service, Trout Unlimited and Anabranch Solutions are undertaking the most ambitious meadow restoration project in Wilderness that has ever been attempted in California involving 14 meadows within designated wilderness. This fall, we began work on a pilot project at Casa Vieja Meadow in the Golden Trout Wilderness in the Inyo National Forest using LTPBR methods to restore hydrologic function, floodplain connectivity, diversify instream and floodplain habitat and support hydric meadow vegetation. The constraints of working within designated wilderness provide both challenges and opportunities and sets a precedent not just for wilderness meadows, but 1000s of acres of meadows in non-wilderness that can benefit from the approaches, methods, and opportunities created by using process-based techniques to restore degraded meadow sites. LTPBR is a relatively new approach in California though it has been extensively used with great success in stream restoration in other western states. This project and the lessons learned from it will help set precedent for this approach in Sierran meadows and beyond.

The Hundred-Year Summer —PBR, Fire, Flood, and the Return of Beavers to Tasmam Koyom

Kevin Swift, Swift Water Design

Tasmam Koyom is a large Sierra meadow near Lake Almanor, and it's had a pretty exciting couple of years since being returned to the Maidu Summit Consortium by PGE, after 120 years of white ownership. As though making up for lost time, the meadow is rapidly returning to health through a surprising convergence of events.

In fall 2020 and summer 2021 two rounds of process-based restoration were hand-installed on Yellow Creek mainstem, using all local materials and zero heavy machinery. Then the Dixie Fire burned almost the whole meadow in July, and 50+ head of stray cattle moved onto the delicate new growth. Next was a 100-year rain event that swept through in October, carrying away some structures and adding to others, while reworking the streambed, forming large new depositional zones and awakening relict channels.

At some point in late October or early November beaver returned to the valley, and their sign was discovered during the third round of implementation which was completed in mid-November. As all this was happening there were some camera traps on the meadow that survived, many of us made multiple trips and took photos and drone imagery, and the results are worth seeing.

This presentation is a high-speed tour of macro-scale events changing a meadow, process-based restoration responding, and the resulting recovery happening in real time—no waiting needed. Discussion will include restoration and TEK partnerships, techniques for building in deep/high flow channels, fire interacting with hand-placed wood structures, NDVI imagery of meadow surfaces pre-and post-burn, dealing with cattle, discovery of long-buried beaver evidence, the elephant in the room, and much more. No charts, no graphs, just a good, heart-warming story with lots of photos.

A Decade of Data and Lessons Learned from Restoring a Sierra Meadow Complex

David Shaw, PG, *Principal Hydrologist/Geomorphologist and President/CEO, Balance Hydrologics (Presenter), and Co-authors:* ***Beth Christman, Ph.D.,*** *Director of Restoration Programs, Truckee River Watershed Council,* ***Kealie Pretzlav, Ph.D.,*** *Project Professional Geomorphologist, and* ***Benjamin Trustman,*** *Senior Staff Hydrologist, Balance Hydrologics*

Over the past two decades, agencies and non-governmental organizations have worked to restore degraded mountain meadows in California's Sierra Nevada to increase water supply and ecological resiliency to climate change and wildfire. Mountain meadow restoration goals and objectives often relate to increasing groundwater storage and late summer baseflow, improving floodplain connectivity, re-establishing wetland and riparian functions and habitat. Balance Hydrologics, the Truckee River Watershed Council, the U.S. Forest Service, and other cooperating agencies have conducted a long-term program to monitor system response to various restoration approaches that were employed at Perazzo Meadows on the Tahoe National Forest in Sierra County, California. Prior to restoration, the channel meandered through the meadow in an incised, single-thread channel, with limited connectivity to the adjacent floodplain induced by concentrated runoff from historical roads and logging railroads in the upper watershed, along with channelization within meadows. Restoration approaches have consisted of large-scale earthwork operations and wood structure placement to aggrade and revegetate the channel, spread flows across the valley floors, and re-activate relict channels. Hydrology and biologic data collected over the 10 years following implementation has improved our understanding of variability in system response associated with this method, and we have learned that a) increases in seasonal groundwater storage associated with this method are variable, averaging approximately 0.6 acre-feet per acre of restored meadow; b) summer release of stored groundwater can increase late season baseflow by nearly 0.5 cfs or 1 ac-ft/day, c) channel and meadow equilibration over the decade following implementation can reduce some of these more immediate effects, d) most summertime and some wintertime flood events are attenuated by the modified meadow form, and e) biologic communities respond to the changed channel form and hydrology, with wetland communities becoming more vigorous.

Restoring Headwaters along Davy Brown Creek in the Los Padres National Forest

Mauricio Gomez, *South Coast Habitat Restoration (Presenter), and Co-authors:* ***Kristie Klose Ph.D.,*** *Los Padres National Forest, and* ***Jason White,*** *MESM, South Coast Habitat Restoration*

Every year, efforts to recover Southern California Steelhead trout continue to face challenges. As wildfires continue to degrade habitat throughout the state, efforts for steelhead recovery in Santa Barbara County region of the Los Padres National Forest Southern California Steelhead trout populations continue to face challenging conditions in the Los Padres National Forest. As our watersheds continue to experience the impacts of droughts and wildfires, trout populations continue to be negatively impacted and populations are having a difficult time rebounding.

The impacts of wildfires on local trout populations over the past 10 years continue to impact watersheds and habitat. This presentation will share data from a long-term analysis of aquatic invertebrate communities post-wildfire and how riparian systems can act like refuges for aquatic species such as steelhead trout and California red-legged frogs. The presentation will also share efforts to improve habitat accessibility along Davy Brown and Munch Creeks, two refugia watersheds, where three barriers to steelhead trout migration were removed and over three miles of habitat were restored. These barrier removal projects were decades in the making and had many partners along the way. Through partnership, the Los Padres National Forest and South Coast Habitat Restoration were able to implement this regionally important project to restore steelhead trout and provide them unimpeded access to refugia watersheds that have not burned in decades.

Factors Affecting Spatiotemporal Variation in Survival of Endangered Winter-Run Chinook Salmon Outmigrating from the Sacramento River

Jason Hassrick, *ICF Fish and Aquatic Sciences (Presenter), and Co-authors:* ***Arnold J. Ammann, Sara N. John,*** *and* ***Miles E. Daniels,*** *NMFS, SWFSC; and* ***Russell W. Perry,*** *U.S. Geological Survey, Western Fisheries Research Center*

Among four extant and declining Chinook salmon (*Oncorhynchus tshawytscha*) runs in California's Central Valley, none have declined as precipitously as Sacramento River winter-run Chinook Salmon. Using acoustic telemetry, we examined conditions that influenced reach-specific movement and survival of outmigrating juveniles during a prolonged, multi-year drought from 2013-2016, followed by one of the wettest years on record in 2017. Our objective was to model how time-varying riverine covariates and reach-specific habitat features influenced smolt survival. Model selection favored a model with mean annual flow, intra-annual deviations from the mean flow, reach-specific channel characteristics, and juvenile salmon travel time. Mean annual flow had the strongest positive effect on survival. However, a negative interaction between annual and intra-annual flow indicated that within-year deviations from the annual mean flow had larger effects on survival in low flow years. These factors resulted in higher survival in years with pulse flows or high flows. Increased river velocity was negatively correlated to survival, suggesting that compromised volitional migration rates increase exposure to predators. Covariates of revetment and wooded bank habitat were generally positively correlated with survival, but the effect of fixed habitat covariates on survival depended on whether fish were in the upper, middle, or lower sections of the river. Survival declined as a function of depth, the ratio of channel width to depth, and as water temperatures increased. Off-channel habitat, tributary density, river gradient, and diversions had no measurable impact on survival. Larger and more rapidly moving fish experienced higher survival. Survival was lower in longer reaches. Fish slowed downstream migration in the upper river in the wet years, in consecutive reaches associated with the greatest degree of off-channel habitat available in 2017 in all years, and in the lower river in the most critically dry year. This talk uses the analysis of fish movement behavior to recommend where targeted research to identify holding habitat and restoration will be most effective at improving outmigration survival of a declining salmon run that exhibits extended instream rearing in the Sacramento River relative to other life history strategies.

Minimum Flows to Support Smolt Outmigration During Drought

Brian Kastl, MSc, *University of California, Berkeley (Presenter), and Co-authors:*
Mariska Obedzinski, MSc, Sarah Nossaman Pierce, *and* ***Elizabeth Ruiz,*** *CA Sea Grant;*
Krysia Skorko, MSc, *and* ***Mia van Docto, MSc*** *, Trout Unlimited; and* ***Ted Grantham, Ph.D.,***
University of California, Berkeley

Droughts in the Mediterranean climate of coastal California present unique policy needs to protect lifecycle bottlenecks of migratory salmon. Endangered Coho salmon (Onchorynchus kisutch) of California's Russian River often encounter low flows in the spring and early summer during their outmigration from tributary streams as smolts. However, little is known about the flows that smolts require to successfully outmigrate. This study uses a unique depth-of-flow monitoring approach—the riffle crest thalweg (RCT) method—to investigate how variation in hydrologic and geomorphic characteristics influence outmigration of Coho salmon. We measured water depths at 12 riffle crest thalweg sites, spread over 0.5–2 km-long reaches, in each of five tributary streams over the March–June 2018 and 2019 outmigration seasons. Next, we converted continuous stage gage data to continuous riffle crest thalweg depth estimates, which we analyzed in relation to observed smolt movement past PIT antennas from 2012 to 2019. Findings indicate that median RCT depths during outmigration range from 6–23 cm and minimum passage depth thresholds vary by stream from 3 to 13 cm. Years with greater RCT depths in May are associated with longer outmigration season durations, extending up to three weeks later in spring, compared to years with the shallowest depths. Simultaneous discharge measurements and RCT measurements also allowed us to develop a rating curve for each stream that describes how RCT depths change with incremental changes in discharge. Discharge required to reach minimum outmigration depth requirements varies by a factor of six among streams. Interannual stability of rating curves suggests that they are useful for informing instream flow management over multiple years in these coastal, salmon-bearing streams. We also found that the lowest observed seasonal streamflow narrowed the outmigration window by over 30% in drought years compared to the wettest years. As human water use and droughts continue to threaten the ability of salmon to out-migrate as smolts, monitoring RCTs represents a low-cost, informative approach for developing environmental flow policies.

California Drought Influences Steelhead Productivity Through Impacts on Spring Smolt Conditions

Haley A. Ohms, Ph.D., *NOAA Fisheries SWFSC and UCSC Collaborative Fisheries Program (Presenter), and Co-authors:* ***David A. Boughton, Ph.D.,*** *and* ***Brian C. Spence, Ph.D.,*** *NOAA Fisheries SWFSC*

Climate change is increasing the frequency and intensity of droughts in California. Worsening droughts are expected to have dire consequences for steelhead; however, the research supporting this expectation is incomplete. Most drought research has focused on how low summer flows harm the juvenile life stage, but other life stages affected at different times of year could be more important. Namely, low spring flows could negatively affect the growth and migration of pre-smolts and smolts, and low winter flows could hinder spawner migrations. We used the recent California drought (2012–2015) to examine how drought conditions affected juvenile, smolt, and spawner life stages, and influenced population productivity in eight north-central California steelhead populations. We used dynamic factor analysis to measure the synchrony in population productivity from 2002–2019 and to assess correlations with regional environmental conditions. We looked for possible drought impacts at different life stages by examining long-term correlations with freshwater flows and temperatures, and checking for anomalous model residuals during drought years. Steelhead productivity was highly synchronous among all eight populations. To our surprise, summer flow conditions affecting the juvenile stage were not correlated with long-term population productivity, except in one population, and summer drought conditions had no detectable impact on population productivity. Instead, spring flow conditions affecting the pre-smolt/smolt stage explained the long-term synchrony among the populations, including a decrease in productivity associated with the drought. After accounting for spring flow conditions at the smolt stage, population productivity was asynchronous, suggesting that smolt flows are an important regional driver for steelhead productivity in California. Ocean temperatures were only correlated with long-term productivity in two populations, and the marine heat wave did not appear to have additive negative impacts on population productivity. Our results suggest that future droughts may have the greatest impact on California steelhead through low spring flows affecting the pre-smolt/smolt life stage, and that drought-mitigation measures may be more effective if they focus on spring flows.

Conservation and Restoration of Adaptive Genomic Variation

Devon Pearse, Ph.D., NMFS Southwest Fisheries Science Center, Santa Cruz, CA

Research on the evolutionary genomic characteristics of natural populations has made spectacular progress in the past few years, largely due to the advances in sequencing technology and analysis. In this talk, I will present examples of genomic variants associated with important life-history phenotypes in salmonids and discuss the complex ways in which genomic variation and the environment interact to affect phenotypic variation and individual fitness. However, it is far from clear how our understanding of adaptive genomic variation can or should affect conservation and restoration practices, and consideration must be given to the biological realities of dynamic natural habitats and the factors that affect the distribution of adaptive genomic variation within species. Finally, I will highlight the implications of using specific genomic targets to set conservation priorities.

Running the Gauntlet: the Burdens of Aquatic Pathogens and River Conditions on California's Central Valley Chinook Salmon

Camilo Sanchez, *University of California, Davis, (Presenter), and Co-authors:* ***Florian Mauduit, Amelie Segarra, Felix Biefel,*** *and* ***Richard Connon,*** *School of Veterinary Medicine, Davis, California, USA,* ***Benjamin Atencio*** *and* ***Miles E. Daniels,*** *UC Santa Cruz/National Oceanic and Atmospheric Administration, Santa Cruz, CA, USA, and* ***Sascha L. Hallett,*** *and* ***Stephen D. Atkinson,*** *Department of Microbiology, Oregon State University, Corvallis, Oregon*

California Central Valley Chinook salmon (*Oncorhynchus tshawytscha*) face many challenges throughout their life cycle, but a particularly high risk of mortality occurs during their early life stages in freshwater during outmigration. During this period, they face elevated risk for pathogen infection, and fluctuating river conditions, a poorly understood interaction. To that end, we conducted sentinel fish exposure studies across major migratory corridors of Central Valley Chinook salmon during their outmigration. We assessed pathogen prevalence in the water (environmental DNA, eDNA), in fish (pathogen DNA in fish tissue), and the connections between them, while also accounting for river conditions such as flow and temperature. Coinciding with peak outmigration, we deployed hatchery-reared juvenile Chinook in cages (n=30 x three cages) in April of 2021 at two sites in the Feather River, two sites in the North Sacramento River, two sites in the Sacramento River (Delta), and three sites in the San Joaquin River; and sampled unexposed hatchery fish for comparison (reference controls). Five fish per cage were subsampled at days seven and fourteen for gill, kidney and intestinal tissue. Water samples were collected at deployment sites for eDNA pathogen detection, concurrently with tissue samples. We targeted 47 common salmonid pathogens in tissues and eDNA samples. In water samples we detected six pathogens in the Feather River, nine in the North Sacramento River, five in the Sacramento River (Delta), and nine in the San Joaquin River (Delta). In gill samples, we detected six pathogens among fish in the Feather River, six in the North Sacramento River, five in the Sacramento River (Delta), and eight in the San Joaquin River (Delta). Pathogens commonly detected across both water samples, and gill tissues include *Ceratonova shasta, Parvicapsula minibicornis*, and *Ichthyophthirius multifiliis*. Also of note, *Candidatus Branchiomonas cysticola*, was detected commonly in gill tissue but has not been detected in water samples, so with the exception of *C.B. cysticola*, our eDNA assays were good predictors of which pathogens infected caged fish. We anticipate further analysis of these data to help describe the landscape of infection across these migration corridors and its correlation with environmental parameters, with implications for fisheries, and water management; and restoration efforts.

Restoring Key Salmon Habitat in the Klamath River to Increase Population Resilience to Climate, Drought, and Wildfire Impacts

Will Harling, ***Director, Mid Klamath Watershed Council***

Populations of threatened SONCC Coho and Spring Chinook salmon in the Klamath Basin are trending towards extinction due to significant changes in climate coupled with habitat loss and press disturbances from human activities in the instream and ocean environments. While we wait for long-term actions to reverse or temper climate trends, extensive instream restoration is needed to maintain the genetics of these threatened salmon populations. In addition to Klamath dam removal beginning in 2023, the Mid Klamath Watershed Council and partners, including the Karuk Tribe and US Forest Service, are showing significant population benefits from coho habitat restoration actions in Horse Creek and Seiad Creek, tributaries to the Klamath River. These projects, including off-channel habitats, channel restoration, addition of large wood, beaver dam analogs, helicopter wood loading, and more, show the benefits of watershed-level restoration approaches and point to key elements for successful project implementation and function. Diverse habitats provide a much broader array of instream temperatures, offering a “portfolio effect” to salmon threatened by elevated temperatures here on the southern range of salmon. While significant restoration actions to benefit Spring Chinook salmon beyond dam removal are lagging, this talk will address potential options in the Salmon River watershed to protect this critical run.

Restoration Elements of the Klamath River Renewal Project

Daniel Chase, *Resource Environmental Solutions (Presenter),*
and Co-authors: ***Gwen Santos*** *and* ***Dave Coffman,*** *RES*

Removal of four hydropower dams (Iron Gate, Copco 1, Copco 2, and J.C. Boyle) on the Klamath River in northern California and southern Oregon represents the largest dam removal and river restoration project in the country. The project will restore free-flowing conditions and volitional fish passage to more than 400 miles of currently cut-off anadromous fish habitat upstream of the lower-most dam, Iron Gate. RES was selected by the Klamath River Renewal Corporation to lead restoration for this ambitious effort, as well as accept liability associated with ensuring restoration meets ecological and biological performance standards and long-term goals/objectives. RES is leading design and implementation efforts for the restoration of nearly four miles of priority tributary streams and associated fish habitat, as well as vegetation restoration for approximately 2,000 acres of previously inundated lands. Restoring volitional fish passage to hundreds of miles of the Klamath River, once the third largest producer of salmon on the West Coast, will be an important achievement for this large, complex project. Area Tribes have relied on salmon as a vital resource for generations; rehabilitation of salmon and steelhead populations is not only environmentally important but critical to sustaining their culture. RES will rely on native seed propagation for revegetation of upland, riparian, and wetland habitats, and large wood placement to stabilize sediments and improve habitat for native fish and increase river and tributary functionality. This presentation provides a general overview of the project, anticipated benefits to anadromous species, restoration goals and approach, and key elements of stream, riparian, and wetland restoration.

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(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

Don Allan
SRF Board President
donallan51@gmail.com

Will Arcand, PG, CEG
CA Dept of Fish and Wildlife
arcand.will@gmail.com

Jonny Armstrong, Ph.D.
Oregon State University Department of Fisheries, Wildlife, and Conservation Science
Jonathan.armstrong@oregonstate.edu

Eli Asarian
Riverbend Sciences
eli@riverbendsci.com

David Ayers
UC Davis
deayers@ucdavis.edu

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

Sarah Beesley, MS
Yurok Tribal Fisheries Department
sbeesley@yuroktribe.nsn.us

Dane Behrens, Ph.D., PE
Environmental Science Associates
DBehrens@esassoc.com

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

Francisco Jesus Bellido Leiva
UC Davis
fjbellidoleiva@ucdavis.edu

Chris Berry
City of Santa Cruz
cberry@cityofsantacruz.com

Mike Berry
CDFW and DWR (retired)
codydog601@gmail.com

Anne Beulke
UCSC
abeulke@ucsc.edu

Eric Bjorkstedt
NOAA SWFSC and HSU
eric.bjorkstedt@noaa.gov

Steve Blumenshine
CSU-Fresno
sblumens@csufresno.edu

Gabrielle Bohlman
US Forest Service
gbohlman@fs.fed.us

Sally Bolger
Hanford ARC
sallyb@ecologicalworkforce.org

Rosealea Bond
UCSC and NOAA NMFS SWFSC
lea.bond@noaa.gov

Nick Bouwes, Ph.D.
Utah State Univeristy
nbouwes@usu.edu

Abel Brumo
Stillwater Sciences
brumovsky@gmail.com

Mary Burke
CalTrout
mburke@caltrout.org

Todd Buxton, Ph.D.
U.S. Bureau of Reclamation
tbuxton@usbr.gov

Mark Capelli
NOAA Fisheries
mark.capelli@noaa.gov

Julie Casagrande
San Mateo County Parks
jcasagrande@smcgov.org

Mark Cederborg
Hanford ARC
m.cederborg@hanfordarc.com

Beverly Chaney
Monterey Peninsula Water Management District
beverly@mpwmd.net

Dan Chase
Resource Environmental Solutions
dchase@res.us

Emily Chen
Department of Environmental Science, Policy, and Management; UC Berkeley
emily-chen@berkeley.edu

Damion Ciotti
US Fish and Wildlife Service
damion_ciotti@fws.gov

Matt Clifford
Trout Unlimited
mclifford@tu.org

Brian Cluer, Ph.D.
NOAA Fisheries
brian.cluer@noaa.gov

Sean Cochran
CDFW
sean.cochran@wildlife.ca.gov

Redgie Collins
Cal Trout
rcollins@caltrout.org

Ben Cook
Trout Unlimited
Benjamin.Cook@tu.org

Doyle Coyne, MS
Cal Poly Humboldt
djc62@humboldt.edu

Adam Cummings
USFS-PSW
adam.cummings@usda.gov

Ryan Diller
California State Parks
ryan.diller@parks.ca.gov

Brock Dolman
OAEC-Bring Back the Beaver
brock@oaec.org

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

Emily Fairfax, Ph.D.
CSU Channel Islands
emily.fairfax@csuci.edu

Elise Ferrarese
Trout Unlimited
elise.ferrarese@tu.org

Jerome Fiechter, Ph.D.
University of California at Santa Cruz
fiechter@ucsc.edu

John Field, Ph.D.
NOAA / SWFSC
john.field@noaa.gov

Keane Flynn
University of Nevada, Reno
keaneflynn@nevada.unr.edu

John Carlos Garza, Ph.D.
UC Santa Cruz and NOAA Fisheries
carlos.garza@noaa.gov

Philip Georgakakos, Ph.D.
University of California Berkeley
pgeorgakakos@berkeley.edu

Charnna Gilmore
Scott River Watershed Council
charnnagilmore@gmail.com

Mauricio Gomez
South Coast Habitat Restoration
mgomez@schabitatrestoration.org

Brandi Goss
UC Davis
begoss@ucdavis.edu

Ted Grantham, Ph.D.
UC Berkeley
ted.grantham@gmail.com

Brandt Gutermuth
Trinity River Restoration Program
BGutermuth@usbr.gov

Jessica Hall
California Urban Streams Partnership
jessica.hall@ghd.com

Anna Halligan
Trout Unlimited
Anna.Halligan@tu.org

Lauren Hammack, PCI
Prunuske Chatham, Inc.
lauren@pcz.com

Chris Hammersmark, Ph.D., PE
cbec, inc. eco engineering
c.hammersmark@cbecoeng.com

Will Harling
Mid Klamath Watershed Council
will@mkwc.org

Katrina Harrison
McBain & Associates, Applied River Sciences
katrina@mcbainassociates.com

Jason Hassrick
ICF
jason.hassrick@icfi.com

Sean Hayes, Ph.D.
NOAA Fisheries
sean.hayes@noaa.gov

Aaron Hebert
Midpeninsula Regional Open Space District
ahebert@openspace.org

Barry Hecht, CHG, CEG
Balance Hydrologics
bhecht@balancehydro.com

Mark Henderson, Ph.D.
USGS
mark.henderson@humboldt.edu

Lisa Hulette
WRA, Inc.
lisa.hulette@wra-ca.com

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

Matt Jamieson, MFA
Integral Consulting
mjamieson@integral-corp.com

Ken Jarrett
Stillwater Sciences
ken@stillwatersci.com

Chris Jasper
Vollmar Natural Lands Consulting
cjasper@vollmarconsulting.com

Alexander Jensen
University of Washington
jensena1@uw.edu

Rachel Johnson
NOAA Fisheries
rachel.johnson@noaa.gov

Chris Jordan
NOAA/NMFS/NWFSC
chris.jordan@noaa.gov

David Kajtaniak
CA Department of Fish and Wildlife
david.kajtaniak@wildlife.ca.gov

Brian Kastl
UC Berkeley
briankastl84@gmail.com

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

Justin Kay
California Institute of Technology
justinkay92@gmail.com

Dylan Keel, MS student
Cal Poly Humboldt
djk388@humboldt.edu

Suzanne Kelson, Ph.D.
University of Nevada, Reno; McBain Associates
skelson@unr.edu

Joseph Kiernan
NOAA Fisheries
joseph.kiernan@noaa.gov

Kwanmok Kim, Ph.D.
UC Santa Cruz and NOAA affiliate
kwanmok.kim@noaa.gov

Andrew Kinziger
Cal Poly Humboldt
andrew.kinziger@humbodt.edu

Kristen Kittleson
County of Santa Cruz
kristen.kittleson@santacruzcounty.us

Cynthia Le Doux-Bloom, Ph.D.
Cal Poly Humboldt
cml136@humboldt.edu

Brian LeNeve
retired
brian@brianleneve.com

Brett Leonard
California Conservation Corps
brett.leonard@ccc.ca.gov

Thomas Leroy
Pacific Watershed Associates
TomL@pacificwatershed.com

Michael Love, PE
Michael Love and Associates
mlove@h2odesigns.com

Kate Lundquist
Occidental Arts and Ecology Center
kate@oaec.org

Lisa Lurie
RCD of Santa Cruz County
llurie@rcdsantacruz.org

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

Steve Madrone
Humboldt County
smadrone@co.humboldt.ca.us

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

Leah Mellinger
UC Davis
Lmmellinger1989@gmail.com

Cyril Michel
NMFS Southwest Fisheries Science Center
cyriljmichel@gmail.com

Darren Mierau
California Trout
DMierau@caltrout.org

Ann Moriarty
Friends of Pinole Creek Watershed
anniebmoriarty@gmail.com

Jeffrey Mount, Ph.D.
Public Policy Institute of California
mount@geology.ucdavis.edu

Chelsea Neill
Balance Hydrologics
cneill@balancehydro.com

Sarah Nossaman Pierce, Ph.D.
CA Sea Grant
snossamanpierce@ucsd.edu

Larry Notheis
California Conservation Corps
Larry.Notheis@CCC.CA.GOV

Kevin O'Connor, Ph.D.
Central Coast Wetlands Group
koconnor@mlml.calstate.edu

Haley Ohms, Ph.D.
UCSC/NOAA
hohms@ucsc.edu

Laura O'Leary
Peninsula Open Space Trust
loleary@openspacetrust.org

Devyn Orr, Ph.D.
USDA ARS
orrdev@oregonstate.edu

Freddy Otte
City of San Luis Obispo
fotte@slocity.org

Jonathan Owens
Balance Hydrologics, Inc.
jowens@balancehydro.com

Devon Pearse
NOAA/NMFS
devon.pearse@noaa.gov

Kristine Pepper, PE
CDFW
kristine.pepper@wildlife.ca.gov

Matt Peterson, MS
FISHBIO
mattpeterson@fishbio.com

Sarah Phillips
Marin RCD
Sarah@marinrcd.org

Tyler Pilger, Ph.D.
FISHBIO
tylerpilger@fishbio.com

Cassie Pinnell
Vollmar Natural Lands Consulting
cpinnell@vollmarconsulting.com

Karen Pope, Ph.D.
USFS Pacific Southwest Research Station
karen.pope@usda.gov

Sabra Purdy
Trout Unlimited, Anabranch Solutions
sabrapurdy@gmail.com

Erin Ragazzi
State Water Resources Control Board
enragazzi@waterboards.ca.gov

David Revell, Ph.D.
Integral Consulting
drevell@integral-corp.com

Analise Rivero
CalTrout
riveroanalise@gmail.com

Jim Robins
Alnus Ecological
jrobins@alnus-eco.com

Heather Rosmarin
Friends of Pleasant Hill Creeks
pleasanthillcreeks@gmail.com

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

Zane Ruddy
BLM
jruddy@blm.gov

Sierra Ryan
County of Santa Cruz
sierra.ryan@santacruzcounty.us

Megan Sabal, Ph.D.
Oregon State University
megan.sabal@gmail.com

Patrick Samuel
California Trout
psamuel@caltrout.org

Camilo Sanchez
University of California, Davis
csanchez@ucdavis.org

William Satterthwaite, Ph.D.
NOAA National Marine Fisheries Service
will.satterthwaite@noaa.gov

Daisy Schadlich
Trout Unlimited
daisy.schadlich@tu.org

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

Jason Shaffer, MS student
Cal Poly Humboldt
jts112@humboldt.edu

David Shaw, PG
Balance Hydrologics, Inc.
dshaw@balancehydro.com

Rachel Shea, PE
Michael Love & Associates
shea@h2odesigns.com

Bob Simmons
Walnut Creek Watershed Council
bobsimmons2866@gmail.com

Jay Stallman
Stillwater Sciences
jay@stillwatersci.com

Thomas Starkey-Owens
Water Program, Yurok Tribe
trs338@humboldt.edu

Kevin Swift
Swift Water Design
kevin@swiftwaterdesign.com

Rachelle Tallman
UC Davis
rtallman01@gmail.com

Kris Taniguchi-Quan
Southern California Coastal Water Research Project
kristaniguchi@yahoo.com

Ross Taylor
Ross Taylor and Associates
rossntaylor@sbcglobal.net

Brook Thompson
Stanford University
brookmthompson@gmail.com

Luke Tillmann, MS
cbec eco engineering
l.tillmann@cbecoeng.com

Michael Tillotson, Ph.D.
ICF
mike.tillotson@icf.com

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

Mia van Docto
Trout Unlimited
mia.vandocto@tu.org

Kelly Vasbinder, Ph.D.
University of California, Santa Cruz
kvasbind@ucsc.edu

Darren Ward, Ph.D.
Cal Poly Humboldt
darren.ward@humboldt.edu

Thomas Williams, Ph.D.
NOAA Fisheries
tommy.williams@noaa.gov

Alison Willy
SRF Board
alison.willy44@gmail.com

Daniel Wilson
NOAA - National Marine Fisheries Service
dan.wilson@noaa.gov

Leslie Wolff
NMFS
leslie.wolff@noaa.gov

Christopher Woltemade, Ph.D.
Shippensburg University
christopher@pcz.com

Sarah Yarnell, Ph.D.
Center for Watershed Sciences, University of California, Davis
smyarnell@ucdavis.edu

Erik Young
Trout Unlimited
skagitsalmon@gmail.com

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

Julie Zimmerman, Ph.D.
The Nature Conservancy
julie.zimmerman@tnc.org

Poster Session

Influence of Snowpack, Flow, Air Temperature, and Smoke on Klamath Basin Stream Temperatures Including Long-Term Trends
Presented by Eli Asarian
Riverbend Sciences
eli@riverbendsci.com
Co-authors: Lyra Cressey and Bonnie Bennett, Salmon River Restoration Council; Jon Grunbaum, Klamath National Forest; LeRoy Cyr, Six Rivers National Forest; Toz Soto, Karuk Tribe; and Crystal Robinson, Quartz Valley Indian Reservation

Tasked Regional Remote Sensing Strategy to Support North Coast Watershed And Forest Resilience
Presented by Tim Bailey
Watershed Research
and Training Center
tim@thewatershedcenter.com

Post-Fire Effects and Management of Mill Creek Tidewater Gobi
in Santa Cruz County
Presented by Ashley Baillie
California Conservation Corp's Watershed Steward Program in partnership with AmeriCorps: County of Santa Cruz Public Health, Environmental Health Department
abaillie@mlml.calstate.edu

Using a Foreign DNA Tracer
to Calibrate Natural Environmental DNA Signals of Coho Salmon (*Oncorhynchus Kisutch*)
in Small Streams
Presented by Gavin Bandy
Cal Poly Humboldt
gbb70@humboldt.edu

Effects of Climate Extremes on Geomorphic Responses to Process-based Restoration
Presented by Brian Bartell
WRA
bartell@wra-ca.com
Co-author: Paul Blank, Napa RCD

NOAA Fisheries
Presented by Andrea Berry
NOAA's NMFS
andrea.berry@noaa.gov

Process Based Restoration Effects on Vegetation Communities
in Degraded Burned
and Unburned Headwater Meadows
in the Sierra Nevada
Presented by Matt Berry
USDA Forest Service Pacific Southwest Research Station
mattedmondberry@gmail.com

Ecological Workforce Initiative
Presented by Sally Bolger
Ecological Workforce Initiative
sallyb@ecologicalworkforce.org
Co-presenters: Jim Robins, Alnus Ecological;
and Mark Cederborg, Hanford ARC

Restoring Coastal Lagoons & Wetlands on California's Scenic Highway 1-Moving the Highway Inland Away From Coastal Erosion
Presented by Katherine Brown
Caltrans (District 5)
Landscape Architecture
katherine.brown@dot.ca.gov

The History and Current Status of Pacific Lamprey
in the SLO Creek Watershed and What's Next
Presented by Hannah Brown
Watershed Stewards Program
hannah.brown@ccc.ca.gov

California Environmental
Water Network
Presented by Amy Campbell
The Nature Conservancy
acampbell@tnc.org

Bullock Bend Sacramento
River Restoration
Presented by Rob Capriola
Westervelt Ecological Services
rcapriola@westervelt.com
Co-presenter: Mark Young, Westervelt Ecological Services

Comparison of 2-Dimensional Hydrodynamic Models for Habitat Evaluation
Presented by Tyler Caseltine
Cal Poly Humboldt
tjc406@humboldt.edu

Trends of Pink and Chum Salmon Observations in California
Presented by Emily Chen
UC Berkeley
emily-chen@berkeley.edu
Co-presenters: Cho Adolfo and Rachael Ryan, UC Berkeley

Increasing Phosphorus Binding Capacity in Wetland Sediments:
A Laboratory Bench-scale Feasibility Study for Phoslock
Presented by Adam Cohen
Stillwater Sciences
acohen@stillwatersci.com

Exploring why Pink salmon (*Oncorhynchus gorbuscha*) are in Lagunitas Creek
Presented by Emily Cox
Marin Water Fisheries Program
ecox@marinwater.org
Co-presenter: Kalvin Joe, WSP

Watershed Stewards Program
Presented by Shelby Crawford
Watershed Stewards Program
-Team Leader
shelby.crawford@ccc.ca.gov

How Many Smolts are Consumed by Predators in the Delta: Quantifying Predation with Molecular Methods
Presented by Cory Dick
Cal Poly Humboldt
cmd114@humboldt.edu

Remote Stream Incubation in the Russian River Watershed
Presented by Dustin Geisen
WSP serving at CA Sea Grant Russian River Salmon and Steelhead Monitoring Program
dustin.geisen@ccc.ca.gov
Co-presenter: Samuel Funakoshi,
CA Sea Grant Russian River Salmon and Steelhead Monitoring Program

Towards Refining eDNA Surveys: A Proof-of-Concept for Using Foreign eDNA to Evaluate eDNA Transport Dynamics in Natural Stream Settings.
Presented by Braden Herman
California Polytechnic University, Humboldt
bah107@humboldt.edu

Long-term Effectiveness of Large Wood Enhancement in Lagunitas Creek
Presented by Annabelle Howe
Marin Water District
annabellehowe15@gmail.com

Eureka Water Probes
Presented by Joanna Howerton
Eureka Water Probes
jhowerton@waterprobes.com

Redrawing the Santa Monica Mountains
Presented by Akosa Ibekwe
WSP; RCDSMM
akosa.ibekwe@ccc.ca.gov

Lower Mainstem Eel River Sonar Monitoring Project, Humboldt County, CA 2018-2022
Presented by David Kajtaniak
CA Department of Fish and Wildlife
david.kajtaniak@wildlife.ca.gov

Historical Salmonid Movement Timing on the Mainstem South Fork Eel River
Presented by Avi Kertesz
Stillwater Sciences
akertesz@stillwatersci.com

Off-Channel Habitat Restoration on Commercial Timberlands In Humboldt County
Presented by Keith Lackey
Humboldt Redwood Company
KLackey@hrcllc.com
Co-presenter: Anna Halligan , Trout Unlimited

Cal Poly Humboldt - MS in Engineering & Community Practice (and Other Degree Updates)
Presented by Margaret Lang
Cal Poly Humboldt
mml1@humboldt.edu

Striped Bass Predation on Steelhead
Presented by Brian LeNeve
Carmel River Steelhead Association
brian@brianleneve.com

Identifying, Characterizing and Integrating Sedimentary Architecture Conditions into Your Stream Channel Restoration Plans
Presented by Tom Leroy
Pacific Watershed Associates
toml@pacificwatershed.com
Co-author: Brian Cluer, NOAA Fisheries

Adapting to Change; Improvised Two-Stage Sampling for Spawner Surveys in the Time of Covid
Presented by Christopher Loomis
CDFW
christopher.loomis@wildlife.ca.gov
Co-presenter: Shannon Filbey, CDFW CWPAP Fortuna

Beaver and Process Based Restoration in California
Presented by Kate Lundquist
Occidental Arts & Ecology Center WATER Institute
kate@oaec.org
Co-presenter: Brock Dolman, Occidental Arts & Ecology Center WATER Institute, and Kevin Swift, Swift Water Designs

Non-Engineered Large Wood Structure
Implementation in the Eel River Watershed
Presented by Marisa McGrew
Eel River Watershed Improvement Group
marisa.mcgrew@humboldt.edu
Co-presenter: Alyssa Owen, WSP

Steelhead Abundance Following Invasive Species Suppression Efforts in a Small Coastal Stream
Presented by Matt McKechnie
Stillwater Sciences
mmckechnie@stillwatersci.com

Hydrologic Modeling for Streamflow Enhancement in Russian River Tributaries
Presented by Matthew O'Connor
Coast Range Watershed Institute
mattoconnor@sonic.net

Long Term Trends In Juvenile Coho Salmon Movements in the Lower Trinity River, CA
Presented by Max Ramos
Yurok Tribe
mramos@yuroktribe.nsn.us

Creek Restoration in the Walnut Creek Watershed (Contra Costa County)
Presented by Heather Rosmarin
Walnut Creek Watershed Council
heatherrosmarin@gmail.com
Co-presenter: Bob Simmons, Walnut Creek Watershed Council

A Spotlight on Lamprey! Occurance Distribution and Passage Barriers in San Lorenzo River Watershed
Presented by Jay Ryan
Watershed Stewards Program
jay.ryan@sjsu.edu

Doing Work with the California Conservation Corps
Presented by Brian Starks
CCC
brian.starks@ccc.ca.gov
Co-presenters: Brett Leonard, Meredith Hardy, Kyle Maxwell, CCC

Sister Salmon: Spatiotemporal Overlap in Chinook and Coho Salmon Spawning in the Santa Cruz Mountains
Presented by Issi Tang
Watershed Stewards Program serving with NOAA Southwest Fisheries Science Center
isabelle.tang@noaa.gov
Co-presenter: Noël Clark, WSP

The Beauty is in the Ear of the Beholder: A Tale of Otolith Shape and Size in Salmonids
Presented by Pedro Valencia Landa
UC Santa Cruz
pvalenc4@ucsc.edu

Till Death Do Us Part
Presented by Ben van Hamersveld
California Conservation Corps
Watershed Stewards Program
ben@vhfamily.com
Co-presenter: Jeremy Johnson, CDFW Arcata

UAV LiDAR for Riparian Topographic Surveys, Geomorphic Monitoring and Change Detection
Presented by Scott Walls
walls land+water, LLC
scott@wallslandwater.com

Design and Implementation of a Cascading Roughened Channel
Presented by Jason White
Environmental Science Associates
jwhite@esassoc.com

The California Voluntary Drought Initiative: Engaging Stakeholders and Communities in Watershed Conservation and Management
Presented by Dan Wilson
NOAA NMFS
dan.wilson@noaa.gov
Co-authors: Rick Rogers, NOAA California Coastal Office; Dereka Chargualaf, NOAA California Coastal Office; Howard Brown, NOAA California Central Valley Office; Evan Sawyer, NOAA California Central Valley Office