36th Annual Salmonid Restoration Conference

April 11-14, 2018 **Fortuna River Lodge**

The Art and Science of Watershed Restoration

Conference Co-sponsors

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Welcome to the 36th Annual Salmonid Restoration Conference

The Art and Science of Watershed Restoration

To be engaged in the salmon restoration field is to constantly experience the sensation of swimming upstream, navigating barriers, and taking a leap of faith against challenging odds. In the last year, California has endured raging fires, climate extremes, devastating mud slides, and water infrastructure failures. Nationally, federal efforts to deregulate environmental laws and invalidate scientific truths compromise water quality standards and endangered species protections that we rely on to safeguard salmon.

Now more than ever, it is important for watershed restoration practitioners to convene and converse.

The Annual Salmonid Restoration Conference has become the largest salmon restoration conference in California and brings together scientists, restorationists, planners, engineers, landowners, students, tribal members, and the next generation of watershed stewards. This conference is truly a meeting—a meeting of minds, ideas, colleagues, and practitioners.

The 36th Annual Salmonid Restoration Conference on the banks of the mighty Eel River is a fitting place to gather, inspire, and recharge. The North Coast of California is the epicenter of community-based watershed restoration. The theme of this year's conference is "The Art and Science of Watershed Restoration," and the conference agenda highlights innovative efforts to restore legacy watersheds, reintroduce salmon to historic habitats, and revitalize working landscapes. The practice of watershed restoration and salmonid recovery embodies elements of art and science, and evolves spatially as we start to witness the ecological effects and fish response to our restoration actions.

Conference participants will have the opportunity to see exemplary restoration projects from the Lower Klamath to the Salt River estuary, the tributaries of Salmon Creek to Humboldt Bay, as well as innovative projects in the Mattole headwaters, the Lower Eel, and tidal wetlands in the Eel River Delta. This year's conference agenda explores a range of issues including aging infrastructure, effectiveness monitoring, temperature impairments, biological responses, salmon reintroduction to historic habitats post-Klamath dam removal, Eel River ecology, streamflow enhancement and streamlined permitting, and ecological and policy issues that affect recovery.

Some SRF Board and staff members after our Board retreat.

Dana Stolzman,
SRF Executive Director
and Conference Agenda Coordinator

Workshops explore a range of watershed restoration techniques and approaches including: Using an optimization model to select fish passage barrier remediation; Devising instream flow criteria for small coastal streams; Effectiveness monitoring of instream restoration projects; Identifying appropriate site-specific methods and target criteria for instream large wood restoration efforts; and Speaking of Science—a workshop to improve presentation and facilitation skills.

The Plenary session will focus on the landscape of restoration and how both art and science inform our thinking about the future of this evolving field. Renowned geomorphologist Colin Thorne will give a talk entitled, *Thinking Outside the Channel—Learning from History and Working with Nature to Restore Riverine-floodplain Connectivity*. UC Berkeley Professor Stephanie Carlson will discuss *Evolutionary Enlightened Management Strategies for Conserving and Restoring Pacific Salmon and Trout*. Research ecologist Frank Lake will present on *Fish and Fires—Integrating Traditional and Western Knowledge Systems and Landscape Restoration Strategies to Address, Adapt to, and Confront Large-scale Wildfires in an Era of Climate Change*. Tribal member serving on the Klamath River Renewal Corporation, Wendy Poppy George, will focus on revitalization in Native Country.

The crafting of the SRF annual Conference is a yearlong interactive process. The production and coordination of the annual conference is a collaborative effort that engages SRF's Board of Directors, co-sponsors, and colleagues. We sincerely thank all of the field tour, workshop, and session coordinators who do an outstanding job of creating a dynamic agenda as well as all of the dedicated presenters who share their knowledge and expertise.

We appreciate all of our co-sponsors who generously contribute their ideas, time, and resources to the production of the conference. Thanks to all the conference participants who migrate tirelessly to participate in the premier salmon restoration conference in California and for joining us in our efforts to enhance the art and science of restoration and ultimately recover wild salmonid populations.

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Wednesday, April 11

Saturday Morning Concurrent Session

Saturday Afternoon Concurrent Session

Celebrating a Culture of Restoration

Honoring our Watershed Heroes

Every year, the Annual Salmonid Restoration Conference provides an opportunity to honor the contributions that individual practitioners have made to California's fisheries restoration field. Prior to the conference, Salmonid Restoration Federation (SRF) accepts nominations for the awards listed below. Award recipients are honored during the Conference Cabaret and Banquet that is held on the final night of the four-day conference.

Restorationist of the Year

SRF's Restorationist of the Year Award was conceived as a way to honor grassroots salmonid habitat restorationists. It was first presented in 1992 to Bill Eastwood, co-director of the Eel River Salmon Restoration Project, to acknowledge his work to help salmon and for his innovative design modification to the McBain downstream migrant trap.

The award was renamed the Nat Bingham Memorial Restorationist of the Year award following Nat's death in 1998. Nat was a fisherman and a tireless advocate for salmon. Since Nat's death, SRF has honored a restorationist each year at our annual conference with a roast and toast during the Cabaret and Banquet. The honored recipient gets to steward an exceptional brass sculpture, created by noted sculptor Dick Crane, that captures the spirit of salmon, of fish-loving people, and the state of California where these practitioners live and work a life dedicated to the recovery of the species. At the awards ceremony, the previous recipient parts with the sculpture and passes it onto the next honoree.

Lifetime Achievement Award

The Lifetime Achievement Award honors a lifetime of work and contribution to the salmonid restoration field in California.

The Golden Pipe Award

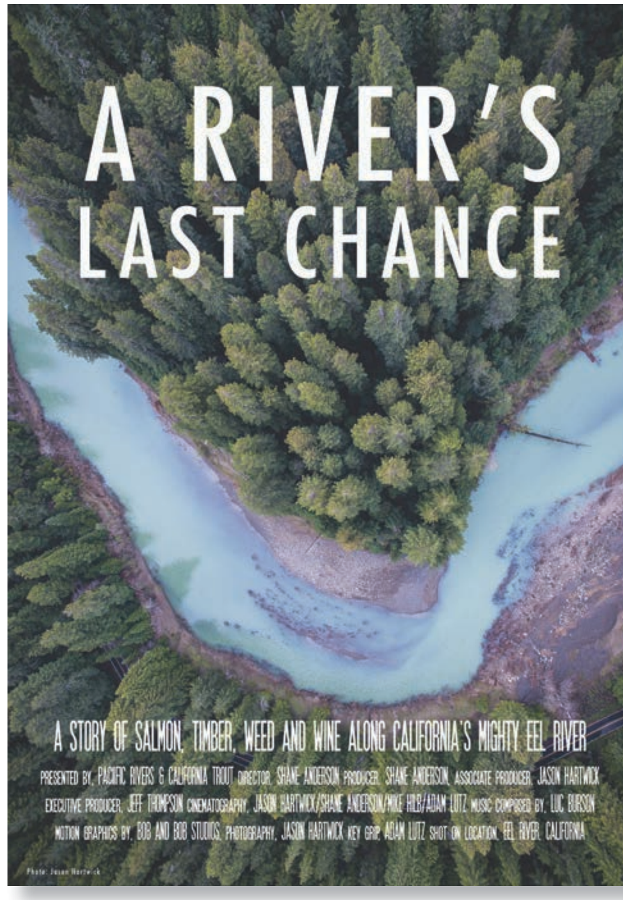
The Golden Pipe is an award for innovators in the salmon restoration field, whether their work be fish passage design, engineered log jams, or championing beavers as restoration partners.

Gordon Becker Memorial River Advocate Award

The restoration community mourns the loss of our cherished colleague and friend, Gordon Becker. He was an adventurer, a scientist, and an effective advocate for healthy rivers and fisheries. Gordon served as an expert witness in the campaign to remove or modify Stanford University's 125-year old Searsville Dam and Stanford's water diversions that harm threatened steelhead trout in San Francisquito Creek. His deep knowledge and enthusiasm for restoring the San Francisquito Creek watershed's native steelhead population helped to propel restoration efforts forward. Gordon shared his expertise freely, as well as his hopes and dreams for a better future for western rivers and watershed management.

The Gordon Becker Memorial River Advocate Award is for candidates who have been strong river advocates or stewards.

Conference Events



Thursday, April 12

SRF Annual Membership Meeting 5:30pm

SRF Membership and Supporter Dinner 6:30pm

Screening of *A River's Last Chance* 8pm

Friday, April 13

Poster Session and Reception 7 - 10pm

Dance to Kingfoot Saturday evening at the banquet!

Saturday, April 14

Banquet, Awards Ceremony, and Dance!
Doors open at 6:30pm

Thank you to our exclusive beer sponsor!

Devising Regionally Protective Instream Flow Criteria for Unregulated Coastal California Streams

Wednesday, April 11

Workshop Coordinators*: William Trush, Ph.D.,* *Co-Director HSU River Institute, Department of Environmental Science and Management, Humboldt State University and* ***Darren Mierau,*** *CalTrout*

Luna Leopold concluded that the physical laws governing channel formation of a great river are the same as those governing a small one. By understanding how physical processes of rivers big and small similarly perform hydraulically, environmental flow needs can be quantified regionally. In the morning, hydraulic units with their section and bedform control over streamflow depth and velocity will be explored from a biological perspective, including how a stream channel's riffle crest cross-sections govern seasonal recession, baseflow velocities, and depths. Real spatial and real temporal variability will then be folded into hydraulic performance to demonstrate how specific life history and large-scale ecosystem flow needs are met. The afternoon will begin with a synthesis of the morning's science, and then chart a pathway to regionalizing an environmentally protective diversion strategy for the South Fork Eel River. Workshop participants will be provided quantitative examples allowing them a hands-on opportunity to test-drive the regional strategy proposed.

Identifying Appropriate Site-Specific Methods and Target Criteria for Large Wood Restoration

Wednesday, April 11

Workshop Coordinators*: Anna Halligan,* *North Coast Coho Project Director,* *and* ***Elizabeth Mackey,*** *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.

The morning portion of the workshop includes several presentations from large wood restoration practitioners on a wide-array of implementation techniques. These presentations will include hands-on construction demonstrations and video footage, as well as provide an opportunity for participants to work through some mathematical calculations.

The afternoon will consist of some directed small group discussion as well as a facilitated panel discussion. Discussion topics will include considering project outcomes when selecting treatment methods, the effectiveness of structure designs in achieving particular outcomes, and how to determine appropriate wood loading densities for various project types.

Accelerated Recruitment: Cost Efficient Restoration Techniques for Enhancing Instream Habitat in California Coho Streams

Chris Blencowe, *Registered Professional Forester, Blencowe Watershed Management, (Co-presenter) and* ***Ken Smith, LTO,*** *Pacific Inland Inc. (Co-presenters)*

The accelerated recruitment methodology is a cost-effective restoration approach that has proven successful in improving instream shelter and habitat throughout several coastal Mendocino and Sonoma County streams. This approach avoids static, permanently anchored structures of traditional large wood projects. Large wood loading is intended to mimic the natural recruitment process. We have used two techniques: (1) direct falling of riparian trees into stream channels and (2) cutting/salvaging trees outside of the riparian zone and using rubber tired equipment to place woody material unanchored in the active channel. Treatment logs are allowed to adjust using hydraulic forces under natural flow conditions. Our results suggest that the accelerated recruitment method may offer a competitive advantage compared to more traditional restoration methods in appropriate watersheds that have consolidated ownerships, significant available timber, and little risk to downstream infrastructure. These techniques represent an important tool for rapidly and efficiently increasing the pace and magnitude of coho salmon habitat restoration at the watershed scale in appropriate locations. This presentation will focus on detailing the procedures and techniques used in accelerated recruitment methods, including specific approaches to direct falling and strategically placing wood instream with rubber-tired equipment.

30 Years in the Making: California Conservation Corps Instream Large Wood Restoration Techniques

***Brett Leonard,** Fish Habitat Assistant, California Conservation Corps*

The California Conservation Corps (CCC) has been an active member in the fisheries restoration community and the CDFW Coastal Fisheries Restoration Program (previously known as the Salmon Restoration Program) for over 30 years. During this time, the CCC has installed more than 6,500 instream habitat structures that have directly benefited listed salmonid species. This experience has helped the CCC to amass a considerable amount of institutional knowledge and expertise with several large wood loading techniques. This presentation will focus on specific methods and techniques used by the CCC to install large wood structures, including hand labor to relocate and reposition logs; traditional anchoring methods (i.e. bolting with threaded rebar, cabling, etc.); soft anchoring/wedging; and felling trees. This presentation will also discuss how the CCC's use of these techniques has changed over time, and how the Corps continues to develop and adapt their techniques for installing large wood structures.

Restoring Wood's Essential Role in Controlling Channel Grade and Stability in Small Streams

Michael Love, *Michael Love & Associates, Inc.*

In smaller streams within historically forested watersheds, wood played an essential role in controlling the channel grade, retaining and sorting coarse bed material, maintaining hydrologic connectivity with the floodplain, and providing long-term geomorphic stability. Wood in smaller streams often forces the bed morphology of the channel, such as in forced pool-riffle or step-pool channel types, as described by Montgomery and Buffington (1997). Observing streams in undisturbed old-growth dominated forests reveals the roles that wood plays in creating and maintaining stream structure and diversity. However, the vast majority of smaller streams in northern California and the Pacific Northwest have experienced disturbance involving removal of large wood and loss of mature riparian vegetation and the root-zones that crisscrossed the channel bed and banks. Some of this disturbance dates back more than a century, while others are much more recent. The result is widespread channel incision (lowering of the channel bed) throughout these forested watersheds. This fundamental change to these streams results in channel instability, and bed and bank erosion at the detriment to salmonid habitat and downstream water quality.

Channel incision in small streams resulting from loss of wood controls can be reversed through the placement of large wood in the near term, and eventually natural recruitment as the riparian forests mature and provide large wood inputs. However, the objectives and approach used to design wood placement for restoring incised channels differs from most other large wood placement projects. The approach requires multi-reach scale characterization of the channel morphology, including a detailed surveyed profile, followed by strategic siting of wood controls. Placed wood must be arranged to catch and retain bed material and small woody debris while avoiding creating fish barriers.

This presentation will begin with describing the process of channel incision in disturbed forested streams and the impacts incision has on stream stability, fish habitat, and water quality. It will then describe field indicators and evaluation techniques used to identify channels experiencing ongoing or recent incision, and the amount of incision that has likely occurred.

How to Keep Your Wood from Floating Downstream: Interactive Computations for Stability of Large Wood Structures

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

What are the hydraulic forces that act on a large wood structure and how significant are they? Why should I care? Does it require math? (Hint … yes!)

Understanding these forces will give you a useful tool to improve the stability and success of your instream wood structures. In this part of the workshop we will briefly review the factors that should be considered when using large wood for stream restoration projects. This will be followed by an interactive session to walk through typical computations for a simple structure. We will conclude with a group discussion about "what-if" scenarios and strategies for anchoring large wood.

Building Salmonid Habitat Complexity and Resiliency in Tributaries of the Lower Klamath River—Innovations and Lessons Learned

Rocco Fiori, *Engineering Geologist, Fiori GeoSciences and* ***Sarah Beesley,*** *Fisheries Biologist, Yurok Tribe (Co-presenters)*

Our restoration team has been working to restore fish habitats in the third to fifth order tributaries of the Lower Klamath River since 1996. Many of these streams are ephemeral, with subsurface flow conditions occurring during the rainless summer months. The wildland setting and dry streambed conditions provide the ability to develop and evaluate the effectiveness of different restoration designs in a low cost and limited risk environment. Our projects do not require costly dewatering or expensive water quality management efforts typical of restoration projects conducted in perennial streams. We have developed and have proof of design for a suite of post-assisted log jams and roughness features that provide immediate habitat benefits for salmonids, and enhance the trajectory of natural recovery processes.

Our design pallet includes the complementary use of willow baffles, channel and floodplain roughness elements, woven jams, and large engineered log jams (ELJs), i.e. bar apex and abutment jams. Large ELJs are intentionally built to be either semi-permeable or permeable. Where positive flow obstruction is needed semi-permeable jams are used. Yet where a more dynamic response is allowable we build highly permeable log jams that rely on vertical posts, oblique pins (e.g. batter piles), and inclined key members (rootwad logs) for stability. All features are constructed with native materials, i.e. local alluvium, logs, slash and plant materials only, no metal or imported rock is used. In dry streambeds with coarse gravel substrates, it is more cost-effective to "trench in" vertical posts rather than use a driver to set piles. In settings with small gravels and sands, an excavator mounted hydraulic hammer can be used to effectively drive posts an additional 5 to 10 feet below the depth of the foundation trench. In settings underlain by cohesive silts and clays, piles can often be set with the bucket on an excavator.

Thus far we have had one large ELJ, of twenty-five, disaggregate during a recent 15-year flood event. Logs mobilized from this ELJ were either racked on to existing jams or formed new jams within 2,500 feet of their original location. The apparent failure mode of this ELJ was related to the weakening of the vertical posts by decay (5-years of extreme wetting and drying) and possible damage of the posts during construction, as well as an increase in the upstream surface area of the ELJ (due to a significant amount of racked material).

Our restoration program owes its success to an interdisciplinary collaborative approach that builds on information and techniques developed in low-risk (to life and property) settings and from well-funded research level projects. The Yurok/Fiori GeoSciences team has developed techniques and approaches that has attracted collaborators and partners with the goal to restore properly functioning conditions for fish and wildlife within wildland and working landscapes of the Klamath Basin. An overview of techniques and lessons learned from our suite of low-cost, process-based restoration projects will be presented. Topics will include design approach, factor of safety analysis, and performance outcomes.

Simple Large Woody Debris Structures, Big Geomorphic Changes

Marjorie Caisley, *Senior Hydraulic Engineer, California Department of Fish and Wildlife*

In recent years, CDFW has seen a trend in large woody debris (LWD) structures to increase the number of pieces of wood and the overall size of the structures to create a larger geomorphic impact on the project reach. These larger and more complex structures tend to be on larger streams (>30 feet wide at bankfull) and require engineering calculations to show that the structures will remain in place during storm events and will produce the desired geomorphic changes. These structures are a necessary development in that they improve fish habitat by recovering geomorphic functions in larger streams. At the same time, CDFW has been continuing to fund simpler, non-engineered LWD structures on small (<30 feet wide at bankfull) coastal streams. In most cases, the intent of these projects has been to provide pool scour and cover and some gravel trapping and sorting. However, considering the level of habitat and geomorphic degradation of these small streams and the prevalence of fish in these streams, it is imperative to have larger geomorphic goals for LWD projects on smaller streams. Many small coastal streams present great opportunities for geomorphic restoration because they are in areas with large landholdings, big trees, and relatively little infrastructure. Within these areas, restoration professionals and practitioners should be looking for opportunities to reduce stream power by spreading the flow out. These opportunities include existing side channels, elevated gravel bars, inset benches, and floodplains.

Recently, simple LWD projects on small streams have started to adapt the methods of wood placement to improve the ability of structures to trap gravel and reverse channel incision. The updated methods include using more pieces of wood, using opposing and channel spanning structures, placing the ends of the wood higher on the bank, and shaping the structures to catch additional woody debris. This presentation will discuss these updated methods, and will examine how these methods have the potential to affect the stream morphology for hundreds of feet upstream, changing bedrock and cobble bed streams to gravel bed streams with alternating bars, pools and riffles.

Salmonid and Watershed Restoration: Focusing on Process-Based Design after 30 Years of Techniques

Chris Moore, *Riparian Specialist/Watershed Technician, Pacific Watershed Associates, Inc.*

Building natural processes back into stream systems is a critical factor in successful restoration of salmonid habitat. But are we designing to restore natural processes or simply implementing a set of techniques?

Considering funding trends that prioritize an engineered approach to instream salmon habitat restoration, I will focus on answering the question: Are we focusing on design techniques over base principles?

Practitioners across the North Coast have taken many approaches to improve salmonid habitat over the last few decades. These have included accelerated recruitment; constructed logjam structures, both anchored and unanchored; engineered logjams, rock weirs, and rock barbs; and a suite of related approaches. However we may feel about these different approaches to restoration, they are specific techniques and methods that must be applied in an appropriate context. As we move forward in our goal to bring back salmonids to our watersheds, it is worth placing more emphasis on base principles of design over techniques.

In this talk, I will be addressing a number of questions for the restoration community:

- How are we currently using good design to improve natural process first and foremost?
- Should we create a more focused approach to design and implementation that focuses on dynamic systems and natural process over static construction techniques?
- How do we assess and design for the whole watershed?
- How do we work as a community of practitioners to develop designs based on principles over techniques?

By using base principles of design, we can better work toward restoring natural process and allow the streams to provide improved ecological functions in a way that will benefit salmonids as well as improving the whole system.

Panoramic of South Fork Ten Mile River Stream Habitat Enhancement Project; Rod Vogel, Anna Halligan, and Elizabeth Mackey of Trout Unlimted pictured.
Photo by Libby Earthman, *Trout Unlimted*

Effectiveness Monitoring of Instream Restoration Projects —Lessons Learned and Where Do We Go From Here

Wednesday, April 11

Workshop Coordinators*: **Bob Pagliuco,** NOAA Restoration Center, and **Ross Taylor,** Ross Taylor and Associates*

Restoration Project types and techniques are constantly evolving as we learn more about fish and habitat response to various types of restoration. Physical and biological monitoring at an individual project and larger watershed scale is essential to understanding these relationships. The purpose of this workshop is to explore various restoration project effectiveness monitoring approaches and learn how project and watershed level physical and biological data are helping us evaluate these projects. In addition, this workshop will have a group discussion that explores existing monitoring data and provides input on what data would be most useful to collect in the future to advance restoration effectiveness science. Presentations in this session will focus on restoration effectiveness monitoring efforts for salmon and steelhead restoration projects and be prepared to explore ideas on where we need more effectiveness monitoring data to advance restoration science.

The Pudding Creek BACI Experiment: A Paired Watershed Approach to Effectiveness Monitoring

Elizabeth Mackey, *Trout Unlimited (Presenter),* ***Sean Gallagher,*** *California Department of Fish & Wildlife,* ***Wendy Holloway*** *and* ***Greg McClary,*** *Pacific States Marine Fisheries Commission;* ***Emily Lang,*** *Lyme Redwood Company; and* ***David Wright,*** *The Nature Conservancy*

Despite many large well-funded restoration efforts, much debate remains over the effectiveness of various restoration techniques and studies linking habitat improvements with increased fish abundance are relatively rare (Roni et al. 2010, Roni et al. 2008, Cederholm et al. 1998). Past successful experiments linking large wood augmentation to Coho population response have used many years of pre-and post-implementation monitoring, as well as proportionally large treatment areas in the study streams (Solazzi et al. 2000, Johnson et al., 2005). Much of the literature suggests that the use of a whole watershed approach to restoration is necessary to produce significant and measurable changes in fish abundance (Roni et al. 2012, Roni et al. 2008, Pess et al. 2005, Wohl et al. 2005).

Pudding and Caspar creeks in coastal Mendocino County, California have been operating as Coho Salmon and steelhead life-cycle monitoring stations since the mid-2000s, and a large body of data and results already exist from previous evaluations of both streams (Gallagher and Wright 2012, Wright et al. 2012, Gallagher et al. 2012, Gallagher et al. 2014). To determine if the installation of instream large wood to coastal California streams can be used to increase smolt production, we have initiated a paired watershed Before-After Control-Impact (BACI) experiment in Pudding and Caspar creeks. By treating 80% of the available salmonid habitat in Pudding Creek with instream large wood, we anticipate creating a measurable increase in Coho Salmon and steelhead growth, production, and survival by increasing both the quantity and quality of summer and winter habitats relative to a control stream (Caspar Creek). In addition to the continued life-cycle monitoring on both streams, this study incorporates extensive year-round effectiveness monitoring to measure seasonal physical stream habitat attributes and seasonal juvenile salmonid abundance, growth, and survival.

Here, we provide an overview of the study design and monitoring methods, as well as present data from the first five years of the Pudding/Caspar Creeks BACI study. This presentation will examine the results to date, and will highlight the effects of the extended drought periods of 2014 and 2015 on project monitoring data. We will also briefly discuss the potential implications of these extreme weather anomalies and climate change on future effectiveness monitoring efforts.

A Study of Aquatic Habitat and Fish Behavioral Response to Enhanced Flows in a Russian River Tributary

Gabriel Rossi, Department of Integrative Biology, UC Berkeley

Porter Creek is a 7.5 square-mile (20 km[1]) tributary to the Russian River in Sonoma County that provides over-summering habitat for juvenile steelhead trout (*Oncorhynchus mykiss*) and Coho salmon (*O. kisutch*). In 2014, a vineyard landowner on Porter Creek entered into a voluntary drought agreement to release water stored in an off-stream reservoir, through a telemetered pipe system and into the stream channel in order to maintain suitable habitat conditions for rearing juvenile salmon and passage for out-migrating smolts. The novel streamflow enhancement system was completed in 2017 and has the capacity to release up to 150 acre-feet of stored water into the creek each year, at a rate of up to 400 gallons per minute (gpm), or 0.9 cubic feet per second. In the summer of 2017, we began a study to quantify the effects of flow enhancement on the connectivity, quantity, and quality of rearing juvenile salmon habitat during the low-flow season. From June to September, water from the enhancement system was released in controlled pulses for 1 to 2 weeks, at constant rates ranging from 50 to 400 gpm. After each flow-pulse treatment, we surveyed habitat and water quality parameters below and above the flow enhancement outlet. In addition, we initiated a BACI study of fish behavior above and below the enhancement project using stereo-video methods. Here we present preliminary results from the first year of these studies, and discuss how flow enhancement programs offer an opportunity to quantify critical relationships between flow, fish habitat, and behavioral responses, and can help to inform regional instream flow management.

Tools and Methods to Monitor the Effectiveness of the Dry Creek Habitat Enhancement Project, Russian River Basin

Neil Lassettre, *Sonoma County Water Agency (Presenter) and Co-authors:*
David Manning, Mark Goin, Celeste Melosh *and* ***Eric McDermott,*** *Sonoma County Water Agency*

The Dry Creek Habitat Enhancement project is being carried out as part of the Reasonable and Prudent Alternative of the Russian River Biological Opinion (Biological Opinion). The goal of the project is to restore six miles of juvenile coho and steelhead habitat (non-contiguously) along 14 miles of Dry Creek, a tributary to the Russian River that enters near Healdsburg, CA. The programmatic Biological Opinion outlines habitat goals (characteristics, area to be created, types of habitat) to be achieved over 15 years from 2008 to 2023, with a decision point in 2018 after construction of the first three miles to determine whether to continue with the next three miles. The decision will be informed by data collected according to the Dry Creek Adaptive Management Plan (AMP), which details performance metrics, monitoring types (implementation, effectiveness, validation) and scales (spatial, temporal) and rating criteria. Effectiveness monitoring focuses on the physical response of Dry Creek to enhancement measures, and due to the expected lag time in biological response, is a major driver determining project success or failure, and ultimately continuation past 2018. The primary performance metrics in the AMP focus on optimal ranges of depth, velocity, and cover at baseflow (110-175 cfs). The Sonoma County Water Agency (Water Agency) is using several methods to collect and analyze data to evaluate project performance against these metrics, but also to inform future project design, and detect physical change along Dry Creek. The Water Agency is using traditional survey and flow measurement tools (total stations and flow meters), along with terrestrial laser scanning (TLS), and more recently structure from motion using aerial photography collected by a small Unmanned Aerial System to collect topographic and hydraulic data. The data are integrated within a GIS to visualize, characterize, and quantify juvenile coho and steelhead habitat area by performance metric (singly and combined) to detect habitat change through time, and to detect physical change of in-channel and floodplain areas (scour and fill) using geomorphic change detection. The results of the monitoring program have led to changes in elements of project design, and proved useful in evaluating and re-designing projects after large 2016-2017 storms.

Differing Responses of Natal and Non-natal Juvenile Coho Salmon to Restoration Actions in McGarvey Creek, a Tributary to the Lower Klamath River

Jimmy Faukner, MS, *Yurok Tribal Fisheries Program (Presenter) and Co-authors:*
Nicholas Som, Ph.D., *U.S. Fish and Wildlife Service, Arcata Field Office;*
and ***Toz Soto, BS,*** *Karuk Tribe Natural Resources Department*

Four alcoves were constructed in the lower portion of McGarvey Creek during 2011 to 2014. Monitoring juvenile Coho Salmon (*Oncorhynchus kisutch*) response to the alcoves consisted primarily of summer and winter population estimates. Estimated Coho Salmon abundance was variable in each of the alcoves but fish were documented using all four features. As a result of channel migration shortly after construction, one of the alcoves became a side channel. Although based on a single side channel feature, our data suggests that juvenile Coho Salmon in McGarvey Creek may use side channels more than alcoves.

The majority of restoration activities within the watershed have been conducted in the lower portion of McGarvey Creek. Therefore, juvenile Coho Salmon over-winter survival and winter emigration rates were compared from groups of fish implanted with Passive Integrated Transponder (PIT) tags in a lower and upper reach of the watershed. Winter emigration rates were higher and survival was lower for fish in the lower reach compared to the upper reach during years of drought. Channel drying was the major cause for high mortality of fish in the lower reach. The data collected to date suggests that restoration activities in lower McGarvey Creek have provided limited benefits to natal Coho Salmon during years of drought. We speculate that alcoves built higher in the watershed where channel drying does not occur could have provided more benefit to natal Coho Salmon.

McGarvey Creek supports a high proportion of Coho Salmon PIT tagged in the middle Klamath River region that are detected over-wintering in lower Klamath River tributaries. Non-natal Coho salmon have been documented using all four constructed features in lower McGarvey Creek. In general, non-natal survival was greater and winter emigration was lower compared to natal fish. Lower McGarvey Creek, which seemed to provide limited benefits for natal fish did provide substantial benefits for non-natal fish even during drought years.

Future restoration efforts in McGarvey Creek include the installation of Beaver Dam Analogs (BDA's) during the summer of 2018. These features should ameliorate channel drying in lower McGarvey Creek during the summer and fall. Employing fish rescue and relocation to the pools formed by the BDA's could substantially increase natal Coho Salmon survival especially during years of severe drought. Measuring increased non-natal use relative to this restoration action will be more difficult to assess.

Using Science to Guide Coho Restoration In the Middle Klamath River: If You Build it, They Will Come

Toz Soto, *Lead Fisheries Biologist, Karuk Tribal Fisheries Program (Presenter) and Co-authors:* ***Will Harling,*** *Executive Director, Mid Klamath Watershed Council;* ***Charles Wickman,*** *Fisheries Program Director, and* ***Mitzi Wickman,*** *Fisheries Program Coordinator/GIS Specialist,* ***James Peterson,*** *Fisheries Monitoring Program Coordinator, Mid Klamath Watershed Council; and* ***Sophie Price,*** *Fisheries Biologist, Karuk Tribal Fisheries Program*

For the past 15 years, The Karuk Tribal Fisheries Program and the Mid Klamath Watershed Council have been designing and implementing stream restoration projects within the Mid Klamath eco-zone. These projects have been focused on improving habitat for anadromous fish populations, specifically targeting coho salmon (*Onchurynchus Kisuch*). These efforts have been focused in small systems with shallow groundwater and within low gradient valley streams that historically produced large numbers of coho salmon (i.e. Seiad Creek, Horse Creek, and Scott River). Working with what nature has already provided has proven to be a successful model in implementing restoration projects that focus on increasing the rearing capacity of coho streams targeting specific life histories based on ecology studies. Physical pre-project monitoring such as tracking ground water levels and detailed terrain mapping are incorporated into our approach to building habitats in the best possible locations. We are doing both processed-based projects aimed at long-term habitat resilience along with direct enhancement projects that yield instant results. Post-project monitoring at all sites has allowed us to track various biological and physical changes of these projects and has given us unique insight into how projects change as they age, which can better inform us on what restoration techniques are most effective and how to improve upon existing projects.

Monitoring the Physical and Biological Effects of Beaver Dam Analogues in the Klamath River Basin

Michael Pollock, Ph.D., NOAA Fisheries, Northwest Fisheries Science Center

We review the interim results of a long-term study to assess the physical and biological effects of beaver dam analogues. We examined the effects of beaver ponds on stream temperature, groundwater levels, juvenile salmonid abundance, seasonal survival and growth, as well as the ability of juvenile coho salmon and steelhead trout to cross over or around BDAs. We also qualitatively assessed beaver response, riparian vegetative response and the response of the avian community. Initial results suggest significant, measurable changes in groundwater elevations approximately 500m both upstream and downstream of BDAs. Stream temperature responses are less apparent. Juvenile coho salmonid use of the BDA ponds was very high, and there was significant use by juvenile steelhead trout. The monitoring of juvenile fish passage over and around BDAs showed some interesting and unexpected movement patterns. Beaver have begun to colonize the site and modify the BDAs. The riparian and emergent vegetation has responded favorably, and bird use of the area, particularly piscivores, appears to be increasing.

Annual, Seasonal, and Diurnal Variation in Fish Use of Constructed Slough Habitat in the Mattole River Estuary

Nathan Queener, *Mattole Salmon Group*

Following construction of 250’ of off-channel habitat at the upper tidal extent of the Mattole estuary in May of 2014, fish use of the excavated slough and nearby features has been documented using snorkel surveys. Species presence and abundance has varied dramatically—annually, seasonally, and diurnally—emphasizing the dynamic nature of estuarine environments, the importance of considering fish movement and use of nearby habitats, and abundance at larger scales when monitoring biological effectiveness of restoration projects.

Summer and fall use of the slough was dominated by steelhead parr, although counts fluctuated from a high of nearly 3000 in late September 2015, to less than ten observed in multiple dives in the summer of 2014 and 2016, presumably due to periods of low dissolved oxygen (D.O.), more favorable conditions outside the slough in other portions of the estuary/lagoon, or overall population abundance. Winter surveys observed surprisingly few fish overall, even when conducted at night when cryptic behavior is less prevalent. Coho parr were observed in a seasonal wetland with emergent vegetation from January 2016 until the feature dried up in April 2016. During the spring months, Chinook young-of-the-year (YOY) were the most numerous salmonid, although there were substantial differences in their abundance and timing among the years 2015-2017. Chinook YOY were observed at the tidal margin as early as March.

Diurnal variation in juvenile steelhead and Chinook use of the slough and adjacent portions of the estuary/lagoon during the summer appeared to be driven primarily by feeding opportunities and avoiding the risk of predation, not water quality constraints. While temperature and D.O. within the constructed slough differed from the estuary/lagoon, fish movement in and out of the slough did not clearly track favorable temperature and D.O. conditions. On multiple nighttime surveys, hundreds of Chinook and steelhead parr were observed feeding in areas of shallow (<1’ depth) water with no cover, that they were completely absent from the previous or subsequent day. Diurnal movement of fish is rarely accounted for when monitoring habitat use, but may be a very important consideration, especially in estuarine environments.

Where water clarity is favorable through a range of flow conditions, snorkel surveys are a flexible and minimally invasive sampling method that can provide detailed information on fish behavior and habitat use at a low cost, although as with any monitoring approach practitioners should be aware of the limits of the spatial and temporal scope of their data.

The Old Man and the SEE: Lessons Learned From 15 Years of Monitoring Coho Salmon Life History and Habitat Restoration Projects in the Stream-Estuary Ecotone

Michael Wallace, *Environmental Scientist, CA Department of Fish and Wildlife*

Over the last two decades there has been a growing awareness by the research and restoration communities of the importance of estuaries to juvenile Coho Salmon (*Oncorhynchus kisutch*). However, one may ask; if we have been studying salmonids for over 100 years, why did it take so long for us to figure this out? I will attempt to explain how early habitat loss combined with specific Coho Salmon life history traits extended the misconception that estuaries were not an important component of their life history. I will present results and lessons learned about the diverse life histories of Coho Salmon and their use of the stream-estuary ecotone (SEE) of Humboldt Bay from 15 years of monitoring by the California Department of Fish & Wildlife (CDFW). CDFW conducted fish and water quality sampling throughout the SEE to describe basic water quality and determine fish use, residence times, and rearing patterns of juvenile salmonid using the SEE. This newly acquired knowledge along with numerous other studies from the North American Pacific Coast resulted in many habitat restoration projects being planned and constructed in the SEE of Humboldt Bay and other northern CA estuaries. Therefore, CDFW also sampled selected habitat restoration projects in the Humboldt Bay SEE to assess their performance and to provide information to the restoration community to help design and improve future projects. In addition to presenting our results and specific lessons learned from each generation of restoration projects, I will also discuss three overriding concepts to keep in mind. First, realize the value of an iterative approach to SEE restoration projects so we capitalize on successful aspects of each project while not repeating mistakes. Second, historic SEE habitat around Humboldt Bay connected multiple adjacent tributaries allowing movement between streams and encouraging non-natal rearing. Habitat restoration projects that "reconnect" a suite of tributaries will be most beneficial to Coho Salmon populations. Finally, recognize that historic SEE habitat was ephemeral and parts of this habitat were continually being created and destroyed. Historically there was enough area for this to occur and still provide adequate SEE habitat for rearing salmonids; however, this is no longer the case in most places. Presently we are usually required to try to restore this habitat "permanently" to fixed locations, but his strategy will require periodic maintenance and will likely require changes in permitting and long-term funding.

Effectiveness Monitoring of Fish Passage Projects in California

***Leah Mahan**, Habitat Restoration Specialist, NOAA Restoration Center*
*and **Ross Taylor**, Ross Taylor and Associates (Co-Authors)*

Fish passage barrier removal is an ongoing restoration technique that is seen as generally and immediately beneficial. Over the past 10+ years, fish passage partners and agencies in California have been conducting monitoring at fish passage barrier removal sites to learn more about project effectiveness. Monitoring the biological response of salmonids to passage barrier removal projects has given us more information on how salmonids recolonize previously blocked habitat, and the life stages that benefit from barrier removals in particular locations or settings. Monitoring the physical/channel response to barrier removal projects has given us information on effectiveness of different passage techniques, and has provided insight into how habitat is influenced by specific on-site treatments. These studies help us refine our designs, monitoring plans and expectations of specific project benefits as we plan and prioritize future fish passage projects. In addition, biological monitoring of salmonid re-colonization of newly opened habitat can be pondered in the context of salmon and steelhead recovery targets to gauge a projects potential contribution to recovery. Barrier removal monitoring over the past 10+ years has increased our overall understanding of biological and physical responses to barrier removals. As a result, more questions have been generated and additional ongoing monitoring is aimed at answering these questions. By identifying these outstanding questions, we can look for opportunities to answer them through collectively targeting, and then monitoring, upcoming barrier removal projects.

Temporal Patterns and Environmental Correlates of Young-of-the-Year Coho Salmon Movement into Non-natal Seasonal Habitats

Seth Ricker, *California Department of Fish and Wildlife*

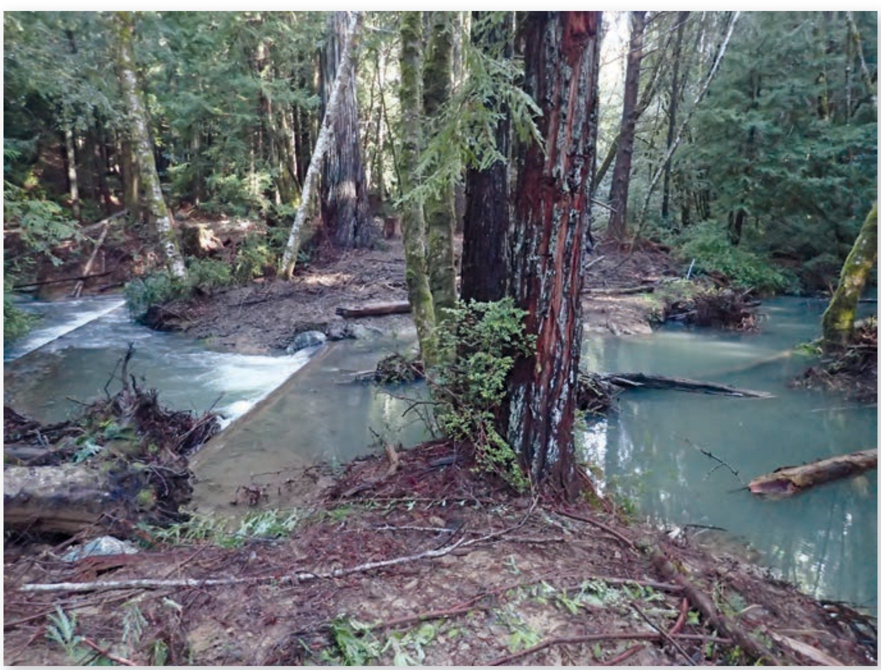
Creation and re-connection of floodplain habitats is an important restoration action for recovery of juvenile coho salmon in California. Typically, these restoration sites are located in low gradient, wide-valley stream segments, often low in watersheds. These areas are almost exclusively non-natal areas, with spawning and emergence of fry having taken place kilometers upstream. While the re-distribution of fish from spawning areas to non-natal rearing areas is well documented for coho salmon, the variability in the timing, magnitude and conditions under which juvenile salmon move to seasonal habitats is less understood. If, when, and of what magnitude this redistribution occurs can confound effectiveness evaluations of restored sites based upon sampling of fish use. I use records of Passive Integrated Transponder tagged juvenile coho salmon detections at stationary Stream Width Antenna sites from multiple years, across multiple coastal northern California watersheds to describe movement patters and elucidate environmental drivers. Effectiveness monitoring programs designed to use fish presence or catch as a response to certain restoration treatments will need to consider how to control for seasonal and annual variability in coho salmon re-distribution patterns.

Instream Restoration and Groundwater Recharge in the Mattole Headwaters Tour

Wednesday, April 11

Field Tour Coordinators*: **Tasha McKee,** Sanctuary Forest Inc. and **Sam Flanagan,** Bureau of Land Management*

The Mattole headwaters tour will focus on restoring drought resilience, summer streamflows, floodplain connectivity, and in-channel habitat for salmonid populations. Despite the generally low gradient, gravel-bedded channels of the Mattole River headwaters, pervasive channel incision presents a number of constraints on anadromous fish utilization. Since 2012, Sanctuary Forest and the Bureau of Land Management have been working to address these constraints in Baker Creek, a 4.1 square kilometer tributary to the upper Mattole River. The tour will encompass both instream and upslope approaches for restoring groundwater needed to sustain summer flows. The instream reach hosts a range of instream woody debris work begun in 2012 with the objective of increasing groundwater levels, improving instream habitat, and reconnecting historic floodplains. The tour is intended to spur discussion on restoration in incised stream channels where several factors conspire to limit salmonid productivity: depleted streamflows, lack of instream habitat, and poor floodplain connectivity. Information on the geologic setting, past cycles of valley filling and incision, and hydrologic ramifications will be discussed. Here restoration work was initially focused on raising the channel bed to improve floodplain and groundwater connectivity, in addition to improving instream habitat complexity. More recently, efforts have focused on enhancing groundwater retention along the adjacent alluvial terraces through creation of a series of seasonal wetlands. Participants will view the results of past instream work, recently implemented groundwater recharge features, and review data on groundwater responses, water quality, and fish use. Tour leaders will include key partners in project planning and implementation who will share their experiences with challenges, lessons learned, and results. Leaders include Tasha McKee, Sanctuary Forest Inc.; Sam Flanagan, Bureau of Land Management; Joel Monschke, Stillwater Sciences; Campbell Thompson, Mattole Salmon Group; John Neill and Anthony Lovatto, John Neill GEC INC.; and Michelle Robinson, Pacific Watershed Associates.



Mattole headwaters
Photo by Sam Flanagan, BLM

Tidal, Off-Channel, Instream, and Upslope Restoration in Humboldt Bay Tour

Wednesday, April 11

Field Tour Coordinators*: Mitch Farro, Pacific Coast Fish, Wildlife and Wetlands Restoration Association and* ***Chris Herbst,*** *Pacific Watershed Associates*

This tour will visit different types of projects and discuss issues involved with developing priorities and the challenges of working on public vs. private lands. We will visit two different project areas, starting with the Humboldt Bay National Wildlife Refuge located at the mouth of Salmon Creek. The field trip will visit the location of the major tide-gate replacements, salt marsh restoration and new tidal channel excavations and off-channel ponds. We will then travel to visit road decommissioning and instream LWD projects in Ryan Creek, where the new Humboldt County Community Forest is located. The trip will look at off-channel habitat created at the mouths of stream crossing and drainage swale excavations, instream large woody debris structures, and wetland habitat created along decommissioned road reaches.

Stream crossing associates with road decommissioning work in Ryan Creek, a tributary to Humboldt Bay.
Photo provided by Pacific Watershed Associates

Speaking of Science and Facilitating Community Engagement Workshop

Thursday, April 12

Workshop Coordinators*: **Janine Castro,** U.S. Fish and Wildlife Service and National Marine Fisheries Service and* ***Miriam Volat,*** *Soil Scientist and Facilitator, Occidental Arts and Ecology Center*

Speaking of Science

The morning part of this workshop is focused on improving oral presentation skills for scientists and engineers. Participants will leave the workshop with an improved skill set, including a checklist to develop and deliver memorable presentations. The workshop is highly interactive and builds on the collective experience of the audience and the instructor.

Topics:

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

Facilitating Community Engagement —Running Effective Collaborative Meetings

The afternoon workshop is focused on public engagement processes for scientists, engineers, and project managers involved in restoration projects and research that include multiple stakeholders and interactions with diverse parts of the community. Participants will leave the workshop with a clear design process for one meeting engagements or longer processes as well as a tool kit of mini-processes to use in your design.

Topics:

- Designing and planning for your entire public engagement process
- Creating agendas that get results
- Assessing, creating and sustaining commitment and communication
- Simple facilitation skills and tools that make meetings enjoyable

Using an Optimization Model to Select Fish Passage Barriers for Remediation

Thursday, April 12

Workshop Coordinators*: Lisa DeBruyckere,* *California Fish Passage Forum and* ***Ross Taylor,* *Ross Taylor and Associates*

FishXing Overview is focused on an overview of both California Department of Fish and Wildlife Section IX Passage Assessment Methodology and FishXing software, and includes group exercises involving case studies.

The California Fish Passage Forum has been developing FISHPass, a decision support tool that assists in identifying cost-efficient mitigation actions to maximize the amount of accessible habitat above barriers, using a mixed integer linear programming formulation. The tool integrates information on barrier passability, potential habitat, and mitigation cost. The tool also accounts for spatial structure of barrier networks as well as interactive effects of mitigation decision on longitudinal connectivity. This workshop focuses on testing FISHPass in a variety of watersheds along the coast of California, giving fish passage practitioners, and others involved in fish passage barrier remediation, an opportunity to test the model in a variety of watersheds. The goal of the workshop is to familiarize fish passage practitioners with FISHPass and its utility in optimizing fish passage barriers for remediation.

The morning component of the workshop will include an overview of CDFW Section IX Passage Assessment Methodology, FishXing software, and group exercises.

The afternoon component will include an introduction to decision support tools, an overview of the FishPass model and a demonstration of the functionality and utility of the model.

Salmonid Habitat Restoration in Lower Klamath Tributaries Tour

Thursday, April 12

Field Tour Coordinators*: Rocco Fiori, Fiori GeoSciences, and* ***Sarah Beesley,*** *Yurok Tribe*

The Lower Klamath portion of the tour will focus on restoring complexity and resiliency to instream and off-channel habitats to support self-maintaining salmonid populations. The Yurok Tribal Fisheries Program and its restoration partners have been using a bio-geomorphic approach that promotes the geomorphic processes necessary to form and maintain productive instream and off-channel habitat features. These techniques include: excavations that mimic or enhance naturally occurring valley landforms such as side-channels, alcoves, remnant oxbows and wetlands; constructing log jams that provide cover, promote pool scour, sediment sorting and metering, and induce favorable hydraulics and connectivity to off-channel features; constructing infiltration galleries to facilitate surface and ground water exchange that enriches dissolved oxygen levels in constructed off-channel features; and bioengineering that integrates the use of willow and other riparian plants to add root cohesion, hydraulic roughness and vertical and horizontal vegetative structure and diversity to the site. On-going monitoring indicates that natal and non-natal juvenile and adult fish utilize these habitats as soon as they are available. Case examples from four different hydro-geomorphic settings will be presented that illustrate design considerations and constraints and provide associated biological and physical monitoring results.

Large wood installation in the Lower Klamath. Photo by Sarah Beesley

Lower Eel River Restoration, Flood Reduction, and Habitat Connectivity Tour

Thursday, April 12

Field Tour Coordinators*: Jeremy Svehla, PE* and *Brett Vivyan, PE,* *GHD Inc.* and *Michael Love, PE,* *Michael Love and Associates, Inc.*

The lower Eel River has had a long history of anthropogenic impacts including logging, urbanization, channelization of tributaries, and diking and draining of tidal wetlands. These impacts have adversely altered corridors and habitat in the lower watershed critical for all life-stages of Coho, Chinook, Steelhead, Coastal Cutthroat and Pacific Lamprey among many other anadromous fish. This tour will visit diverse project sites including the Salt River Ecosystem Restoration Project which is a multi-benefit project led by the Humboldt County Resources Conservation District, the Rohner Creek Flood Reduction & Habitat Enhancement Project, and the Strongs Creek Fish Passage Improvement Project; the last two are in the City of Fortuna. The tour will include constructed tidal channels, floodplains, side-channels, large wood structures, geomorphically-based and concrete fishways, a sediment management area, and landscape-scale revegetation efforts. Project goals, engineering design, implementation, and monitoring will be discussed at each of the project sites.

Phase 2, Salt River Ecosystem Restoration Project Following 2015 Restoration
Photo provided by GHD

Restoring Tidal Wetlands: Inclusive, Process-based Restoration in Working Landscapes Tour

Thursday, April 12

Field Tour Coordinators: ***Kerry McNamee,*** *Northcoast Regional Land Trust;* ***Conor Shea,*** *U.S. Fish and Wildlife Service;* *and* ***Craig Benson,*** *Redwood Community Action Agency*

The Wood Creek, Martin Slough and White Slough watersheds share a similar land-use history with other historic tidal wetland/estuarine habitat in Humboldt Bay in that, the vast majority (>90%) of the habitat was diked and leveed over the last 150 years for conversion into pasture land. These changes to the landscape have largely eliminated available habitat to estuarine dependent juvenile salmonids, especially coho salmon whose life cycle exhibits their retention in fresh and brackish water for approximately one full year after emerging as fry. The conversion from tidal wetlands and slough channel bottom lands to diked and drained grazing lands in the early to mid 1900s has created an agrarian culture that many identify with here in Humboldt County. Many believe that our landscapes can either broadly support cows or coho, however we believe that with the right combination of seasonality and landscape types, it is possible to restore and foster both the strong ecological nursery grounds that tidal wetlands provide for juvenile salmonids, as well as maintain the rich pastoral lands which embody the cultural history of our local agricultural economy.

This tour will visit three project sites which embody inclusive strategies to balance restoration and working landscapes, including the Wood Creek Aquatic Habitat Enhancement Project (Phases I, II and the Phase I Adaptive Management Area), which is led in partnership by Northcoast Regional Land Trust, U.S. Fish and Wildlife Service, NOAA Restoration Center, California Department of Fish and Wildlife, and the State Coastal Conservancy; the tide gate portion of the Martin Slough Enhancement Project which is led in partnership by Redwood Community Action Agency, Mike Love & Associates, GHD, NOAA Habitat Restoration Center, California Department of Fish and Wildlife, the City of Eureka, and Northcoast Regional Land Trust; and the White Slough Tidal Wetlands Restoration Project led by the U.S. Fish and Wildlife Service. An overview of the entire Martin Slough Enhancement Project will be presented at the Wood Creek project site. The tour will include constructed tidal channels, large wood structures, various stages of restored and abundant tidal wetland habitat, a pasture actively undergoing restoration to balance high brackish marsh vegetation with agriculture use, a hydraulically-based and large scale tide gate, and if possible, a demonstration of capturing and tagging juvenile coho salmon. Each project's context, goals, engineering design, implementation, management strategies, challenges, and successes will be discussed at the project sites.

The Wood Creek Phase II restoration project at Northcoast Regional Land Trust's Freshwater Farms Reserve.
Photo provided by NRLT

Thinking Outside the Channel—Learning from History and Working with Nature to Restore Riverine-Floodplain Connectivity

Colin Thorne, Ph.D., *School of Geography, University of Nottingham, UK (Presenter)*
and ***Brian Cluer,*** *NOAA-National Marine Fisheries Service, Santa Rosa*

Geological and historical evidence indicates that most rivers had multi-channel planforms that were fully connected to wetland floodplains during the 400+ million-year period between the emergence of woody vegetation on planet Earth and the onset of river channelization by people. Recognizing this, the Stream Evolution Model (SEM) developed by Cluer and Thorne (2014) added anastomosing precursor and successor stages to the single-thread configurations featured in 1980s Channel Evolution Models. They also evaluated the ecosystem benefits provided by streams in different stages of evolution, based on how ecosystem functions relate to physical forms and processes. In this presentation, we propose that the art and science of river restoration can be advanced by: 1) learning from history that a single-thread, meandering channel is generally not the most appropriate target morphology, 2) recognizing the advantages of maximizing riverine-floodplain connectivity, and 3) working with nature's river restorers to increase the future resilience of restoration projects, while accelerating recovery and potentially reducing cost. The SEM shows that the common restoration practice of building habitat features in incised, single-thread channels with relatively high unit stream power (SEM stages 2-4) cannot restore habitats or ecosystem benefits lost from a former floodplain-connected stream with low unit stream power (SEM stage 0) because biophysical and geomorphic processes essential to supporting a diverse and resilient aquatic-riparian-floodplain ecosystem cannot operate effectively. Furthermore, designing channels that inundate the floodplain only once a year (or less frequently) prevents stream evolution processes from creating a more ecologically diverse and robust riverine-floodplain system, which can be counterproductive in the long-term. Eco-physical processes are both affected by, and help drive, stream evolutionary stages. Recent research in bio-geomorphology reveals that native plants and animals, both large and small, significantly alter flow and sediment processes, generally reducing instability and increasing habitat diversity. For example, historically, beaver played significant roles in alluvial valley processes and ecology by enhancing deposition or reversing channel incision following disturbance. Beaver extirpation, followed by floodplain development by European settlers, diminished habitat from pre-disturbance levels and led to the new norm—incised channels. Given their life cycles, salmon recovery will be difficult withouvt at least some stream reaches being restored to SEM Stage 0—a pre-disturbance morphology where streams inundate their floodplains multiple times per year for prolonged periods of time. Beaver dams were pervasive in the historical range of salmonids and, in their natural or analogue form, can be a powerful tool in incised channel restoration to Stage 0. This presentation will close by providing accounts of recent advances in restoration science and practice realized during innovative projects that focus on working with nature's river restorers as well as physical processes, to reconstruct multi-thread channels that are fully-connected to their riverine floodplains.

Evolutionary Enlightened Management Strategies for Conserving and Restoring Pacific Salmon and Trout

Stephanie Carlson, Ph.D., UC Berkeley, Carlson Lab

There is growing appreciation for the importance of diversity within and among populations of Pacific salmon and trout for their long-term sustainability. From classic studies like Shapovalov and Taft (1954) that highlighted 34 life histories within a population of *O. mykiss* to recent research exploring the consequences of among population diversity for the stability of resource flows to fishing communities, it is now well-appreciated that diversity within and among populations spreads risk of extinction. The general idea is that some life histories perform better under a given set of conditions, and that conserving the full suite of diversity thus provides some insurance against environmental variation and change. This body of work highlights the importance of considering biodiversity below the species level in management and restoration efforts. In fact, shifts in intraspecific diversity might serve as an early indicator of undesirable population change. Conserving or restoring intraspecific diversity within and among populations of Pacific salmon and trout is a proactive strategy for managing for resilient populations in an era of rapid global change.

Fish and Fires—Integrating Traditional and Western Knowledge Systems with Landscape Restoration Strategies to Address, Adapt to, and Confront Large-Scale Wildfires in an Era of Climate Change

Frank Kanawha Lake, Ph.D., *Research Ecologist, U.S. Forest Service, Pacific Southwest Fire and Fuels Program*

Fire has been an important ecological and cultural process in western landscapes for millennia. Many American Indian tribes and salmon species inhabiting watersheds in northern California and the Pacific Northwest adapted to living with wildland fires. Following Euro-American settlement, changes in fire regimes, water and resource management practices, fire suppression and exclusion activities, and other impacts to watersheds have negatively affected many wild salmon populations. In an era of increasing environmental disturbances and climate change, many federal, tribal, state, non-governmental, and private entities are planning strategies and implementing landscape restoration treatments. This presentation will share examples of how tribal traditional and western knowledge, as an integrated systems approach, can inform and guide restoration at various scales of the landscape. Examples of tribal knowledge about indigenous fisheries management, harvesting practices, and fish habitat requirements, to modern fuels and wildland fire management activities will be presented. Additionally, considerations for addressing and integrating landscape scale fuels, wildland fire, and fisheries restoration approaches are covered. The presentation will speak to efforts for "Advancing the Art and Science of Watershed Restoration," focusing on innovative techniques to restore and recover wild salmon with considerations of wildland fire effects.

World Renewal—Revitalization in Native Country

Wendy Poppy Ferris-George (Hupa/Karuk/Yurok/Chameriko),
Klamath River Renewal Corporation

Four dams on the Klamath River have blocked fish passage and have created catastrophic events to an entire ecosystem for more than a century. Native American people who depend on the Klamath River for subsistence purposes have had to transform their lives and watch the desecration of their homelands. Find out what dam removal means to the local tribal people and what rejuvenating their historic lifestyle will look like once the largest dam removal project in the world is complete.

Overview of Klamath River Dam Removal and Salmon Reintroduction to the Upper Klamath Basin

Friday Afternoon Concurrent Session

**Session Coordinator*: Mike Belchik,* *Senior Scientist, Yurok Tribe*

The decommissioning and removal of four dams on the Klamath River is on track to occur in 2020. As with recent dam removals, there are a range of expectations and a range of understanding of the process of removing the dams, monitoring the resources, and minimizing direct and indirect impacts on the natural resources and ecological processes in the watershed. This session will provide an update on the implementation of the dam removal and review the schedule of activities as well as plans for monitoring physical and biological aspects of the river. The purpose is to provide a very up-to-date and concise overview of the process being implemented and the proposed schedule of activities.

Strategies for Repopulating the Upper and Middle Klamath River with Salmon and Steelhead Following Dam Removal

John Carlos Garza, Ph.D., NOAA Southwest Fisheries Science Center and University of California, Santa Cruz

In about two years, the largest dam removal/ river restoration project in history will be underway, with the primary goal of restoring fish populations in the upper and middle Klamath River and its tributaries. The removal of the four dams will open up extensive new spawning, rearing, and migratory habitat for salmon and steelhead, but the path to repopulation of the newly available areas is far from clear and will be dramatically different for the four groups of anadromous salmonid that are expected to utilize them. I will present an overview of strategies for facilitating the re-emergence of self-recruiting populations of coho salmon, fall-run Chinook salmon, spring-run Chinook salmon, and steelhead trout in areas above Iron Gate Dam. I will discuss general repopulation strategies, from volitional recolonization to translocation, as well as release strategies and the role of captive propagation. Finally, I will discuss strategies for the selection of both donor stocks and individual fish and how they will need to differ for the different groups of fish. Throughout, I will draw on the current state of science surrounding such re-population and stock reconstitution projects and on experience from other restoration projects in California and further afield.

An Update on the Reintroduction Implementation Plan of Anadromous Fishes into the Oregon Portion of the Upper Klamath Basin

Mark Hereford, *Klamath Fisheries Reintroduction Planner, Oregon Department of Fish and Wildlife and* ***Alex Gonyaw,*** *Fisheries Biologist, The Klamath Tribes (Co-presenters)*

The goal of this Reintroduction Implementation Plan is to establish viable, naturally produced populations of anadromous fishes in the Oregon portion of the Upper Klamath Basin following the removal of four dams on the Klamath River. We will present an update on development of this plan. We will discuss the current suitable habitat and restoration projects in the upper basin, as well as limiting factors and critical uncertainties regarding reintroduction efforts that are currently present. Due to the current variability of abundance and distribution of fall and spring-run Chinook salmon, coho salmon, steelhead, and Pacific lamprey in the Klamath Basin below Iron Gate Dam, each species will require a unique approach to reintroduction in upper basin habitats. Decisions regarding the approaches to be taken for reintroduction of each species will be based on the availability of a source population below the dams. These factors have led to the development of a conceptual approach to reintroduction of anadromous fishes into the Upper Klamath Basin which will be the foundation for the development of strategies for monitoring recolonization and active reintroduction of anadromous fishes.

Persistence and Characteristics of Chinook Salmon Migrations to the Upper Klamath River Prior to Exclusion by Dams

John B. Hamilton, *U.S. Fish and Wildlife Service (Presenter) and Co-authors:* ***Dennis W. Rondorf*** *and* ***Lynne A. Casal,*** *USGS;* ***William R. Tinniswood,*** *Oregon Dept. of Fish and Wildlife;* ***Ryan J. Leary,*** *Klamath Tribes;* ***Tim Mayer,*** *USFWS; and* ***Charleen Gavette,*** *NMFS*

Using the accounts of early explorers, ethnographers, images from pioneer photographers, and information from archaeologists, anthropologists, magazines, newspapers, and government reports, we have updated the historical record of Chinook salmon migration past the current location of Iron Gate Dam (IGD). The updated record is conclusive that salmon historically migrated to the Klamath Upper Basin. Reports to the contrary may have been during periods of intermittent interruption of salmon runs. Examined in total, the updated record now provides a glimpse of the character of historical runs. Most of the observations of returning adult salmon occurred in the fall, but they were recorded during all seasons of the year, suggesting that runs were seasonally diverse and consisted of various salmon life histories. The majority of accounts indicate that Chinook salmon were abundant and provided robust in-river tribal and recreational fisheries upstream from IGD. In addition, runs were prolific enough to support four general fishing areas that included small scale commercial harvest at least through 1911. The greatest focus of adult Chinook salmon was in the Sprague River in the fall and was associated with significant harvest. This analysis also resolves the question of when historical migrations of Chinook salmon to the Klamath Upper Basin ceased. While salmon runs were impacted by an 1889 dam at Klamathon, California, by exploitation by in-river fisheries supporting canneries, by abusive mining practices, and by other destruction of their habitat, we found that migrations persisted into the Klamath Upper Basin through the fall of 1912, when they were completely excluded by an early phase of the construction of Copco 1 Dam. Blocked migrations to historical habitats are now slated to be reversed either through fishways or dam removal. As managers consider habitat restoration, reintroduction, and associated monitoring plans for Chinook salmon upstream from the current location of IGD and in the Klamath Upper Basin, they will likely look to the historical record for guidance. Our review substantiates the historical persistence of salmon, their migration characteristics, and a broad population baseline that will be key to future commercial, recreational, and tribal fisheries in the Klamath River and beyond.

Genetic Analyses of Contemporary and Ancient Samples Provide Insights into Restoring Upper Klamath Spring Chinook

Tasha Q. Thompson, University of California, Davis, Center for Watershed Sciences

Recent research revealed that adult migration time in Chinook salmon is influenced by a genetic locus of major effect. Here, we apply these results to inform the restoration of spring-run Chinook in the upper Klamath basin after dam removal. We explore the importance of including appropriate genetic variation in the restoration stock by analyzing the evolutionary history of the migration type locus, identifying a haplotype associated with migration type across populations, and testing the strength of the haplotype's association with migration type. We find that coastal spring-run Chinook alleles descended from a single evolutionary origin and the association of the haplotype with migration type appears to be complete. To determine if the same genetic variation was also present in the upper Klamath prior to dam construction, we tested nine ancient Chinook samples from archaeological sites above Klamath Lake and identified six spring-run Chinook and three fall-run Chinook. The spring-run samples came from sites occupied in the spring or throughout the year, and the fall-run samples came from a location with a historic fall salmonid fishery. The combination of these results indicates inclusion of spring-run alleles in the restoration stock will be vital for the restoration of spring-run Chinook in the upper Klamath. To explore whether Klamath fall-run Chinook populations may be reservoirs of spring-run alleles that could be used for spring-run Chinook restoration, we tested smolts from the Scott and Shasta Rivers. We found that spring-run alleles are not being maintained in those rivers, indicating that Klamath fall-run populations are most likely not viable options for restoring spring-run Chinook.

Klamath River Dam Removal and the Klamath River Renewal Corporation

Mark Bransom, *Executive Director, Klamath River Renewal Corporation*

The Klamath River Renewal Corporation (KRRC) is an independent nonprofit organization formed in 2016 as part of the amended Klamath Hydroelectric Settlement Agreement (KHSA). Signatories of the amended KHSA, including the States of California and Oregon, local governments, Tribal nations, dam owner PacifiCorp, irrigators, and several conservation and fishing groups, appointed KRRC to take ownership of four PacifiCorp dams—JC Boyle, Copco Nos. 1 & 2, and Iron Gate—and then remove these dams, restore formerly inundated lands, and implement required mitigation measures in compliance with all applicable federal, state, and local regulations. KRRC is undertaking baseline monitoring and field studies and will be responsible for monitoring and adaptive management after dam removal. KRRC and PacifiCorp's joint application for license transfer and KRRC's application for license surrender will be evaluated by FERC and are subject to environmental review under NEPA, CEQA, and other environmental permitting processes. Dam removal will begin as soon as 2020. Sediment release will take place between January and March to minimize impacts to aquatic species. The prior NEPA analysis (2012) found that impacts from dam removal on lower river salmonids (particularly sediment impacts) would be short-term and last approximately one to two years. Populations are expected to recover from sediment impacts by year five, after which significant benefits to migratory fish are expected. Specifically, fall-run Chinook populations could increase by up to 80%. These issues will be more closely studied in the forthcoming FERC, NEPA, and CEQA analyses. Anticipated KRRC project benefits include: 1) anadromous fish passage to and from at least 420 miles of historical habitat above Iron Gate Dam (when combined with fish passage at Keno Dam), 2) anadromous fish access to low gradient historical habitat of critical importance to spawning and rearing under Copco 1 and Iron Gate Reservoirs, 3) natural recruitment of spawning gravel and river processes within and below the Hydroelectric Reach, 4) elimination of much of the elevated late summer/fall water temperatures in and below the Hydroelectric Reach by removing the largest reservoirs, 5) improved dissolved oxygen and pH conditions, 6) elimination of much of the algal toxins produced in the Hydroelectric Reach and transported downstream, and 7) reduced concentrations of myxospores associated with carcasses accumulating below hatchery facilities, thus reducing disease. This presentation will provide an overview of field studies, analyses, and process overview leading to dam decommissioning and removal.

Restoring to Stage Zero, Recent Innovations in the Restoration Science: Reports from the Field

Friday Afternoon Concurrent Session

Session Coordinator*: Brian Cluer, Ph.D.,* *NOAA Fisheries*

During the first decade of the new millennium, conventional thinking that the single-thread, meandering channel represented the 'natural' course for an alluvial stream, and that the return period for a flood large enough to inundate the floodplain was between 1.5 and 3 years, was increasingly questioned. During the second decade of the new millennium, river restoration theory and practice has started to apply new thinking based on the principles that, prior to human modification, most alluvial streams had channels that were multi-threaded and that they overflowed on to their floodplains several times a year. Recognizing this, the Stream Evolution Model (SEM; Cluer and Thorne 2013) extended existing Channel Evolution Models (Schumm et al. 1984, Simon and Hupp, 1986) to include multi-thread channels, highly connected to their floodplains as precursor (Stage 0) and successor (Stage 8) forms, genetically related to the single-thread, incised channels featured in Stages 1 to 7. This expanded continuum of alluvial channel patterns was linked to published habitat and ecosystem benefits using 26 common biological and hydro-physical attributes. The analysis of the links between physical processes, stream form, and ecosystem services revealed clear distinctions between streams that are fully-connected with their floodplains (i.e., in Stages 0 and 8) and those that have become disconnected due to channelization (Stage 2) and/or incision (Stages 3 to 7), spotlighting the poor performance of >1 yr RI bankfull channels. Insights gained by practitioners who have applied the SEM in the contexts of stream problem assessment and restoration design has led to a number projects aimed at restoring multi-thread or anastomosed patterns (i.e., Stage 0) instead of single-thread meandering channels (i.e., Stage 1) in historic deposition zones.

This session will first set out the historic, geomorphic, and biotic basis for restoring to Stage 0, and, second, will provide a platform for restoration practitioners to share their first-hand experiences of Stage 0 projects, from inception, through to design, construction, and effectiveness monitoring. The sessions will feature consideration of the advantages and risks of restoring to Stage 0, focusing particularly on concerns expressed by some stakeholders and regulators, including issues such as fish passage, stranding risks, and provision of deep pools.

Winter Habitat and Floodplain Enhancement in Lagunitas Creek —Phase 1 Project Construction

Gregory Andrew, MS, Marin Municipal Water District

During the summer, 2017 construction season, we completed construction on the first half of the ten project sites for the Lagunitas Creek Winter Habitat and Floodplain Enhancement Project. This presentation discusses the implementation of these projects. The purpose of the project is to stabilize and improve Lagunitas Creek salmonid populations by increasing the winter habitat carrying capacity for coho salmon (*Oncorhynchus kisutch)* and steelhead trout (*O. mykiss*) in Lagunitas Creek. The project purpose is also to improve water quality to benefit the sediment Total Daily Maximum Load (TMDL) goals for the creek.

These projects are designed to modify hydrology and enhance and restore existing floodplain and instream habitat at the first five of ten locations in Lagunitas Creek. The proposed objectives are to install Bar Apex Jams (BAJs) and Log Debris Retention Jams (LDRJs) in the channel and excavate 1,000 feet of floodplain channel through adjacent riparian habitat, in order to: 1) Increase over-winter and floodplain habitat; 2) Reconnect the stream to its floodplain (improve floodplain connectivity); 3) Enhance floodplain habitat (improve floodplain habitat complexity); and 4) Enhance instream habitat (improve rearing, shelter, and frequency of large woody debris).

The mechanisms by which the project will benefit salmonid habitat and water quality include: 1) Increasing the available over-winter rearing habitat for juvenile salmonids; 2) Providing juvenile and adult salmonid flow refuge habitat both in the floodplain side channels and in the enhanced main channel/base-flow habitat of Lagunitas Creek; 3) Increasing and improving salmonid shelter habitat; 4) Increasing wood loading and frequency of woody debris structures for use by salmonids; 5) Sorting and storing sediment, in the main channel and out onto the floodplain; and 6) Increasing patchiness of gravel–cobble and cobble–boulder complexes for use as salmonid spawning and juvenile winter rearing habitat.

The project sites completed this year entailed installation of two BAJs which necessitated excavating the stream bed of Lagunitas Creek and temporarily diverting the creek into by pass channels that could handle the 8 cfs summertime flow. Two LDRJs were installed in the live channel and constructed by driving an excavator out over the creek on crane mats supported by k-rails. The 1,000 foot long floodplain channel was excavated along a remnant side channel, through willow-alder riparian corridor. Collectively, the Phase 1 projects will restore a little over a half-mile of floodplain habitat.

There has been work of a similar nature conducted on other Central Coast streams but the BAJs and LDRJs are the first of their type for the region. This $1.2 million construction project is being supported with grant funding from California Department of Fish & Wildlife, California State Water Board, and the U.S. Fish and Wildlife Service. The project sites are located on National Park Service and California State Parks lands. My presentation will describe the entire project team. I will also discuss the challenges encountered and field modifications we developed as the project was being implemented.

Historical Basis for Restoring to Stage Zero

Sean Baumgarten *(Presenter) and Co-authors:* ***Robin Grossinger*** *and* ***Erin Beller,*** *San Francisco Estuary Institute-Aquatic Science Center (SFEI-ASC)*

Recent incorporation of the Stage 0 concept into river restoration theory and practice is based, in part, on increasing evidence for the prevalence of multi-thread channels prior to extensive human modification. Such evidence draws substantially on historical records of diverse origin, synthesized to elucidate patterns of natural channel morphology. When well documented from multiple sources, such glimpses of pre-modification channel systems can improve our understanding of their ecological and physical characteristics, landscape setting, and mechanism of transformation into simplified single-thread channels.

Over the past two decades, researchers at the San Francisco Estuary Institute have studied the historical characteristics of over two-dozen stream systems throughout California. These studies provide evidence for multi-thread channels in a wide range of watersheds in Mediterranean and semi-arid climates, extending the geographic extent of evidence for these systems. In this presentation, we survey these studies to illustrate common themes in multi-thread systems in California. These systems were common in low-gradient settings of most watersheds studied. Multi-thread systems were often found where high groundwater supported year-round wetland complexes, providing high ecological value in regions with extended dry seasons. Multi-thread reaches were so visually and functionally distinct from single-thread reaches further upslope that they often had different names. As a result of conversion, newly simplified channels often appear quite natural in the late 19th and early 20th centuries. Several case studies will provide compelling illustration of these patterns.

Five Mile Bell Restoration Project: A Stage 0 Restoration Case Study in Coastal Oregon

Paul Burns, *Fisheries Biologist, U.S. Forest Service, Siuslaw National Forest*

Five Mile Creek is the largest tributary to Tahkenitch Lake on the Central Oregon Coast. These coastal lake systems contain some of the most productive coho salmon (*Oncorhynchus kisutch*) streams in the Pacific Northwest with adult spawning peak counts often exceeding 250 fish per mile. This high production occurs even though streams such as Fivemile Creek were pushed to the sides of the valley, straightened and diked to facilitate agriculture, and quickly moved from a channelized stage 2 to degrading and widening stages 3 and 4 (Cluer and Thorne 2013). Fortunately some of the smaller tributaries were spared from agricultural manipulation and maintain some of the historic valley, floodplain, and stream characteristics that provide examples of former stage 0 stream systems in these stream valleys.

The Five Mile Bell Project is a decade long restoration effort conducted in 5 phases that began in 2012. Restoration focused on the re-establishment of historic geomorphic processes of an extremely low gradient 100 acre valley floor including stream, floodplain and native plant communities. The stream channel portion of the project was initially focused on determining the appropriate size of the channel to construct. As the project progressed, monitoring of Phase I work which was mostly floodplain and native vegetation restoration, revealed rapid development of complex aquatic and terrestrial habitats on the floodplain. Based on this monitoring and a robust peer review process with other restoration practitioners, subsequent phases have been modified to encourage the development of stage 0 conditions while still meeting the development of our native plant communities.

2017 implementation marked the completion of Phase III of the project which included the regrading, and subsequent non-native vegetation removal, of 41 acres of valley bottom to the desired floodplain and channel elevations based on the PowerSlope method (Powers et al., 2018, In Prep) Over 5,000 feet of channel filling and aquatic organism relocation along with multiple channel and flow path development with the associated placement of 350 trees as large woody debris were completed this summer. To date, over 100,000 native plants of over 50 species have been planted, including culturally significant species.

Throughout the first 3 phases of the project we have been able to adapt our restoration strategy based on the initial results of the implementation in prior years. We have used a mix of channel construction and non-channel construction techniques to provide varied habitat types and allow for multiple trajectories of stream development. We have also been studying the pros and cons of construction in one year and then allowing revegetation efforts to establish vegetation cover prior to restoring the stream flow to the restored surface.

A Process to Restore Chaos, Stage Zero Experience from the U.S. Fish and Wildlife Service

Jared McKee, *(Presenter) and* ***Damion Ciotti,*** *U.S. Fish and Wildlife Service*

Stage Zero conditions are gaining momentum as a design goal for fluvial restoration projects. But how is a restoration project designed where Stage Zero conditions are the goal? In this presentation, it will be proposed that three general principles should be considered for stream restoration projects which seek to address the adverse impacts of channel incision and move a system towards Stage Zero conditions. These principles are founded in the idea of process-based restoration and work by capitalizing on the natural recoverability and variability of fluvial systems. First and foremost, restoration practitioners must perform an analysis to determine the Stream Evolution Corridor (SEC) so that stakeholders understand the spatial extent of the dynamic system and impacts to the system which prevent unimpeded self-healing can be assessed. Secondly, practitioners should focus on the removal or modification of anthropogenic structures in order to accommodate a more dynamic fluvial system and not impede channel evolution and Stage Zero development. Finally, base level control must be considered. This means addressing the incision at its most basic level and creating a stopping point for which the stream will no longer incise but begin to aggrade. With this method, habitat form is revealed as sediment system connectivity and fluvial process is adaptively restored. The key metric for evaluating a restoration action is the resulting change in space potentially available for fluvial energy to create habitat within the delineated SEC. A case study of the application of this approach from the foothills of the Sierra Nevada will be presented. Doty Creek is in the Feather River watershed and is critical habitat for steelhead. In three years approximately half of the floodplain/ stream system evolved from a single thread channel dominated by oak and grassland to a permanently flooded stage zero condition with highly complex stream and wetland morphology. Restoration investments have been relatively low (less than $50,000) and include levee removal, livestock fencing, planting, and beaver dam analogue (BDA) construction. The project does not involve stream or floodplain reconstruction beyond the use of BDAs or beaver to meet stream and floodplain form objectives. The project provides an ideal demonstration of maximum stream restoration with minimum intervention. It is also an opportunity to experiment with stage zero restoration under the confines of an active cattle-grazing operation. Specific methods, lessons, and mistakes will be discussed.

Stage 0 Restoration Approach, Design, and Construction

Paul Powers, ***Fisheries Biologist, U.S. Forest Service, Deschutes National Forest***

Within the Pacific Northwest Region of the Forest Service, adoption of the Stage 0 (Cluer and Thorne, 2013), or process-based restoration approach began on the arid, east side of the Cascade Mountain Range. The earliest projects of this type were designed and implemented in second order streams flowing through degraded meadow systems. As a result of anthropogenic disturbance coupled with the loss of beaver, these project areas had experienced head cutting and channel incision followed by a lowering of the alluvial aquifer and a transition from wetland to arid terrace. In these areas, the restoration design deviated from the historic approach of headcut stabilization and instead sought to recover the entire wetland complex by working at the valley scale. This resulted in the development of broad wetland complexes with no constructed stream channels.

The rapid succession of wetland features and attributes observed in these early projects prompted restoration specialists to expand this approach to larger, bedload dominated systems on a variety of landscapes ranging from lacustrine valleys in the Oregon Coast Range, to moderate gradient valleys in the West Cascades (1-2%) and Klamath Basin (6%). The same general approach was followed on all of these landscapes, which included the development and construction of a depositional valley as opposed to the design and construction of a "balanced" channel. These project types restore fluvial processes and in turn restore ecological benefits that have been largely lost in many river systems (Bellmore et al. 2013, 2015, 2017).

The design of these projects begins with the primary goal of maximum floodplain connectivity. Rather than design channels that are connected to the floodplain at a bankfull discharge event, this approach, instead, constructs valley surfaces and aims to maintain a base flow water surface and alluvial aquifer that is at or near the valley floor elevation. Development of this design relies heavily on the valley slope and connecting surfaces longitudinally and laterally. This presentation walks through how to design these Stage 0 projects and provides examples of the methodology (Powers et al., In Prep). Newly developed GIS mapping based on LiDAR derived elevations allows us to effectively display historic surfaces as well as interpret how the current valley matches or deviates from that historic condition.

Design and Implementation of Secondary Channels in Dry Creek, Sonoma County, California

***Jason Q. White**, Environmental Science Associates (Presenter), and Co-authors: **Aaron A. Fulton, PE, Jorgen A. Blomberg**, and **Ann E. Borgonovo, PE**, ESA*

The Sonoma County Water Agency (SCWA) is restoring secondary channels along the dynamic lower reaches of Dry Creek as part of the Dry Creek Enhancement Project. Improving degraded habitat in Dry Creek, the largest tributary in the Russian River watershed, is key to the recovery of Coho salmon and Steelhead in the region. Dams and in-channel gravel mining operations along Dry Creek and the Russian River have initiated system-wide incision and contributed to contemporary geomorphic conditions. In the 1980s, the upper half of the Dry Creek watershed was impounded and the ensuing modified hydrology reduced disturbance events and increased vegetation survival which has transformed a once multi-threaded, complex, gravel-bedded channel with sparse riparian vegetation, to a single, uniform channel, with a robust and substantial riparian corridor. This geomorphic template, when combined with elevated summer base flows, has resulted in poor rearing habitat conditions for Coho salmon and Steelhead in Dry Creek.

As a restoration design engineer for the Dry Creek Enhancement Project, Environmental Science Associates (ESA) has developed a unique approach to designing secondary channels that restores the multi-threaded channel networks and improves perennial habitat conditions. The approach focuses on replacing the natural disturbance processes that create secondary channels, processes that are currently prevented by densely established vegetation and reduced winter high flows. Due to a high incoming sediment supply from upstream tributaries, a wide incised stream corridor, and the potential backwater from the Russian River, the lower Dry Creek reaches tend to be depositional, creating challenging conditions for constructing self-maintaining perennial features. Under such conditions, a relatively small amount of deposition can result in the loss of constructed habitat features. ESA's approach required an understanding of natural physical processes specific to gravel-bedded multi-threaded channels, including bifurcations, confluences, bed morphology, and flow forcing obstructions. ESA's secondary channel design utilized a nested approach which considered sedimentation processes at various scales.

The record 2017 winter has provided a great opportunity for learning and adapting ESA's secondary channel design approach. The first secondary channel designed by ESA for SCWA's Dry Creek Habitat Enhancement Project was implemented in the summer of 2016. It was immediately tested by an extremely wet 2017 winter, which included a total of 70 inches of rainfall, well above the average of 45 inches in the Dry Creek watershed. This generated sustained high flow (greater than the minimum annual peak flow) releases for approximately nine continuous weeks. Portions of the newly constructed secondary channel filled in with one to four feet of coarse gravel. Based on an understanding of secondary channel processes and observations during the high flows, it is hypothesized that the differential rate of deposition in the main channel and the new secondary channel was due to an imbalance in flows and sediment transport energy between the two channels. This presentation will provide a brief background on Dry Creek, describe ESA's unique approach to designing secondary channels, discuss construction and performance, and share lessons learned and adaptations made to current and future designs.

Streamflow Enhancement: Planning, Science, Strategies and Lessons Learned

Friday Afternoon Concurrent Session

Session Coordinator*: Monty Schmitt, The Nature Conservancy*

This session will explore the planning, science, strategies, and lessons learned from efforts to improve flows for fish and water security for landowners. Presenters will discuss efforts to create flow objectives; opportunities and challenges for using tools and policies for increasing flows including storage and forbearance, 1707 dedications, and the North Coast Instream Flow Policy; documenting benefits; and explore collaborative approaches to advance stakeholder-driven improvements in water resource management.

Maximizing Incentives to Enhance Streamflow in Coastal California: Integrating Instream Flow Dedications and ESA Recovery Initiatives

Dan Wilson, *NOAA Fisheries,*
and ***Peter Kiel,*** *Ellison Schneider Harris & Donlan LLP (Co-presenters)*

Instream flow dedications are identified as high priority actions in NMFS' Recovery Plans for ESA-listed Central California Coast (CCC) coho salmon, Central C0ast Chinook salmon, North Coast steelhead, CCC steelhead, and Southern Oregon Northern Coastal California coho salmon in coastal California. Instream flow dedications are generally made to increase rearing or spawning capacity in streams to which flow is dedicated. These dedications are voluntarily initiated by the water right holder and may be memorialized in a forbearance agreement or a Water Code section 1707 petition approved by the State Water Resource Control Board. The procedural requirements for making these dedications are complex, and while recent efforts have provided helpful guidance in navigating those processes (SWIFT 2016), there are also a few underutilized incentives available to water right holders willing to go through the process. These incentives are available outside of the water rights process and can include federal tax deductions for qualified landowners and Safe Harbor assurances through the Endangered Species Act. Water right holders can obtain these incentives without significant additional expense and time. This session summarizes the current process for making instream flow dedications and discusses various strategies being used and that could be used to maximize incentives for water right holders to make an instream flow dedication.

A Coordinated Approach for Developing Statewide Environmental Flow Regulations in California

Julie Zimmerman, The Nature Conservancy

Establishing environmental flow targets is a priority for numerous programs in California. Although methods vary, each effort aims to determine flow conditions necessary to protect ecological integrity in light of competing water uses. Methods vary based on the ecological endpoint of management concern (e.g., fish, macroinvertebrates, habitat), stream type, and preferences of the implementing agency, and include a variety of established methods. Unfortunately, lack of coordination among programs and efforts leads to inefficiencies, difficulty in comparing approaches, inability to share outputs, and creates potential for competing recommendations. An ad-hoc statewide technical workgroup consisting of UC Davis, Southern California Coastal Water Research Project, The Nature Conservancy, UC Berkeley, and the U.S. Geological Survey has convened to develop a framework for organizing environmental flow analyses across California and providing consistent science-based recommendations for applying appropriate methods to inform setting and managing of environmental flows. We propose a tiered approach that promotes consistency and coordination in establishing, maintaining, and monitoring in-stream flow requirements for California. The overall goal of this effort is to support various regulatory and management agencies in developing and implementing local, regional, and statewide in-stream flow targets to protect aquatic life beneficial uses. A tiered approach allows for rapid development of statewide environmental flow recommendations based on natural variability of ecologically-relevant flow metrics (Tier 1) and guidance on appropriate methods for developing more refined and site-specific flow targets depending on stream class, management context, and desired ecological outcomes (Tier 2). We propose to use case studies to demonstrate implementation of the framework in different stream classes, spatial scales, and management contexts, and to compare flow recommendations using the rapid functional flows approach and other, more site-specific and detailed approaches.

Managing Diversions in Unregulated Streams Using a Modified Percent-of-Flow Approach

Darren Mierau, CalTrout

In Mediterranean climate-type river systems, naturally low seasonal stream flows are often overexploited, which has implications for managing flows for environmental as well as human needs. Traditional approaches to instream flow management are not well suited to unregulated systems with strong seasonal patterns of water availability and many water diverters, and are challenging to implement in such systems. They often do not protect the full range of variability in the annual hydrograph, require extensive site-specific data, expensive modelling, or both. In contrast, holistic flow management strategies, such as percent-of-flow (POF) strategies, are designed to protect multiple ecological processes and preserve inter-annual flow variability. However, POF approaches typically require real-time streamflow gauging and often lack a robust metric relating a diversion rate to ecological processes in the stream. To address these challenges, we present a modified percent-of-flow (MPOF) diversion approach where diversions are allocated from a streamflow baseline which is derived from a regional relationship between a conservative streamflow-exceedance and date. The streamflow baseline remains the same from year to year and is independent of water-year type. This approach protects inter-annual flow variability and provides a predictable daily allowable volume of diversion at any diversion point—supporting efficient water management planning. The allowable diversion rate in the MPOF approach is based not on a fixed percentage of the ambient streamflow, but rather on a maximum allowable percentage change in riffle crest thalweg depth, an ecologically meaningful, common hydraulic measurement. In this presentation, we describe how the MPOF approach is a holistic approach well suited to manage diversions in unregulated streams typical of California's Mediterranean climate-type coastal drainages.

An Alternative Approach to Evaluating the Impact of Streamflow Improvement Projects on Small Intermittent Streams: A Case Study on Dutch Bill Creek

Sarah Nossaman, *CA Sea Grant Trout Unlimited (Presenter), and Co-authors:* ***MaryAnn King,*** *Trout Unlimited;* ***Mariska Obedzinski,*** *UC Sea Grant; and* ***John Green,*** *Gold Ridge Resource Conservation District*

Insufficient summer streamflow has long been recognized as a limiting factor to the recovery of coho salmon populations in the Russian River. Since 2009, the Russian River Coho Water Resources Partnership has been working to identify and implement flow improvement projects in high priority coho streams characterized by low summer base flows and dominated by small-scale water users. One of the primary challenges of working in these systems is the hydraulic scale; late-summer flows are miniscule and project effectiveness can be illusive, as even the largest streamflow improvements only return hundredths to tenths of a cubic foot per second (ft3/s) of flow to the stream. We believe that these modest amounts of water are critical to fish when summer base flows near intermittency, so we developed an approach to estimate project success in small, intermittent streams where natural variation within and between water years can mask project-related contributions to streamflow.

Through our studies of juvenile coho survival in relation to flow, we have identified stream habitat connectivity as a key factor in species persistence through the summer season. Based on this finding, a primary objective of the Partnership is to complete projects that will increase the number of days that pools are connected by continuous surface flow. We developed reach-specific connectivity thresholds—the streamflow above which pools remain connected—and deduced that if implemented projects could, collectively, meet or exceed these connectivity thresholds, they could be considered effective at increasing the number of days of stream connection and, therefore, at increasing survival. In some cases, connectivity thresholds were as low as 0.01 ft^3/s, supporting the narrative that projects contributing even a small amount of streamflow can be valuable in tipping the scales in favor of fish survival and should be considered viable investments by project funders.

We recognize that flows greater than those required to maintain connectivity will ultimately be necessary to increase juvenile coho salmon production and achieve full population recovery, but for the immediate future we are focusing on meeting connectivity thresholds in order to prevent extirpation. Using Dutch Bill Creek as a case study, we will explore this approach of evaluating the collective benefits of flow release, storage, and forbearance projects, with consideration of the pre- and post-project hydrographs.

Collaborative Water Management: A Framework for Stakeholder-led Flow Enhancement Projects at a Watershed Scale

Monty Schmitt, *The Nature Conservancy*
and ***Tasha McKee,*** *Sanctuary Forest Inc. (Co-presenters)*

In 2010, the Regional Water Board adopted the Policy for Maintaining Instream Flows in Northern California Coastal Streams (NCIFP) which establishes principles and guidelines for maintaining instream flows for the protection of fishery resources, while minimizing water supply impacts on other beneficial uses of water, such as irrigation, municipal use, and domestic use. The Water Board included the Watershed Approach to promote and support voluntary collaborative efforts to secure new water rights that improve environmental flows. The Watershed Approach, however, requires participants to meet specific provisions including formal agreements, management plans and monitoring to ensure measurable results. The Collaborative Water Management (CWM) Project has developed a model framework for voluntary, watershed-based and stakeholder-driven collaborative water management that employs a suite of water management tools to increase water security and improve environmental flows for fish. The CWM project synthesizes existing informational resources with input from water resource management practitioners working in the North Coast region. The framework is intended to provide the essential information and practical guidance to incentivize and enable landowners to collaborate on projects and management action to improve streamflows. By using existing policies (e.g. NCIFP, 1707, etc.) and established management tools (e.g. coordinated management of diversions, storage and forbearance, large wood restoration, etc.), the framework is intended to maximize feasibility and likelihood of implementation. Include case studies from Mattole.

Working Toward Instream Flow Enhancements: Modeling Hydrology and Water Use to Inform Policy Development in Critical Salmonid Streams

Valerie L. Zimmer, State Water Board Resources Control Board

The State Water Board (Water Board) and the Department of Fish and Wildlife (CDFW) are implementing a suite of actions to enhance flows statewide in at least five stream systems that support critical habitat for anadromous fish. This effort is underway in the following initial stream systems: Mark West Creek (Russian River), South Fork Eel River, Shasta River, Mill Creek (Sacramento River), and the Ventura River. Current efforts by the State Water Board include developing surface water-groundwater hydrology models, assessing water demand estimates and water use data, and modeling water management scenarios. The SWB, CDFW, and project partners are collecting hydrological, biological, and geomorphological data in target basins and are conducting instream flow studies in order to understand the flows required to maintain fish in good condition. This talk will discuss the efforts thus far, future efforts, and anticipated challenges in setting meaningful criteria and measuring the success of flow enhancement policy.

Eel River Ecology, Restoration Challenges

Saturday Morning Concurrent Session

Session Coordinator*: Darren Mierau,* *North Coast Director, CalTrout*

The Eel River, California's third largest river entirely in California, offers unparalleled opportunity for ecosystem restoration and recovery of abundant salmonid populations. The Eel River once sustained huge runs of salmon and steelhead, abundant cutthroat trout, and Pacific lamprey and green sturgeon—important species for local tribes and valuable indicators of ecosystem health. But the river has been transformed during the past century and a half, from one of the most biologically rich and productive river ecosystems along the Pacific Coast to a degraded river with impaired ecosystem functions.

Restoration scientists, agency managers, Tribes, NGOs, and citizen groups have made tremendous efforts over the past decades to restore this valuable natural resource and momentum has been building in recent years. Recent salmon and steelhead abundance trends have ticked upward, offering a glimmer of hope.

But the Eel is at an important crossroads. To sustain and accelerate recent momentum, a landscape-scale, science-based, "all-hands-on-deck" recovery initiative is needed. We must double down on watershed/habitat restoration, invest heavily in tidal marsh and estuarine habitat in the delta, protect water quality across the Eel's seven sub-basins listed as sediment and temperature impaired, thoroughly analyze the feasibility of decommissioning Pacific Gas and Electric's (PG&E) Eel River Dams, and implement new water policies and guidelines to protect against excessive water diversion for cannabis cultivation.

This session will focus on key programs and initiatives brought forward by citizens, resource agencies, tribes, and non-profit groups that offer hope of restoring a wild, healthy, and resilient Eel River.

Restoring Wild Fish Abundance to the Eel River: A Basin-Scale Effort to Increase Salmonid Habitat Capacity and Watershed Resiliency

Darren Mierau, ***North Coast Director, CalTrout***

The Eel River once sustained large populations of Chinook and coho salmon, winter and summer steelhead, and coastal cutthroat trout. Pacific lamprey and green sturgeon are also recognized as important native species. (Yoshiyama and Moyle, 2010) conducted an historical review of Eel River anadromous salmonids in which they estimated combined annual salmon and steelhead runs historically exceeded one million adult fish in good years (~800,000 Chinook salmon, ~100,000 coho salmon, ~150,000 steelhead). Contemporary salmonid abundance is 'guesstimated' to be in the range of 20,000 to 50,000 adult fish.

CalTrout's campaign to bring back wild fish abundance to the Eel River is founded upon a comprehensive 'Headwaters to Sea' strategy that embraces restoration or enhancement of tidal marsh and wetland habitat across the Eel River delta, opening access to natal spawning and rearing habitat through the removal of fish migration barriers (e.g., tidegates, culverts), restoring and protecting public trust stream flows through a broad regional water management strategy, and addressing impacts resulting from Pacific Gas and Electric's Eel River Dams (Potter Valley Project).

Removal of passage barriers is a well-established restoration strategy to increase habitat capacity. This presentation will focus on CalTrout's barrier removal projects, including: (1) a partnership with The Wildlands Conservancy to modify the historic Cutoff Slough tidegates and install new tidegates into a 100 acre 'Inner Marsh', (2) removal of passage barriers caused by Northwest Pacific Railroad (NWPCo) crossings at Bridge Creek (Humboldt County) and Woodman Creek (Mendocino County), (3) assessing fish passage feasibility at relict structures left by the historic Cedar Creek Fish Hatchery, and (4) assessing current salmon and steelhead habitat capacity in the 288 mi^2 watershed above Lake Pillsbury, to inform the Pacific Gas & Electric Potter Valley Project Federal Energy Regulatory Commission relicensing process which began in 2017.

Revitalizing the Eel River Estuary for Native Fish and Wildlife, and Essential Coastal Resiliency

Michael Bowen, California State Coastal Conservancy

Estuaries provide important nursery habitat, contributing significantly to the life-histories of numerous terrestrial and aquatic species, including anadromous salmonids. Healthy estuaries provide watersheds with additional habitat diversity, allowing greater life history diversity and ultimately greater salmonid population resiliency and productivity.

At 196 miles long, the Eel River and its tributaries form the third largest watershed entirely in California, draining a rugged area of 3,684 square miles (9,540 km2) in five counties. This watershed once supported the Pacific Coast's fourth largest salmon run. The Eel River delta and estuary is the third largest estuary in California. The tidal area of the Eel Delta was estimated to be 6,525 acres in 1870. By 1970, the estuary, inclusive of sloughs and tidal channels, was reduced to 2,200 acres, a 67% reduction. The Soil Conservation Service estimated that by 1989 the Eel River estuary was 40 percent of its original size.

Numerous studies highlight the ecological and social importance of the Eel River Delta and estuary, as well as the urgent need for enhancement. These include: the Natural Resources of the Eel River Delta (NOAA-CDFG, 1974), the Recovery Strategy for California Coho Salmon (CDFG. 2004), the Salt River Watershed Assessment (CDFG, 2005), the Lower Eel River Watershed Assessment (CDFG, 2010), the Final Recovery Plan for the Southern Oregon/Northern California Coast Evolutionarily Significant Unit of Coho Salmon (Oncorhynchus kisutch) (National Marine Fisheries Service, 2014), the State Wildlife Action Plan (CDFW, 2015) and the Eel River Forum's Eel River Action Plan (Eel River Forum, 2016). The Eel River estuary has been designated critical habitat for salmon and steelhead under the Federal Endangered Species Act (ESA). Enhancing habitat function in the Eel River estuary is a key component towards recovery of California's anadromous fish and many other species of tribal, commercial, and recreational importance.

Opportunities for broad-based ecosystem restoration and sea level rise adaptation planning are rare along the Pacific Coast, but several exist in the Eel River Delta. Numerous landowners as well as local, state, and federal agencies, two state universities, tribal governments, industry representatives and nonprofit organizations are working together on several ecosystem-scale projects intended to ensure the Eel River estuary is a working landscape that supports agriculture while providing healthy aquatic and terrestrial habitat. The Eel River Delta and estuary provides an historic opportunity to achieve this vision.

But each exciting opportunity presents a unique series of challenges, each of which threatens the success of an historic opportunity.

Research Efforts Supporting Instream Flow Planning: Hydrology Modeling, Data Collection, and Stream Classification in the South Fork Eel River Basin

Valerie L. Zimmer (Presenter)**, and Co-authors: **Adam Weinberg, Marc Van Camp, Rajaa Hassan, Dan Worth, Kevin DeLano,** and **Robert Solecki,
State Water Resources Control Board

The State Water Board and partners are in the process of studying the hydrology, geomorphology, and water use in the South Fork Eel River Basin. We are developing a surface water-groundwater hydrology model using available stream gauge, land use, and climate data to better characterize the unimpaired flow, stream losses, and water availability in various tributaries. We installed stream gauges in ten tributaries in order to better understand recession hydrographs, low-flow summer conditions, and the variability between individual streams. In addition, we are developing a geomorphic stream segment classification system that will provide a basis for assessing the functional response of habitat quality over a range of flows. These efforts will be used to support the enhancement of instream flows in the watershed.

Revising Field Sampling Protocols to Enhance the Role of Geomorphic Classification in Instream Flows Studies

Colin Byrne, Ph.D., *(Presenter), and Co-authors:* ***Gregory Pasternack, Ph.D.***, *University of California, Davis;* ***Belize Lane, Ph.D.***, *Utah State University; and* ***Samuel Sandoval Solis, Ph.D.***, *University of California, Davis*

Classification of rivers based upon field-surveyed geomorphic attributes remains a prevalent method for describing dominant geomorphic settings and potential restoration strategies. In the context of salmonid ecology, specific river forms and the hydrodynamics associated with these settings are known to influence habitat quality and availability over various life stages. While real-world river form is no doubt dynamic and complex, a river archetype, or a conceptualization of a type of river form, can be used to analyze key hydrodynamic patterns associated with natural or managed flow regimes and provide a resource-efficient link between form and process. Improved understanding of the range of geomorphic settings which exist in a basin can provide a foundation for the generation of river archetypes to rapidly assess the range of hydrodynamic responses to proposed instream flow releases and the associated ecological implications. In the Sacramento River basin, variability and covariance of width and depth undulations along a river corridor were shown to play a significant role in description of ecologically meaningful river form and hydrodynamics. With a new iteration of field sampling along streams in the South Fork Eel basin planned, previous classification results are used to inform field-sampling protocols with a focus on capturing variability of stream form and those geomorphic attributes most important to the definition of river archetypes. Here, we expand on the suite of geomorphic attributes to be surveyed in the field to improve synthesis of archetypal geomorphic settings. These settings generate the two-dimensional hydrodynamic patterns and dependent ecological functionality often associated with near census, or data rich, hydrodynamic model outputs. However, in data limited settings, the importance of surveying the most significant channel attributes is critical. Salmonid ecology, therefore, can continue to be informed by assessment of geomorphic settings and optimization of field sampling protocols.

The Phenology of Food Webs in South Fork Eel River Tributaries: Implications for Water Management

Gabriel Rossi, University of California, Berkeley, Department of Integrative Sciences

Understanding the seasonality (phenology) of stream food webs is critical for a host of restoration and management goals, including salmon and steelhead recovery. Seasonal and inter-annual changes in food webs, cross-ecosystem subsidies, and hydrology play a major role in maintaining function and biodiversity in stream ecosystems (e.g. Power et al. 1995, Studley et al. 1996, Kiernan 2012). However, phenological differences between streams have not been widely considered in allocations of flows (quantity, timing, and water quality) required to sustain freshwater and estuarine ecosystems in California. In California's coastal streams, such as the South Fork Eel River, water is typically allocated to sustain physical habitat (space) suitable for focal life stages of priority salmonid species (Mierau et al. 2017). Yet the performance (growth, survival) of juvenile salmonids is strongly affected by food supply and food web phenology (Power et al. 2008, Nakano et al. 1999, Finlay et al. 2002). Seasonal flow management prescriptions that are based only on physical habitat may fail to protect underlying ecological processes that structure the food webs on which focal species depend (Studley et al. 1996), as well as the variability in ecosystems drivers that support multiple species (Mierau et al. 2017, Richter et al. 1997).

Here we compare the spring through fall phenologies of hydrology and food webs in four South Fork Eel River tributaries: Fox Creek (2.7 km^2), Elder Creek (16.2 km^2), South Fork Sproul Creek (12 km^2), and Mainstem Sproul Creek (44 km^2). Food web phenologies are related to foraging behavior of juvenile salmonids in each of these streams. We consider the implications of phenological differences on management of instream flows and the portfolio of juvenile salmonid life history strategies in the SF Eel River and its implications for restoration and recovery.

The Opportunity for a Wild, Un-Dammed Eel River

Scott Greacen, JD, *Conservation Director, Friends of the Eel River*

The proposed relicensing of two dams on the upper mainstem of the Eel River is likely to be the most consequential choice for salmon and steelhead recovery we will face in this generation in the Eel River watershed. However, the process by which the Federal Energy Regulatory Commission (FERC) will decide whether to grant a new license to Pacific Gas & Electric's Potter Valley Project seems designed to obscure the impacts of the Eel River dams on fisheries, the risks to the dams from seismic and geological factors, and even the basic economics of the hydroelectric plant that is the subject of the federal license.

The Eel River dams are now operated under a flow schedule required by the National Marine Fisheries Service (NMFS) to avoid jeopardizing the survival of Chinook salmon and steelhead trout in the Eel River. Nonetheless, it is increasingly evident that the Eel River dams still function as an ecological trap for young salmon and steelhead, substantially diminishing the value of the fish ladder installed on Cape Horn Dam. The possibility that Pacific Gas & Electric might surrender the license, allowing the Eel River dams to be removed, raises the hope that critically imperiled salmon and steelhead, including summer steelhead, could return to the prime spawning and rearing habitat that has been entirely blocked for nearly a century by Scott Dam.

But Pacific Gas & Electric is proposing to keep the dams as they are and FERC is refusing to require the utility even to study or consider dam removal. Despite the near collapse of the Oroville dam, FERC insists dam safety cannot be addressed in relicensing. The public is largely unable to review documents relevant to dam safety because they are classified as Critical Energy Infrastructure Information.

While we await the reform of basic regulatory institutions, any strategy to secure removal of the Eel River dams must bypass the bureaucratic FERC process.

Cool Matters: Emerging Stream Temperature Science

Saturday Morning Concurrent Session

Session Coordinator*: Eli Asarian,* *Riverbend Sciences*

Water temperature has long been recognized as a key limiting factor affecting the distribution and abundance of salmonids in rivers and streams, particularly for species such as coho salmon, spring-run Chinook salmon, and steelhead which oversummer in freshwater and thus require year-round cool water. Technological advances through past decades and recent years have facilitated development of new tools and approaches to studying water temperature which have yielded new insights. In addition, long-term monitoring programs are accumulating data and tracking the response of stream temperatures to disturbance events, climatic variation, and changes to land and water management. Much has been learned, but much is yet to be discovered. This session will feature presentations with new science on water temperature in freshwater salmonid habitats, with topics such as: new approaches to monitoring, analyzing, and modeling stream temperatures; research into physical processes affecting thermal dynamics, such as riparian vegetation, smoke and fog, and exchange between surface water and ground water; the importance of thermal refugia and thermal diversity; climate change modeling and projections; and assessments of long-term trends.

Spatial and Temporal Patterns of Riparian Shade, Light, and Stream Temperature in Response to Riparian Thinning in Redwood Headwater Streams

David Roon, Oregon State University

Thinning and selective logging are being applied to second-growth forests to accelerate the recovery of old-growth forest characteristics (structure and composition). These restoration practices have largely focused on upland forests, but now there is interest in applying them in second-growth riparian forests. However, as the aquatic responses associated with riparian thinning are currently unknown, this first has to be evaluated experimentally before being applied across larger spatial scales. To address this, we are evaluating the effects associated with experimental riparian thinning treatments in seven locations distributed across three redwood headwater stream networks located on private timberland owned by Green Diamond Resource Company and in Redwood National Park. We measured spatial and temporal patterns of riparian shade, light, and stream temperature following a Before-After-Control-Impact study design. To do this, we are integrating empirical data collection with spatial stream network models to understand responses to riparian thinning at multiple spatial scales. Initial results indicate that pre-harvest conditions inherently varied spatially and seasonally. Initial post-treatment patterns suggest an immediate response in stream temperature associated with the reductions in shade and increases in light associated with riparian thinning, increasing thermal heterogeneity across these headwater stream networks. By evaluating the magnitude and duration of thermal responses associated with riparian thinning across entire watersheds, we hope to better understand the cumulative effects of riparian thinning on the thermal regimes in these redwood headwater streams.

Streams that Cool Down as Summer Heats Up: The Effects of Seasonal Changes in Riverine Canopy on Water Temperature

Ann Willis (Presenter), *and Co-authors:* ***Eric Holmes*** *and* ***Andrew Nichols,*** *University of California, Davis, Center for Watershed Sciences; and* ***Mike Deas,*** *Watercourse Engineering, Inc.*

Maximum water temperatures in streams throughout the western USA typically occur in late summer, coinciding with low stream flow. However, in the spring-fed Big Springs Creek in northern California, where constant-temperature groundwater springs provide relatively stable stream flow throughout the year, peak water temperatures and maximum diurnal variability occur in spring. We attribute this anomaly to the riverine canopy provided by native, emergent aquatic macrophytes (e.g., *Polygonum hydropiperoides* and *Nasturtium officinale*), which mimic the shade function of a riparian canopy. We tested the riverine canopy hypothesis using a 2-dimensional hydrodynamic and water temperature model. Based on the results, we collected monthly aquatic vegetation surveys to improve our understanding of the riverine canopy process. Our results are particularly relevant to reach-scale management strategies for instream flows to address water temperature conditions.

Wildfire Smoke Reduces Summer River Water Temperatures, Potentially Benefiting Cold-water Fishes

Frank Lake, Ph.D., *U.S. Forest Service Pacific Southwest Research Station (Presenter), and Co-authors:* ***Aaron David,*** *U.S. Fish and Wildlife Service; and* ***Eli Asarian,*** *Riverbend Sciences*

To evaluate whether wildfire smoke can cool summer river water temperatures by attenuating solar radiation and air temperature, we analyzed data on summer wildfires, smoke, weather, river discharge, and river temperatures from a 20 year period (1996-2015) at 12 locations in the lower Klamath River basin in Northern California, a large, Mediterranean-climate watershed. Previous studies of the thermal effects of wildfires on rivers have focused on either the effect of the heat of combustion on water temperatures during a fire, or the effect of riparian vegetation losses on post-fire water temperatures. We know of no studies of the effects of wildfire smoke on water temperatures of nearby river systems. Wildfire smoke is difficult to quantify due to high spatial and temporal variability, but we successfully used a newly available daily high-resolution (1-km) dataset of aerosol optical thickness (AOT) derived from satellite imagery to represent smoke density during six years with extensive wildfire activity in Northern California (2006, 2008, and 2012-2015). Solar radiation was substantially reduced on smoky days. We used linear mixed-effects models to evaluate the effect of AOT and other variables on daily mean and maximum summer water temperatures. In the best-fitting models, air temperature was consistently the strongest predictor, followed by AOT at nearly all locations. AOT had a cooling effect on water temperature at all 12 locations. On average AOT had a nearly two times greater effect on daily maximum temperatures than on daily mean temperatures. This smoke-induced river cooling may benefit salmonids and other cold-water adapted species, particularly because wildfires generally occur during the warmest and driest times of year.

Potential Effects of Climate Change on Thermally Suitable Habitat for Salmonids in the Salmon River, California

***Eli Asarian**, Riverbend Sciences and **Jay Stallman**, Stillwater Sciences (Co-presenters), and Co-authors: **Rafael Real de Asua**, Stillwater Sciences; **Joshua Strange, Ph.D.**, Sweet River Sciences; and **Lyra Cressey**, Salmon River Restoration Council*

The spatial distribution and temporal variability of thermally suitable habitats at watershed and reach scales influence salmonid reproduction, growth, and survival and are important considerations in developing aquatic habitat conservation and restoration priorities. Climate change and the legacy of past land uses have impaired summer stream temperatures and degraded over-summering habitat for at-risk salmon and steelhead populations in the Salmon River, California. We identify thermally suitable habitat and explore potential changes in these habitats under future climate change scenarios by analyzing spatially distributed stream surface temperatures and long-term trends in instream temperatures measured at fixed points. We analyzed the fine-scale spatial distribution of stream surface temperatures in mainstem reaches of the Salmon River using airborne thermal infrared (TIR) imagery acquired for 85 river miles in July 2009 during the period with the highest annual temperatures and maximum temperature heterogeneity. We calculated stream surface temperature departures by calculating differences between median temperatures and measured temperatures within 100-meter sample zones and defined thermally suitable habitat based on a 22 C threshold. At the watershed scale, median zone temperatures describe thermally suitable habitat in upstream reaches of the mainstem North Fork and South Fork and a downstream warming trend, with significant reach-scale departures. Cool departures reveal thermal refuges at the larger tributary confluences, associated with shallow groundwater interactions (e.g., seeps, springs, and hyporheic flow emerging from alluvial bars), and in bedrock-confined canyons with extensive topographic shading and deep, thermally stratified pools. Warm departures occur in reaches with wider alluvial channels and floodplains that coincide with more extensive disturbance from historical placer mining. We compiled instream temperature data collected by the Salmon River Restoration Council, U.S. Forest Service, and Karuk Tribe spanning back to the mid-1990s, with at least 10 years of data at 36 sites and shorter records at additional sites. Adapting the U.S. Forest Service's NorWeST model, we estimated summer stream temperatures for 1-kilometer reaches throughout the stream network using spatial stream-network (SSN) models. The models combine observed temperature, landscape attributes (e.g., drainage area, elevation, and canopy), inter-annual climatic variation, and spatial relationships between sites. The models also quantify the sensitivity of stream temperature to inter-annual variation in streamflow and air temperature. We used these sensitivity values to simulate reach-scale stream temperature response to air temperature and streamflow predicted by global climate change models. The long-term dataset and SSN models provide temporal context for the TIR snapshot. Combining the strengths of each approach, we produce fine-scale estimates of temperatures under future scenarios using the sensitivities from the SSN models and the geographic detail of the TIR imagery. These results illuminate the relative vulnerability and resiliency of thermally suitable habitat and inform a comprehensive, long-term strategy for protecting and restoring these habitats in the Salmon River watershed.

Predicting Temporally and Spatially Continuous Estimates of Stream Temperature in Non-monitored Years Using Simple Covariates

Jared Siegel, MSc, (Presenter) *and Co-authors:* ***Kris McNyset, Ph.D.*** *and* ***Carol Volk, Ph.D.,*** *South Fork Research, Inc.*

Temporal and spatial patterns in stream temperature are key factors determining the abundance and distribution of many aquatic species within a stream network. Climate change may alter and limit the future distribution of temperature sensitive species such as salmonids as streams become warmer. Accordingly, there is much interest in understanding temporal and spatial patterns of stream temperature and how these patterns are affected by climate variability. Unfortunately, the ability of scientists to explore these patterns is often limited by the temporal extent of monitoring. We fit summer stream temperature models in two watersheds in Washington state using readily available covariates (point measurements of air temperature, point measurements of discharge, and land surface temperature), combined with easily producible covariates using GIS (e.g., elevation and drainage area), across multiple years of data. These multiyear models were then used to predict temporal and spatial patterns in stream temperature in years outside the temporal range of the data used to fit the models. We found that accounting for discharge and interactions between discharge and other variables can greatly improve model predictions. The inclusion of these variables allows for temporal patterns to be predicted relatively accurately at most sites. Models are generally able to distinguish temperature between different years across the summer. Results suggest that these models may be used to extend the time series of temperature data in many watersheds, increasing the ability of scientists to relate stream temperature to biological data.

Freshwater Temperature Response to Five-year Drought in Two Trout-bearing Streams of Southern California

Andre Sanchez (Presenter) *and Co-authors:* ***Elizabeth A. Montgomery, Krista Adamek, Dylan Hofflander, Jennifer Mongolo,*** *and* ***Rosi Dagit,*** *Resource Conservation District of the Santa Monica Mountains*

Understanding how stream temperatures respond to drought or other climate phenomena is critical to proper management of natural resources and protection of freshwater biodiversity. The objective of this study was to determine if five consecutive years of below-average precipitation in southern California resulted in changed thermal condition in two steelhead (*Oncorhynchus mykiss*) trout-bearing streams in the Santa Monica Mountains. Remote underwater temperature sensors were deployed from May to October at six study sites in Topanga and Malibu creeks between 2011 and 2016. Water temperature was analyzed in terms of magnitude, timing, and duration of change, as well as frequency of critical thermal events for *O. mykiss*, and compared with precipitation, flow, air temperature, wind speed, and humidity. In both study creeks, the most pronounced trend in thermal condition were rising temperature minima, along with associated contraction of diurnal and study period range in temperature.

Modeling Salmonid Habitat for Restoration

Saturday Morning Concurrent Session

Session Coordinator*: James Graham, Ph.D.,* *Humboldt State University*

The session will focus on presenting modeling methods available for habitat modeling and applications of modeling to specific areas for restoration. This would focus on modeling the environmental and anthropomorphic elements that affect salmonid habitat including: topography, hydraulic dynamics, bottom composition, shading, and aquatic temperature. This session would bring together examples of the wide variety of methods available. A panel at the end of the session will discuss steps forward.

Integrating Hydraulic Modeling-Based Simulations of Salmonid Habitat Suitability with Geomorphic, Hydrologic, and Fisheries Data for Restoration Prioritization, Russian River Watershed, CA

Jeremy Kobor, MS, *Senior Hydrologist (Presenter) and Co-author:* ***Matt O'Connor, Ph.D.,*** *Principal Geomorphologist, O'Connor Environmental, Inc.*

This study evaluates more than eighty miles of tributary streams in the Russian River watershed to quantify existing salmonid habitat conditions and identify and prioritize restoration opportunities. The availability of regional high-resolution topographic data (LiDAR) allowed for efficient extraction and analysis of more than 4,500 cross sections and for development of reconnaissance-level one-dimensional hydraulic models. In conjunction with simple, rainfall gauge-driven lumped-parameter hydrologic models, the hydraulic models were used to develop water depth and velocity distributions for channel and floodplain areas over a wide range of flow conditions. The simulation results were used in conjunction with habitat suitability indices to quantify reach-by-reach variations in availability of suitable habitat and examine the relationships between flow and habitat availability. In most reaches, winter rearing habitat availability is most limited at flows greater than winter baseflow and less than bankfull. Over this range of flows, in-channel velocities are generally too high to be suitable and stream stages are too low to activate low-velocity floodplain areas. These findings suggest that winter rearing habitat enhancement projects should seek to enhance habitat conditions for flows within this relatively narrow range where conditions are most limiting.

The habitat availability maps were integrated with existing datasets describing observed salmonid utilization, summer low flow conditions, channel substrate, and pool and large wood distributions to develop reach-by-reach descriptions of available habitat conditions and recommended restoration actions. Opportunities for off-channel habitat enhancement are relatively limited owing to the incised nature of many of the streams and the constraints posed by existing infrastructure. The reconnaissance-level hydraulic analysis provided an efficient means of evaluating many miles of stream channel and identifying candidate sites for off-channel habitat enhancement projects. Candidate sites for both in-channel and off-channel restoration projects were further screened by consideration of ease of equipment access and availability of anchoring sites for large wood structures. Evaluating these secondary considerations provided a means of identifying the most cost-effective and feasible sites for restoration project development. Sample conceptual designs were also developed for a variety of restoration project types. The evaluation of existing habitat conditions and restoration prioritization mapping developed in this study provides restoration practitioners operating in these watersheds with critical information needed to leverage available project implementation funding for maximum habitat enhancement benefits.

Increasing the Availability of Spawning Habitats Through Building Baseflow Patterns as Found in Natural Flow Regimes

Damon H. Goodman, *U.S. Fish and Wildlife Service, (Presenter) and Co-authors:*
Nicholas A. Som, *U.S. Fish and Wildlife Service and Humboldt State University,*
and ***Nicholas J. Hetrick,*** *U.S. Fish and Wildlife Service*

We simulated the effect of un-impounded fall hydrographs on the spatial arrangement and area of Chinook salmon (*Oncorhynchus tshawytscha*) spawning habitats. This relationship was examined at sites with contrasting channel configurations and over a range of hydrologic regimes in a large regulated river in northern California. First, we developed a binomial logistic regression model designed to predict the suitability of locations for redd construction based on physical characteristics. Next, two-dimensional hydrodynamic habitat models were developed at two locations representing confined and unconfined channel forms, encompassing a broad range of channel morphologies common in many large river systems. Hydrodynamic models were leveraged to simulate the amount and spatial distribution of spawning habitat available at single steady flow rates currently used to manage for Chinook salmon spawning habitat, as well as, through a spawning season under a building baseflow fall hydrograph, a pattern common in natural streamflow regimes in the Pacific Northwest of the United States. Building baseflows increased the abundance of spawning habitat over individual streamflows at both the confined and unconfined model sites. Improvements were greater at the unconfined site that included lateral connectivity between the river channel and its floodplain. Furthermore, building baseflows provided spatial separation in preferred habitats over a spawning season, particularly at the unconfined site, which may reduce the threat of superimposition among runs or species. Building baseflows provided a benefit across the range of hydrologic regimes in a 100-year gauge record ranging from 20% to 122% improvements in habitat area over low streamflows currently used to manage for spawning habitat. These results provide an example of the importance of natural flow regimes for benefitting riverine species and are likely applicable globally in streams where spawning habitats vary with streamflow.

A Streamlined Modeling Approach for Quantifying Existing Habitat Conditions and Guiding Restoration

Brian Cluer, Ph.D., *Fluvial Geomorphologist, NOAA Fisheries (Presenter) and Co-authors:*
Charleen Gavette *and* ***Bryan Pestone,*** *NOAA Fisheries*

The modification of stream channels to reduce flooding and increase land use has generally wiped out functional floodplain habitat in the arable parts of the world. This has profoundly affected salmonid populations during their most vulnerable early life stages in two ways. First, their swimming ability is limited when they first emerge from gravel during winter/spring and routine winter storm channel velocities sweep them downstream and out of the watershed. Second, the richest food production, particularly for young fish with small mouths and guts and limited hunting ability, occurs on floodplain and other quiescent off-channel settings. Young juvenile salmon either starve or are swept out of the watershed before they transition to the more robust life stages that can hunt down and eat a wide range of prey items. This set of limiting conditions can be readily modeled with widely available LiDAR topography, gage data, and two-dimensional hydraulic models applying reasonable simplifying assumptions. Once the hydraulic interactions between terrain and a wide range of flows are quantified, simple spreadsheet evaluations of different flows or different terrain conditions can be evaluated in a few minutes.

Results from an example watershed, the Nestucca River, Oregon, modeled with Hec-Ras 2d, offers valuable insights about how incised channels in floodplain settings and flood control projects, dramatically reduce habitat at the early and most crucial salmonid life stages. The modeling of an entire range of flows from winter base flow to the highest recorded flow was accomplished in one day for an 18 km long river, surrounded by 2,600 acres of floodplain. This presentation will show how modeling winter/spring habitat can be simplified and accomplished with widely available information and numerical tools. In addition, the model results give valuable insights into how the landscape interacts with flows, explaining a crucial mechanism that keeps populations depressed, and it can guide effective restoration actions.

Modeling Stream Temperatures with the Inclusion of Irradiance Change due to Forest Biomass Shifts

Jonathan James Halama, Ph.D., *ORISE Fellow with Environmental Protection Agency (EPA) (Presenter) and Co-authors:* ***Robert McKane, Ph.D., Allen Brookes, Ph.D., Bradley Barnhart, Ph.D.,*** *and* ***Paul Pettus, MS,*** *EPA; and* ***Kevin Djang, MS,*** *CSC*

Changes in stream temperature are directly and indirectly due to solar energy loading levels. Solar radiation is a significant environmental driver that impacts the quality and resilience of terrestrial and aquatic habitats, yet its spatio-temporal variations are complicated to model accurately at high resolution over large, complex watersheds. Forest disturbance regimes (e.g., fire, harvest) greatly impact the amount of solar radiation that reaches the earth's surface. Without the explicit representation of changing shade across a dynamically growing and harvested landscape, the quantification of land-use policies cannot be fully assessed prior to policy implementation.

Here we describe the integration of a new solar energy and shade model (Penumbra) with a well-established eco-hydrology model (VELMA) that simulates streamflow and plant-soil dynamics within watersheds. The Penumbra-VELMA integration is designed to simulate how forest cover and disturbance events (harvest, fire, etc.) influence ground-level solar energy over time across large spatial and temporal scales—small plots to watersheds and minutes to centuries. Because Penumbra accounts for shading due to terrain features and vegetative object shadowing, its integration with VELMA enables important questions to be addressed concerning effects of forest management on stream flow and temperature. For example, where and how wide do riparian buffers need to be to provide adequate cold water refuges for salmonid populations during extremely hot and dry conditions? How important is the management of high elevation non-fish bearing streams for maintaining favorable temperature and flow conditions further downstream in fish-bearing streams?

We developed a new stream temperature model that integrates Penumbra and VELMA simulation data to provide a new decision support tool for the assessment of watershed land-management's potential impact on stream temperature due to solar energy shifts caused by biomass change through time. We demonstrate the impact of biomass shifts on the resulting solar energy across the Tectah Creek watershed, a sub-watershed of the Lower Klamath River Sub-basin in northern California, to produce dynamic, spatially-distributed representations of ground-level radiant flux (kilowatts/m^2/month) amidst different disturbance (i.e., harvest) regimes. These regimes included: (1) historic harvest activity replication, (2) suspended forest harvest activity, and (3) forest harvest thinning activity. Results demonstrate that this integrated modeling framework is effective at simulating dynamic high-resolution representations of ground-level energy amidst real and theoretical management scenarios over large and complex watersheds.

Research presented here is aimed to demonstrate the VELMA-Penumbra integration and to reveal the potential use of the coupled models as a decision support tool for communities, tribes, and local, state and federal governments seeking to sustainably manage their respective watersheds.

What's In a Number: Southern Steelhead Population Viability Criteria?

Mark H. Capelli, Ph.D., *Steelhead Recovery Coordinator,*
Southwest Fisheries Science Center, NOAA Fisheries

Recovery plans developed for federally listed species must include "objective, measurable criteria which, when met, would result in a determination… that the species be removed from the list" of endangered or threatened species.

The recovery plans developed by the National Marine Fisheries Service contain prescriptive population criteria intended to meet this requirement. These criteria include both the number and distribution of recovered populations and a mean annual run size. The distribution and number of recovered populations is driven by a fire-frequency analysis intended to preserve the overall biodiversity of the listed species against natural catastrophic landscape change, including wildfire, floods, and stream sediment flux, in Mediterranean-climate landscape dominated by fire-dependent chaparral vegetation. The prescriptive criterion for mean annual run size is driven by the degree of uncertainty about the size of an independently viable population, using Lingley's "random-walk-with-drift" model. That model employed quantitative field data for one anadromous *Oncorhynchus mykiss* population and 19 *O. tshawytscha* populations in California's Central Valley. The central assumption in the modeling exercise is that the distribution and variability of population growth rates are similar between that study and the listed south-central and southern populations.

The resulting criteria provide a 95% chance of persistence of an individual population over a 100-year period and a 95% chance of persistence of the listed species as a whole. The measurable criteria may be higher than needed, especially in small watersheds such as those in the Big Sur and Santa Monica Mountains, which may exhibit characteristics such as more stable over summering conditions, reliable access to spawning and rearing habitats, meta-population dynamics (including interbreeding between anadromous and non-anadromous forms of *O. mykiss*), life-history diversity, or other factors which may play an important role in dampening the fluctuation of population size of individual populations. The criteria are intentionally precautionary because of the threatened and endangered status of the listed southern populations of steelhead. Quantitative data on these factors may identify a different set of measurable population criteria. A monitoring and research program will be essential to refine these criteria.

However, the relatively small existing population size of most southern steelhead populations will necessitate an increase in their current abundance in order to increase the likelihood of their persistence in the near term as well as provide an adequate number of individuals upon which monitoring and research can be conducted to produce statistically meaningful information on population fluctuations and diversity, and therefore viability.

Flow, Form, and Function: Integrated Hydro-geomorphic Modeling Reveals Opportunities and Trade-offs for River Restoration

Belize Lane, Ph.D., *Utah State University (Presenter) and Co-authors:* ***Samuel Sandoval, Ph.D.*** *and* ***Gregory Pasternack, Ph.D.***, *University of California, Davis*

The extent and timing of many river ecosystem functions is controlled by the interplay of streamflow dynamics with the river corridor shape and structure. However, most river management studies evaluate the role of either flow or form without regard to their dynamic interactions. We present an integrated hydro-geomorphic modeling approach to assess the ecological performance (function) resulting from different hydro- (flow) morphological (form) river configurations. The use of synthetic, archetypal channel forms in lieu of high-resolution topographic data reduces time and financial requirements, overcomes site-specific topographic features, and allows for evaluation of any morphological structure of interest. In an application to California's Yuba River, the interacting roles of channel form, water year type, and hydrologic impairment were evaluated across several ecosystem functions related to physical processes, aquatic habitat, and riparian habitat. Channel form acted as the dominant control on key physical processes, while water year type was found to control salmonid habitat functions. Streamflow alteration for hydropower significantly increased redd dewatering risk and altered salmonid habitat suitability and riparian recruitment potential. This study highlights critical tradeoffs in ecosystem function performance and emphasizes the significance of spatio-temporal diversity of flow and form at multiple scales for maintaining river ecosystem integrity. This integrated eco-hydraulic modeling approach is also broadly applicable to other systems and ecosystem functions, where findings can be used to inform river management and design testing with minimal resources and data requirements.

Streamlined Permitting for Restoration Projects —Existing Programs and Potential Reforms

Saturday Morning Concurrent Session

Session Coordinator*: Matt Clifford, JD,* *Trout Unlimited, California Water Project*

Although publicly-funded restoration projects are intended to have net benefits for sensitive species and habitat, their implementation is subject to state, federal, and local permitting laws to ensure that development will not adversely affect these values. Compliance with these laws can consume a significant share of project budgets and can be a source of delay and uncertainty in project schedules. This can create challenges for implementing restoration measures on a scale and timeline necessary for species recovery. To date, attempts to ease compliance burdens by creating "streamlined" permitting pathways for restoration projects have met with mixed results. This panel will: (1) examine the most common ways in which restoration projects intersect with laws governing issues such as water quality, endangered species, water rights, streambed alteration, and local building and planning; (2) describe several "streamlined" permitting pathways under existing laws and policies; and (3) discuss how laws and policies might be amended to reduce the time and expense of permitting restoration projects while minimizing their environmental impacts.

Trinity River Restoration—Does Streamlining the Regulatory Process Allow for More Effective Restoration?

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

In 2000 the Trinity River Record of Decision (ROD) prescribed a suite of activities to restore functioning river conditions and anadromous fish populations. These activities included: variable annual flows, gravel augmentation, and mechanical channel rehabilitation. To implement the ROD, Trinity River Restoration Program (TRRP) staff and partners completed programmatic National Environmental Policy Act and California Environmental Quality Act documents to cover planned activities and acquired long-term permits for work. While flow releases and gravel augmentation generally proceed under programmatic authorizations, specific channel rehabilitation project environmental impact analyses and authorizations are required each year before implementation.

In order to predict and evaluate conditions that result from TRRP management activities, the Program developed a variety of biological and physical models. The TRRP's Trinity River digital terrain model (DTM), which allows design condition modeling at restoration sites, was shared with collaborating agencies and ultimately to update the Trinity River Federal Emergency Management Agency (FEMA) flood insurance rate maps (FIRMs). Prior to the FIRMs update, the TRRP was required to meet relatively minor flood management guidelines. With newly effective FIRMs, regulation increased. Now, in addition to explicit landowner approval, project construction plans must also receive FEMA and County authorization prior to project implementation. This permitting allows only those floodplain changes that maintain current floodway and 100-year flood elevations. While project designs are based on expected conditions, construction requires real-time adjustment to match site conditions and ensure self-maintenance. For example, a design may call for a low-flow side channel while field conditions allow only a seasonal high-flow river connection. Full disclosure and strict adherence to permitted plans may result in sub-optimal project creation while also reducing project maintenance and adaptive management opportunities.

TRRP projects must support long-term fish and wildlife needs while also fulfilling landowner obligations, permit requirements, and environmental mitigation commitments. In the end, implementation funding is reduced in proportion to these obligations. To achieve long-term success, management must remain adaptable and support projects that have been refined based on public perception, expected outcomes, and measurement of prior cumulative impacts. Lessons learned from prior implementation must be used to avoid future problems and to increase river and floodplain interaction, habitat, and self-maintenance but permitting is ultimately completed by committed agency staff.

Dam Insights: Removal of Small Dams Via Programmatic Permitting

Stacie Fejtek Smith, D.Env., *Earth Resources Technology/NOAA Restoration Center (Presenter) and* ***Jonathan Christopher Trilli,*** *Pacific States Marine Fisheries Commission*

Programmatic permitting for fish passage barrier removal is relatively similar throughout California with the exception of small dam removal. Programmatic criteria for small dam removal drastically varies for southern California projects. Southern California currently represents a gap in dam removal knowledge within the scientific literature, therefore complicating programmatic review. With this recognition, the NOAA Restoration Center, NOAA/California Conservation Corps Veteran Fisheries Program, California Department of Fish and Wildlife, U.S. Forest Service and Pacific States Marine Fisheries Commission are collaborating to fill this gap in knowledge to support endangered southern steelhead recovery. The California Fish Passage Forum and NOAA National Fish Habitat Partnership provided funding to continue small dam removal monitoring on six dams in Ventura, Los Angeles, and Orange Counties that started in 2014 and includes capturing pre-dam removal data for three additional dams targeted for removal in 2018. This study aims to understand how sediment released by small dam removal influences streambed morphology under differing regulatory constraints throughout southern California, employing cost-effective long-standing methodologies in order to: 1) understand the hydrologic context southern California streams face under extended drought conditions; 2) examine elevation change in streambeds after dam removal to understand its influence in changing habitat features; and 3) evaluate stream substrate quality in response to small dam removal. Even under extended drought conditions, small dam removal efforts guided by biological opinions had clear benefits to fish passage and habitat quality. Scenarios with sequential dam removal and those operating with limited permit constraints were able to alleviate fish passage constraints but have more complex impact on habitat quality. This study highlights the importance of regional sediment flux and the value of programmatic environmental review when undertaking dam removal with the goal of aiding steelhead recovery.

Water Rights Permitting for Streamflow Enhancement Projects in Coastal California—Existing Tools and the Need to Bring Them to Scale

Matt Clifford, JD, Trout Unlimited

Dewatering problems in coastal California streams tend to be caused by numerous, widely scattered small diversions. The effect of individual diversions is typically small, but their cumulative effect can be quite severe. Conversely, producing meaningful increases in streamflow requires implementing projects at numerous diversions. An issue for such efforts is most of the common methods for reducing the impacts of small diversions—including storage and forbearance, moving points of diversion, and building shared water systems—require new water rights or changes to existing ones. Despite recent reforms, the administrative processes for securing these approvals often take several years and cost many of thousands of dollars. Although these processes are hardly the only barrier to the progress of streamflow restoration work, additional reforms will be necessary to enable agencies to approve a sufficient number of projects on a time scale necessary for the recovery of dwindling salmon and steelhead populations in coastal California. Trout Unlimited is currently working with NGOs and agency staff on a number of potential reforms including better desktop tools for determining water availability and fisheries needs, more extensive planning of desired streamflow conditions at the watershed scale, increased use of agency discretion to identify and approve "good" projects under existing policies, improved coordination between public grant programs and permitting processes, and better definition of regulatory baselines as an incentive to voluntary projects.

Removing Barriers to Restoration. Are We Done Yet?

Jonathan Warmerdam, *Senior Environmental Scientist,*
North Coast Regional Water Quality Control Board

In 2002, California's former Secretary of Resources, Mary Nichols, convened a multi-stakeholder group known as the State Task Force on Removing Barriers to Restoration. The Task Force, composed of a multi-stakeholder group, examined impediments to environmental restoration for landowners and others and developed ten recommendations for removing them. The collaboration produced a report titled Removing Barriers to Restoration, Report of the Task Force to the Secretary of Resources which highlighted categories of obstacles that are consistently cited as impediments to voluntary restoration.

Fifteen years later, regulatory agencies, environmental non-profits, resource conservation districts, and other stakeholders have continued to support improvements and reform California's restoration arena. New permitting programs have formed in an attempt to "streamline" the process and remove the disincentives to stakeholders seeking to conduct beneficial projects. Workgroups have developed to consolidate permit applications, coordinate permitting programs, and develop financial incentives. Yet additional improvements to support restoration projects are still warranted.

This presentation will discuss: (1) the status of several of the recommendations identified by the Task Force, (2) identify ongoing efforts or accomplishments to overcome barriers, (3) highlight some accomplishments within the North Coast Region, (4) discuss persistent challenges to restoration, and (5) provide possible solutions to promote and scale-up restoration actions.

Saving Taxpayer Dollars While Protecting Natural Resources: An Overview of the NOAA Restoration Center's Programmatic Biological Opinions and Coastal Commission Consistency Determinations in CA

***Bob Pagliuco**, Marine Habitat Restoration Specialist, NOAA Fisheries*

State and Federal environmental protection laws have been responsible for several significant victories through the years including rebuilding populations of threatened and endangered species and providing people with clean air and drinking water. These laws were implemented to stop the spread of pollution, reduce habitat destruction for vulnerable species, and protect the public trust resources that every American should be able to enjoy.

Since the 1980's, there has been an enormous effort to restore habitat for fish and wildlife in California. Although these efforts are intended to restore habitat for threatened and endangered species, each project must abide by state and federal environmental laws to ensure that these projects do not create additional harm to the species that they are trying to restore. Because the negative effects of habitat restoration project implementation are often short term and often self-mitigating, a programmatic approach to permitting these efforts has been implemented in California.

The NOAA Restoration Center (RC) has been working with several agencies and partners to develop a statewide programmatic permitting program for habitat restoration projects that benefit NOAA trust resources. Since 2006, the NOAA RC and Sustainable Conservation have developed four Programmatic Biological Opinions throughout coastal California, and is currently working on developing one for the California Central Valley, that have saved taxpayers millions of dollars while still providing protection for threatened and endangered species. In addition, the NOAA RC and Sustainable Conservation have developed two California Coastal Commission Consistency Determination Programmatic Permits that cover the NOAA RC's California habitat restoration efforts in Coastal California.

Improving Restoration Permitting: A New Multi-agency Initiative to Advance Projects Statewide

Erik Schmidt, *Senior Conservation Strategist, Sustainable Conservation*

Sustainable Conservation is working with four state and federal regulatory agencies to develop programmatic permit approvals to expedite habitat restoration and water quality improvement projects in California. Statewide authorizations will be completed in partnership with the Army Corps of Engineers, U.S. Fish and Wildlife Service, NOAA Fisheries, and State Water Resources Control Board, to cover a set of common restoration projects in aquatic and riparian habitat, including multi-benefit projects that prioritize restoration.

Adapting Aging Infrastructure to Sustain Listed Salmonids

Saturday Afternoon Concurrent Session

Session Coordinator*: Eric Ginney,* *Central Valley / Sierra / Cascade Director, ESA*

With many Federal Energy Regulatory Commission (FERC) hydroelectric projects in California reaching middle (old?) age and with energy grid and market incentives evolving with the increase in renewable energy sources, the financial solvency of certain hydroelectric power generation systems is not what it was even just five years ago. Older, more-antiquated systems that don't incorporate pumped storage, peaking, or other options to make them more flexible and lucrative are being found to be unviable. These new realities, coupled with increasing regulatory recognition that fish need water and upstream passage, mean that the factors and incentives that drive decisions on projects—including whether they are even viable—are very different today. The Potter Valley Project on the Eel River and the DeSabla-Centerville Project on Butte Creek are two examples of projects where a deeper look at costs and benefits is suggesting that the value of the water molecules (for agricultural and instream uses) may be more than that of the electrons that those molecules can generate. This session will describe the reasons for the changes in the energy market (renewables, grid, regulatory) that are driving the changes in value of these projects, present examples of hydroelectric projects that may be opportunities to demonstrate new and progressive approaches to holistic water management by re-envisioning these systems as providing multiple benefits for fish and people, and describe ways to systematically identify these opportunities across California and even more broadly across the country.

Changing Energy Markets, Changing Needs: Rethinking Hydropower Dams and Infrastructure

Dave Steindorf, Special Projects Director, American Whitewater

California's energy supply traditionally consisted of three basic categories. Base load kept some power available at all times (nuclear power provided a substantial portion). Peak power met needs during the periods of greatest demand (the heat of the day, evenings when people came home and turned on air conditioning or heaters). Flexible power filled in the gaps as demand went up and down. Traditionally, hydropower provided parts of all three functions. As California transitions to an energy portfolio that has a larger percentage of renewable resources, especially large solar energy installations, the daily needs for base load and peaking power are reduced, while the need for more flexible generation and ramping generation is increasing, particularly when the sun goes down. This creates winners and losers among hydropower projects. The winners are those that can provide the "ancillary services" of turning on or off instantaneously and ramping up or down quickly. The projects that can turn on during high load ("peak") periods are useful, though less valuable than before. The projects that always run at the same rate, 24-7, are increasingly the losers. This creates opportunities for more environmentally protective operation of projects with flexible capacity: in some cases, flexible projects can make more money and still keep more water in rivers. It also creates opportunities to re-plumb projects that are no longer economically viable for power: to focus on water supply or to decommission them altogether. For fisheries and other hydropower advocates, new partnerships may be available with power companies who may keep otherwise obsolete projects on line because it is cheaper than taking them out. If NGOs can use their relationships and local expertise to help dismantle projects in relatively inexpensive but environmentally responsible ways, they will have opportunities to remove obsolete dams while reducing the fiscal impact to electric ratepayers. This presentation will discuss changing energy markets, opportunities for new relationships with power companies, and new opportunities to either upgrade aging infrastructure or remove it altogether.

New Ownership of the DeSabla Hydropower Project: Stakeholders Creating Regulatory Process from Scratch

Chris Shutes, *FERC Projects Director and Water Rights Advocate, California Sportfishing Protection Alliance (Presenter) and* ***Allen Harthorn,*** *Executive Director, Friends of Butte Creek*

In February, 2017, Pacific Gas & Electric Company withdrew its application pending before the Federal Energy Regulatory Commission to relicense the DeSabla—Centerville Project (FERC #803) near Chico, California. The Project's canal system brings water from the West Branch Feather River to Butte Creek. The combined flow in Butte Creek supports the only currently viable run of Central Valley spring-run Chinook salmon. Many stakeholders have diverse vested interests in the Project and hope to see a new operator continue the inter-basin conveyance of water to Butte Creek. While FERC relicensing has clear procedural requirements, timelines, and milestones, there is no set process for decommissioning a project or transferring its ownership. In order to develop a local solution that retains Project benefits and makes the Project economically viable, a group of people from resource agencies, environmental and fishing groups, local residents, water purveyors, and hydropower developers began a stakeholder group to enable an outcome that meets diverse but common interests. This presentation will chronicle the efforts of these stakeholders to engage each other, FERC, Pacific Gas & Electric, and other affected parties, and their efforts to structure discussions and interactions that advance various stakeholder goals, including the protection of salmon in Butte Creek.

Butte Creek DeSabla-Centerville Hydroelectric Project: Decommission or Retool? Salmon Want to Know!

Allen Harthorn, *Executive Director, Friends of Butte Creek*

The DeSabla-Centerville Hydroelectric Project, (FERC #803) owned by PG&E for over a hundred years, is now for sale. In a rapidly changing energy market and with environmental protections for listed salmonid species, marginal small hydropower projects are increasingly being scrutinized for their long term viability. Continuing to operate systems that were built in the last century with open-leaky canals, dams with no fish passage facilities, diversions that entrain salmonids, and reservoirs that heat the water is more and more questionable. Energy prices are down and Operations and Maintenance costs are up. It is time to look at these projects more closely to find ways to guarantee the optimal solutions to restoring and protecting salmonids, especially with 30 to 50 year FERC licenses on the line.

DeSabla-Centerville, located on Butte Creek in the northern Sacramento Valley has a complex system of dams, canals, reservoirs, and power generation facilities. One element of that system is the importation of water from a diversion on the West Branch Feather River through a canal built for gold mining in the 1800's. PG&E and its predecessor have operated the canal for more than a hundred years. In addition, there are two diversions on Butte Creek that started out as wooden diversions that frequently failed and are now impassable concrete barriers. These diversion have never been screened and thousands of fish have been entrained and often abandoned when canals were drained. Nearly 20 miles of upper Butte Creek was almost completely dewatered by these diversions. One important reach of the creek, the Centerville bypass, which is now the main holding area for spring run Chinook salmon, had a minimum instream flow of 10 cubic feet per second (cfs) while PG&E was allowed to divert up to 180 cfs. In the 1980 FERC relicensing of the project state and federal agencies fought hard to double the minimum flow despite the repeated argument from PG&E that they were not responsible for the decline of the salmon. The agencies prevailed and 20 cfs ran through the 1991. In a rare license opener, when PG&E proposed to rebuild the Centerville powerhouse, the agencies again stepped in and demanded doubling the flow again. PG&E ultimately dropped their plans and after 3 years of 40 cfs and repair to the few agricultural diversions in the valley, Butte Creek salmon populations rebounded in extraordinary fashion and filled the partially restored habitat with thousands of spring run Chinook.

Fast forward to the relicensing effort in 2004-2009, NGO's argued, at times against state and federal agencies, for further flow increases. After a grueling battle, the State Water Resources Control Board agreed with the NGOs in their 401 Water Quality Certification. So far nothing has happened except that the Centerville Powerhouse has failed and has been out of commission for seven years. This presentation will explore the options for fully restoring Butte Creek and improving miles of valuable habitat.

The Potter Valley Project: Fish Passage and Flow Opportunities

Patrick Samuel, *Bay Area Program Manager (Presenter), and* ***Redgie Collins,*** *CalTrout*

The Potter Valley Hydroelectric Project is owned by PG&E and consists of the only two main stem dams on the Eel River—Van Arsdale Dam and Scott Dam. The Project diverts flows to the Russian River for hydropower production after which the water is 'abandoned' and used for many purposes including municipal water supply, agricultural production, and fisheries enhancement. Scott Dam blocks fish passage to approximately 288 square miles of habitat in the upper Eel River. This habitat is high elevation (some above 5,000), increasingly important habitat for salmon and steelhead as California's climate changes. PG&E has recently initiated the process with the Federal Energy Regulatory Commission to renew their license to operate the project. We will discuss the opportunities that this process presents to improve conditions for fish in the Eel River and the complex costs and benefits associated with this project.

New Federal Interagency Guidance on Managing Infrastructure in the Riverine Environment

Caroline Ubing, ***U.S. Bureau of Reclamation***

In November 2017, the Advisory Committee on Water Information's (ACWI) sub-committee on Sedimentation (SOS) produced a new federal guidance document. ACWI is a federal interagency group whose purpose is to improve water information for decision-making about natural resources management and environmental protection [*https://acwi.gov/aboutus.html*]. The Subcommittee on Sedimentation promotes interagency collaboration on sediment issues and advances in information gathering, storing, and sharing for decision making about natural resources management and environmental protection. NOAA, Department of the Interior (U.S. Geological Survey, Bureau of Reclamation, National Park Service), U.S. Department of Agriculture (Forest Service, Natural Resources Conservation Service, Agricultural Resource Service), Federal Energy Regulatory Commission, Federal Housing Administration, U.S. Corps of Engineers, Federal Emergency Management Agency, and other agencies participate in the ACWI and SOS.

Riverine infrastructure provides essential services necessary for the operation and development of our nation and its economy. When much of this infrastructure was built, stream processes and ecology were not well understood. In many cases, existing riverine infrastructure is in conflict with the stream environment or at risk from it. Incompatible riverine infrastructure has led to the degradation of stream ecosystems by contributing to habitat loss, water quality deterioration, and physically unstable streams. High maintenance costs are often required to keep such infrastructure viable. This guidance document lays the foundation for infrastructure designers and managers to understand how to build, maintain, or decommission infrastructure in a manner that is both resilient to riverine hazards (i.e., floods and channel migration) and aligned with local stream ecosystem objectives. This document introduces fundamental geomorphic and ecosystem concepts and provides recommended steps for replacing, repairing, or building new infrastructure within stream corridors ranging from roadways and bridges to pipelines and water diversions. It also discusses infrastructure design and management under hydrologic and climatic uncertainty as well as post-flood response.

This presentation will review the new guidance document and its associated resources.

Fins, Feathers, and Fish Food on Floodplain Farm Fields

Jacob Katz, Ph.D., CalTrout

In the Central Valley, over two thousand miles of state and federal levees, along with local flood protection projects, have cut off approximately 95% of historical floodplain wetlands from their river channels. Floodplains are the "solar panels" that power aquatic food webs and create abundant populations of fish and wildlife in large-river valleys. An explosion of life in winter-flooded floodplain wetlands generates huge biomass of bugs and zooplankton—the foundation of the aquatic food web. Floodplains make bugs and bugs make fat fish. Robust, healthy out-migrants return as adults at higher rates. Food energy input is the foundation of abundance. Without hydrologically reconnecting floodplain food factories to river channels, recovery of historical numbers of fish and wildlife will be impossible. Science has shown that it's possible to mimic natural floodplain productivity by inundating floodplain farm fields in winter when they are not in use by farmers. This project will pioneer on-farm water management practices in order to re-integrate the flow of floodplain food resources and nutrients back to the river and the Sacramento–San Joaquin Delta. Reconnecting floodplain food factories to the river and Delta will help recover historical fish and wildlife populations of California's Central Valley.

This presentation will report results from the 2017 pilot year, when the project surveyed existing wetland habitats types over a broad swath of the Sacramento Valley, both inside and outside of the levees. By comparing and contrasting hydrologic conditions and aquatic food web dynamics across the spectrum of existing wetland habitat types (i.e., river channel, managed wetlands, farm fields and bypasses), the project improves understanding of aquatic food web productivity in the Sacramento Valley and assess the potential for these diverse aquatic habitats, including the hundreds of thousands of acres of floodplain farmland and managed wetlands, to contribute food resources to the main-stem river ecosystem, bolster in-river food webs, and help support recovery of endangered fish populations.

Alluvial Fans and Salmonid Habitat: The Forgotten and Challenging Landscape In-Between

Saturday Afternoon Concurrent Session

Session Coordinators*: Michael Love, PE, Michael Love & Associates and Jay Stallman, PG, Stillwater Sciences*

Although fisheries habitat on alluvial fans may not provide the highest quality, the processes occurring on them is commonly essential to maintaining high quality habitats at their proximal and distal margins. When functioning, they can store and meter sediment loads, recharge groundwater, produce cold water springs and seeps at their bases, and support rich and vibrant wetland ecosystems at their distal ends. When these systems are perturbed, the geomorphic responses are often extreme, sometimes resulting in deeply incised channels, or alternatively, aggrading channels and splays of sediment deposited across working landscapes.

Alluvial fans are often critical zones for salmon and steelhead migration to holding, spawning, and rearing habitats located in upstream reaches. The dynamic network of channels and often complex surface and groundwater interactions creates unique challenges to fish passage, especially where water diversions may limit flow availability and alter sediment transport. This session will focus on the hydraulic and geomorphic processes occurring within alluvial fans relative to fisheries habitat and fisheries access to upstream habitat, the causes and responses of dysfunctional alluvial fan systems, and the importance of restoring these processes to create desirable habitats for salmonid recovery.

The Benefits of Restoring Alluvial Fan Processes After a Century of Neglect

Michael Love, PE, *Michael Love & Associates*

Alluvial fans generally form the transition between steeper, confined portions of a stream or river and lower gradient, less confined reaches. Found where steeper streams flow abruptly out of the hills and onto broad valleys or coastal plains, fans are depositional features that build a conical shaped surface through sediment deposition and storage. They form through both channel avulsions near their apex and sheet flow across the surfaces.

Often forming unconfined high ground relative to the floodplains or flood-basins at their distal end, fans were frequently seen as suitable locations for agriculture and establishment of towns and villages. Taming of the streams and rivers flowing on these fans typically involved channelization, causing the channel to incise in the upper reaches of the fan and requiring ongoing dredging in the lower reaches. This resulted in rapid routing of flow and sediments further downstream, overwhelming the receiving bodies. With the ESA listing of salmonids, these maintenance activities have slowed or stopped in many cases, allowing the streams and rivers on fans to revert back towards their depositional state. This has increased overbank flooding on fans, challenging both property owners and fisheries managers.

We are at a point in time that restoration of alluvial fans is necessary from a socio-economic perspective and critical in the recovery of salmonid populations. These fluvial landforms and the beneficial processes they support have long been neglected in the restoration community, and often viewed as simply "migration corridors" leading to upstream habitat. However, when properly functioning, the processes occurring on fans can create and support highly productive wetlands and off-channel habitats below. The active fan allows water to slow and infiltrate, emerging as cold-water springs across their distal end. These processes attenuate flashy runoff from upstream, raising groundwater tables and extending downstream base flows. Also, the process of avulsions and shallow flows across the fan deposits both coarse and fine sediments, thus protecting downstream low-gradient waterways from excessive sediment loads.

Even though natural fan processes can create limited fish passage opportunities due to shallow multi-channel flows, the resulting habitat downstream of restored fans may produce much higher value. This presentation will outline natural fan processes and repercussions of existing dysfunctional alluvial fans and suggest opportunities for process-based restoration of fans to improve habitat while working within the socio-economic boundaries of today's landscapes.

Alluvial Fan Construction in the Pacific Northwest

Paul Powers, *Fisheries Biologist, U.S. Forest Service, Deschutes National Forest*

Within the Pacific Northwest Region of the Forest Service, adoption of the Stage 0 (Cluer and Thorne, 2013), or a process-based restoration approach, began on the arid, east side of the Cascade Mountain Range. The earliest projects of this type were designed and implemented in second order streams flowing through degraded meadow systems. As a result of anthropogenic disturbance coupled with the loss of beaver, these project areas had experienced head cutting and channel incision followed by a lowering of the alluvial aquifer and a transition from wetland to arid terrace. In these areas, the restoration design deviated from the historic approach of headcut stabilization and instead sought to recover the entire wetland complex by working at the valley scale. This resulted in the development of broad wetland complexes with no constructed stream channels.

The rapid succession of wetland features and attributes observed in these early projects prompted restoration specialists to expand this approach to larger, bedload dominated systems on a variety of landscapes ranging from lacustrine valleys in the Oregon Coast Range to moderate gradient valleys in the West Cascades (1-2%) and Klamath Basin (6%). The same general approach was followed on all of these landscapes, which included the development and construction of a depositional valley as opposed to the design and construction of a "balanced" channel. These project types restore fluvial processes and in turn restore ecological benefits that have been largely lost in many river systems (Bellmore et al. 2013, 2015, 2017).

In this presentation I will show project examples that restore alluvial fan/ anastomosing morphology at the valley scale on U.S. Forest Service-managed lands across the state of Oregon. I will also discuss monitoring of these systems and the need to change the language and parameters used to evaluate their effectiveness. Classic monitoring parameters have been developed around channel and planform stability, as opposed to our Stage 0 projects where dynamism and complexity are the goal. In addition, this new approach seeks to restore the fluvial processes associated with depositional valley types (Roni and Beechie, 2013) and thereby restore food web mosaics and complex ecology rather than focus on a target species. Projects of this type have become the norm for depositional valley types on Forest Service managed and partner projects within the Pacific Northwest.

Managing Fish Passage Across the Antelope Creek Alluvial Fan

Jay Stallman, PG, Stillwater Sciences

Efforts to restore spring-run Chinook salmon and steelhead populations in Antelope Creek, which joins the Sacramento River near Red Bluff, California, hinge on improving conditions within a network of distributary channels developed across coalescing alluvial fans formed where Antelope Creek and Little Antelope Creek debouch from the Cascade Range into the Sacramento Valley. The distal margins of these fans are modified by erosion and deposition within the Sacramento River meander belt, creating a distinct longitudinal progression in channel morphology across the fan. Operation of Edwards Diversion Dam, located near the Antelope Creek fan head, contributes to low streamflow and elevated stream temperatures during spring-run Chinook salmon and steelhead migration periods. Through grants from the National Fish Passage Program and Anadromous Fish Restoration Program in 2009, we established flow and water temperature monitoring stations and investigated factors influencing fish passage within the lower Antelope Creek channel network. The State Water Board provided grant funds in 2015 to continue flow and temperature monitoring, determine fish passage flow needs in the primary migration corridor, and design and implement projects to meet fish passage needs. Components of the integrated passage assessment include defining relationships between streamflow and hydraulic conditions at critical passage locations, describing flow and temperature conditions under which fish are observed passing Edwards Diversion Dam, and developing recommendations for minimum streamflows that provide fish passage. In addition to providing adequate high-quality instream flow during critical migration periods, an effective solution for improving fish passage in Antelope Creek and its distributaries downstream of the diversion dam will likely require establishing a channel configuration at distributary junctions that can reliably route baseflow to target reaches. Dynamic channel morphology associated with sediment routing at distributary junctions complicates flow routing and creates unique challenges in managing instream flow.

Debris Basins in Southern Santa Barbara County; Their History and Exciting Future

***Seth Shank** and **Andrew Raaf** (Co-presenters), and **Maureen Spencer,** Santa Barbara County Flood Control and Water Conservation District*

The Santa Barbara County Flood Control District (District) maintains seventeen debris basins along the south coast of Santa Barbara County. Most of these basins were constructed by the Army Corps of Engineers after major wildfires in 1972 and 1964 in order to catch large volumes of rock and debris anticipated after the fires. The newest basins were built in 1991 (after the Painted Cave Fire) and in 2002 after major flooding from large storms in 1995 and 1998. Since their construction, the District has maintained the basins.

The current maintenance program encourages sediment transport and allows riparian vegetation to persist within the basins, however the basins continue to trap sediment that would otherwise flow to downstream stream reaches. The basins are periodically desilted and sediment that would otherwise remain in the system is removed and taken to upland disposal sites. In 2008, the District modified Gobernador Debris Basin and between 2011 and 2013, Lillingston Debris Basin was removed in three phases. The presentation will include brief descriptions, updates, and observations from these two projects. The Lillingston Basin project was also presented at the 2014 SRF Conference.

The District currently has five additional debris basins scheduled for removal, with four of those removals occurring between 2018 and 2019. Using the Stream Simulation Method as the basis of our design, the dam embankments will be removed and the streams through the basins restored. In addition to removing, in most cases, the most upstream man-made barrier to steelhead, removal of the basins will restore important sediment delivery to the streams that has been interrupted for up to 50 years in some cases, and will reduce erosion occurring downstream of the basins. The presentation will provide an overview of our upcoming basin removals, focusing on the two that will occur in 2018, our design, and what we anticipate will occur within these drainage systems once the restoration is complete.

Expect the Unexpected—Monitoring Geomorphic Changes and Evaluating Overall Effectiveness in Meeting Project Goals and Objectives in Highly Dynamic Alluvial Fan Environments—The Hansen Creek Story

Ian Mostrenko, PE, *(Presenter) and* ***Christina Avolio, PE,*** *Herrera Environmental Consultants*

The Upper Skagit Indian Tribe partnered with Skagit County and Northern State Hospital to restore a one-mile reach of Hansen Creek (tributary to the Skagit River) and over 140 acres of alluvial fan floodplain and adjacent wetlands. The project site is located near Sedro-Woolley, Washington at the transition between Hansen Creek's steep headwaters and the edge of the Skagit River floodplain. Historical alterations simplified the physical habitat and restricted salmonid use to the mainstem channel. Responding to significant declines of Skagit River Chinook and coho salmon returns, the goals of the Hansen Creek project included: 1) rehabilitating alluvial fan function and sediment transport and deposition characteristics; 2) improving salmonid habitat; and 3) restoring hydrologic connectivity between Hansen Creek, its floodplain, and the adjacent wetlands.

Project construction began in 2009 and was completed in 2010. The foundation for the project design involved taking a holistic approach to rehabilitate natural geomorphic processes and restore floodplain connectivity. Of primary importance was to do this without a "heavy-hand" engineering footprint. Design features included passively activated distributary channel avulsion points and limited floodplain grading. The generalized grading plan provided for spatially varying floodplain inundation levels to support the proposed revegetation mosaic, provided micro-topographic complexity, maximized potential shallow water edge habitat for salmonids, and focused the flood flows in certain "paths" with strategically placed large wood structures.

The project area has already experienced several sediment rich flood events. Rapid sediment deposition, avulsion, channel evolution and meandering channel formation around the engineered log structures were observed in the first year due to a very large event that occurred within months of construction. Early distributary channel evolution and edge habitat creation in the alluvial fan and wetlands were strongly influenced by these geomorphic changes as well as by densely placed LWD structures and lack of riparian vegetation since the newly planted floodplain had not yet become established. In subsequent years with less than average sediment loading, channel evolution has been influenced more by local hydrologic patterns and quickly establishing vegetation. Channel monitoring downstream of the project area has demonstrated minimal bedload deposition, indicating the fan is successfully sequestering the majority of bedload inputs, and eliminating the need for downstream dredging.

Was the approach of rehabilitating processes and using a lighter engineering hand successful? Should the project have been phased differently? Were the project objectives met? What metrics or measurements should be used to monitor "success" from a geomorphic perspective when the outcome is based on random hydrologic events and complex processes? Is more detailed topographic analysis required in alluvial fan settings with sporadic and non-uniform sediment deposition? Was the planting plan successful given the highly dynamic nature of the alluvial fan and wetland? This presentation will discuss these questions relative to the design objectives, design features, and hydrologic inputs, and will discuss project performance relative to sediment storage, creation of distributary channels and physical habitat, and some observed biological responses to help guide future projects with similar challenges.

Salmonid Habitat Use of the Goodell Alluvial Fan: Would Removal of Anthropogenic Features Increase Fish Numbers?

Rick Hartson, *Upper Skagit Indian Tribe (Presenter) and Co-authors:* ***Christina Avolio, PE*** *and* ***José Carrasquero,*** *Herrera Environmental Consultants*

Goodell Creek flows into the Skagit River near Newhalem, Washington. Its dynamic alluvial fan has been severely impacted by infrastructure during the last century. Facilities such as earthen levees, the North Cascades Highway, and campgrounds have fragmented floodplain habitats and restricted Goodell Creek from accessing its historic alluvial fan, side channels, and portions of the floodplain. Recent fish and habitat surveys provide a snapshot of how fish (Chinook and coho salmon and steelhead) are currently using this alluvial fan system in which the hydraulic and geomorphic process have been anthropogenically altered. This existing habitat and fish-use information was compiled, and along with a literature review and synthesis of regional datasets, was used to develop reference equations for estimating habitat capacity and fish abundance. This presentation will take three primary focus areas, including: 1) a description of the hydrologic, hydraulic, and geomorphic approach used to assess and establish a baseline habitat condition; 2) the evaluation of how fish are using the resulting, existing habitat; and 3) the evaluation of how the first two focus areas can together be used to predict what habitat condition and corresponding fish habitat use may be like if the anthropogenic features limiting natural fan process are removed. We will discuss the results from these three areas of focus within the context of varying climate change resiliency of alluvial fans in natural versus human-modified settings, recognizing that alluvial fans are naturally highly dynamic systems. At the same time, we recognize that the natural regime of disturbance in alluvial fans may determine, limit, or constrain the temporal and spatial scales of fish habitat use.

Biological Responses: Fish Seek River with Ample Flow and Bugs, Not Too Hot!

Saturday Afternoon Concurrent Session

Session Coordinator*: Eli Asarian,* *Riverbend Sciences*

Streamflow and water temperature strongly influence organisms in rivers and streams. Flow regulates disturbance, water velocity, rates of downstream transport, and is an important driver of water temperature. Water temperature controls rates of chemical and biological reactions that have cascading effects throughout the ecosystem, including influences on behavior, species composition, and inter-species interactions. Flow and temperature affect every level of the aquatic food web including primary producers (e.g., algae and aquatic plants), primary consumers (e.g., macroinvertebrate grazers), and predators (e.g., other macroinvertebrates and vertebrates, including fish). Every fish species has its own range of thermal tolerance, but these tolerances can also be affected by other local variables such as prey availability and water velocity. Greater access to food can enable cold water fish to tolerate warmer water, up to a point. Coldwater fish living in environments near the upper edge of their temperature tolerances often seek refuge in areas such as tributary confluences which offer cool water but are close enough to productive mainstem habitats to allow foraging when conditions are suitable. This session will feature a diverse collection of presentations on how flow and temperature influence river food webs as well as fish distribution, behavior, and bioenergetics. Presentations focus on rivers and streams in the Klamath Basin and Eel River Basin.

An Observational, Comparative, Field-based Study of Thermal Tolerance in Juvenile Salmonids as a Function of Food Availability: Implications for Recovery and Restoration

Joshua Strange, Ph.D., Sweet River Sciences

Water temperature is a major ecological factor for aquatic species and strongly influences habitat suitability for salmonids, especially for juveniles of species that over-summer in freshwater, such as spring-run Chinook salmon, coho, and steelhead. Summer water temperatures are also an important consideration when planning and prioritizing restoration sites and recovery actions. Given anticipated impacts with climate change—decreases in summer base flows and increases in water temperatures—summer habitat is likely to increasingly become a limiting habitat factor and a challenge for species recovery. Assessing and mitigating for elevated summer water temperatures requires accurate information on the thermal tolerances of the target species and life-stages. Such metrics are derived from both laboratory and field-based studies and have been extensively published and reviewed in the scientific literature for juvenile salmonids. However, a problematic level of uncertainty in these metrics remains as laboratory studies are excellent at determining underlying physiological thresholds but lack the context sensitivity and complexity of real world conditions. Yet field-based studies have been seriously flawed in various ways, especially by the lack of accounting for food availability, or lack of documentation of co-habitation with other salmonid species, or pre-summer fish distribution. Food ration levels strongly influence thermal tolerances and habitat selectivity by juvenile salmonids and must be accounted for, which is difficult to do in field-based thermal tolerance studies. Herein, I report on a preliminary observational study that used a comparative approach that addressed these shortcomings by: 1) indirectly assessing food rations by examining fish distributions in a study stream with low food rations (Salmon River) compared to a stream with high food rations (Scott River), with both having multiple salmonid species present; and, 2) conducting fish distribution surveys both before and during high summer water temperatures to help verify that water temperatures are responsible for observed shifts in fish distribution, thereby increasing confidence in the resulting thermal tolerance thresholds identified. Having more accurate field-based thermal tolerance metrics and a better understanding of the implications to fish productivity can allow more accurate assessments of habitat suitability along with restoration designs and recovery planning in a warming climate. It's important not to use temperature tolerance thresholds that are too low or too high as this could lead to excluding important areas from consideration for restoration that are functional due to high food ration levels or restoring habitat that won't function in the future during the summer due to excessively high water temperatures. Given the pace and scope of global warming, it is crucial to have an accurate understanding of what water temperatures can truly be tolerated by juvenile salmonids in real-world conditions as a function of food rations.

Decreased Streamflow in a Mountain Stream Ecosystem Reduces Fish Energetic Efficiency and Alters Fish Behavior Through Reduction of Size and Abundance of Invertebrate Drift

Timothy Caldwell, *University of Nevada, Reno*

Streamflow can be considered a “master variable” in stream systems because of its ability to drive processes across multiple trophic levels. In mountain systems, especially those which are regulated, increased frequency of droughts and reductions in snowpack may alter future streamflow regimes and impact ecological processes. We monitored invertebrate drift abundance, size, and diversity as a function of streamflow and related these to fish movement and energetic efficiencies in the Upper Shasta River in California, above and below a large streamflow diversion. Invertebrate drift biomass was significantly less at impaired flows compared to un-impaired flows and average size of invertebrates decreased with streamflow. Generally, fish movement was greater at the impaired flow site (>50% of the time fish were tracked). Fish movement at the upstream site was negatively related to the size of individual prey items and amount of prey available, while significant drivers were not detected in the flow-impaired site. Energetic efficiency was reduced by over 100% when search foraging took place and the net rate of energetic intake was below 0 J s-1 for low flow periods. Our results suggest that fish foraging behavior may be influenced indirectly by altered streamflow through changes to amount and size of invertebrate drift. This shift, coupled with low food availability, results in decreased energetic efficiency. Future prescriptions of flow rates to regulated rivers should account for changes to invertebrate drift, fish behavior, and fish energetics on seasonal time scale.

Interannual Variability in the Timing of Sacramento Pikeminnow Migration in the South Fork Eel River

***Philip Georgakakos, Ph.D. Candidate** (Presenter)*
*and **Mary Power, Ph.D.,** University of California, Berkeley*

Humans are re-shuffling the global distribution of organisms through introductions, climate induced range shifts, and local removal. These processes lead to novel assemblages of species often with diminished economic returns from recreation, harvest, and other ecosystem services. Sacramento pikeminnow (*Ptychocheilus grandis*) were introduced to the Eel River in 1979 and became widespread in the basin in under a decade. These large cyprinids consume many of the native fishes including culturally and economically important salmonids. We use a combination of snorkel surveys and temperature monitoring to understand if and when these large introduced predators move in the headwaters of the South Fork Eel River. We documented that pikeminnow expand their range seasonally. As water temperatures warm in the summer, fish invade previously unoccupied upstream areas. The timing of this range expansion varies inter-annually, likely due in part to antecedent flow conditions and river temperature. In drier warmer years upstream movement occurs earlier. Early movement could negatively impact pikeminnow's native prey by reducing the time predator free refugia are available. These findings imply this invasive animal's impact could increase with the predicted warming and longer periods of drought in the future.

Thermal Refuge for Salmonids at Tributary Confluences in a Warming River Network

Terrance Wang, *(Presenter) and Co-authors:* ***Suzanne J. Kelson, Ph.D. Candidate; Stephanie M. Carlson, Ph.D.***, *UC Berkeley, Department of Environmental Science, Policy and Management; and* ***George Greer, Ph.D. Candidate***, *and* ***Sally E. Thompson***, *Department of Civil and Environmental Engineering*

River networks in California are expected to warm with climate change and modification of land use in catchments. As rivers warm, cold-water dependent native fish species may alleviate thermal stress by moving into cold-water refugia. We explored the use of tributary confluences as thermal refugia by a native salmonid, *Oncorhynchus mykiss*, in the South Fork Eel River, California. Tributary confluences provide thermal refugia because shaded, ground-water fed tributary channels tend to be cooler than sun-exposed river mainstems. Ingress of the cold tributary waters into the mainstem therefore provides a localized thermal refuge. We monitored spatial temperature fields at the confluence of the South Fork Eel River and two of its tributaries, Cedar Creek and Elder Creek, using in-situ grids of temperature sensors. Snorkel surveys were conducted five times a day for five days at each site during summer 2017.

The two tributary confluences had different temperature characteristics, with Cedar Creek being on average 7˚C cooler than the local mainstem, and Elder Creek on average 3˚C cooler. These differences appeared to change the way that fish used the confluence. At Cedar Creek, the salmonid count within the confluence increased as mainstem temperature increased, suggesting that the fish were using the confluence as a refuge. Fish did not preferentially use the coldest locations (14.5˚C) within the confluence, but were most common in locations with temperature between 20-22°C. At Elder Creek, by contrast there was little relationship between temperature and salmonid counts at the confluence.

The results demonstrate spatial variation in the relative importance of confluences as refugia for salmonids. We suggest that tributaries that feed into mainstems at points of warm temperatures may be key thermal refugia sites for native salmonids, and thus of conservation concern.

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The Salt river and the town of Frendale, CA photo by Thomas B. Dunklin

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Instream Restoration
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Tools for Instream Flow Policy Development
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Can eDNA Detect Low-abundance Fish?
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NMFS California Central Valley Office Information Table
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Pre and Post Drought Habitat Mapping in the Santa Monica Mountains
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Habitat Restoration for Spring Chinook on Mill and Deer Creeks, Tehama County
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Americorps Watershed Stewards Program
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The Syncopated Degradation Blues
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Fishery Habitat Restoration Grant Program Projects in Northern California
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Ocean Ranch Unit of the Eel River Wildlife Area Integrative Restoration Planning
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Monitoring Low Water Levels—DIY Equipment
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Capture California Photo Contest
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A Comprehensive Approach to Identifying Post-Fire Erosion and Sediment Delivery Discharge Points in the South Fork Battle Creek
Presented by Todd Kraemer
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Modeling the Central Valley Salmon Angler Survey
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Lagunitas Creek Floodplain Activation Flow Assessment: Modeling Conditions for Coho Rearing
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Sacramento Valley Salmon Recovery Program
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Heliwood Placement in the Mattole
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Predation by Brown Trout on Native Salmonids of the Trinity River, CA
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Using Width Expansions to Address Incision on the Napa River
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The Appearance of Pink Salmon (*Oncorhynchus gorbuscha*) in Lagunitas Creek and Other Coastal Streams Throughout California: What We Know and Possible Explanations
Presented by Justine Brumm
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Assessing Site Potential Shade in the Laguna de Santa Rosa
Presented by Katy Abbott
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and North Coast Regional Water Quality Control Board
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North Tobiasson Deep Water Rearing Structures
Presented by Jan Raether
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Super Size Me: Benthic Macro-Invertebrate Fatty Acid Composition Matters to Juvenile Salmonid Growth Rates
Presented by Cynthia Le Doux-Bloom, PhD
Hoopa Valley Tribal, Fisheries Department
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Maximum Stream Space Using Zero Carbon Energy: Ecologically Based Stream and River Design
Presented by Damion Ciotti
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Too Hot to Thrive: Effects of Long-Term River Warming on Salmon Health in NW Oregon
Presented by Medha Gautham
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Russian River Confluence
Presented by Adriane Garayalde
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Protected Anadromous Resources of the California Central Valley: On the Road to Recovery from Dire Straits
Presented by Katherine Schmidt
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Redwood Empire TU, Grassroots in Action
Presented by Charlie Schneider
Redwood Empire Trout Unlimited
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20 Years of Eel River Restoration
Presented by Isaac Mikus
ERWIG
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Locating Aquatic Refugia During Prolonged Drought in Santa Barbara and Ventura Counties
Presented by Lisa Rachal
Watershed Stewards Program
lisa.rachal@wildlife.ca.gov

Does Freshwater Life History Affect Marine Survival of Coho Salmon?
Presented by Grace Ghrist
Humboldt State University
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Juvenile Coho Salmon Life History Variants in Humboldt Bay Tributaries
Presented by Madison Halloran
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Integrated Water Strategies to Enhance Streamflow in Santa Barbara and Ventura Counties
Presented by Alyssa Obester
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Salmonid Monitoring of Habitat Restoration Sites in the Upper Sacramento River
Presented by Mike Memeo
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Riparian Canopy Modification Experiment —SF Ah Pah Creek
Presented by Jon Pini
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Jonathan.Pini@greendiamond.com

Eel River Floodplain Response to Extreme Flow Events and Drought
Presented by Tim Bailey
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A Mobile Application of DIDSON Acoustic Cameras to Estimate Fish Abundance
Presented by Christopher Loomis
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Beaver in CA: Creating a Culture of Stewardship
Presented by Brock Dolman
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Development of the South Fork Eel River Salmon Habitat Restoration Priorities (SHaRP)
Presented by Julie Weeder
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Klamath Fish Health Assessment Team —Re-alignment and New Leadership
Presented by Dan Troxel
California Department of Fish and Wildlife
dan.troxel@wildlife.ca.gov

Ice Plant Removal and Dune Restoration
Presented by Rachel Stump
CCCrstump@mlml.calstate.edu

21st Annual Coho Confab August 24-26, 2018 Smith River

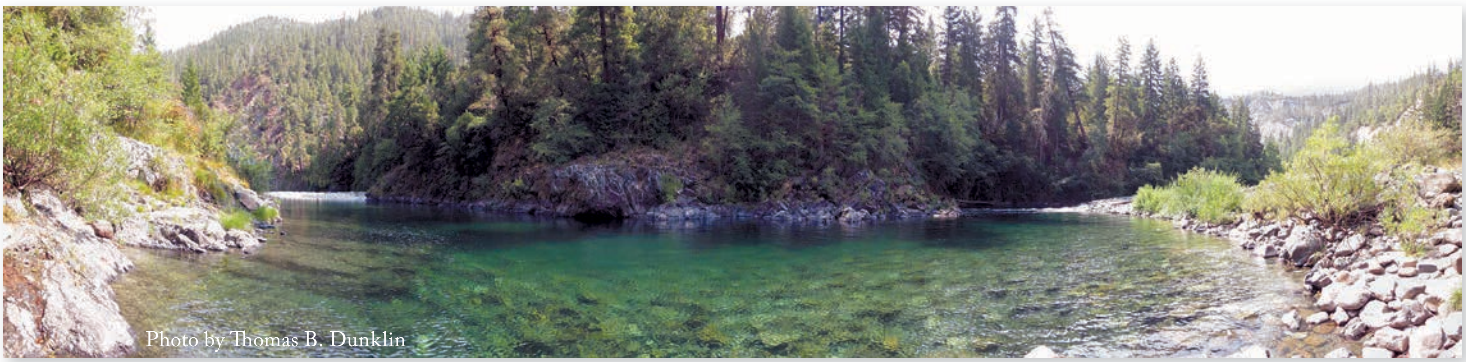
Photo by Thomas B. Dunklin

SRF, with the support of California Department of Fish and Wildlife, will host the 21st Annual Coho Confab at the beautiful Rock Creek Ranch on the South Fork of the Smith River. The pristine Smith River is the largest undammed river in California and is located in the northwest corner of the state in the Siskiyou Mountains. Field tours will include tours of restoration forestry practices, Redwood National Park projects, off-channel habitat, fish passage projects, and large woody debris installations. Participants will have the opportunity to tour stream crossing replacements that range from fish ladders to roughened channels, to stream simulation culverts and bridges. We will offer workshops on underwater fish identification, a river tour of beaver-constructed structures, and engineered log jams in Lower Klamath River tributaries.

Large Wood Restoration Technical Field School

October 29-31, 2018 Mendocino Coast

This Technical Field School is a multi-day education and outreach event intended to train registered professional foresters (RPFs), licensed timber operators (LTOs), landowners, and restoration professionals in several large wood augmentation methods. The specific goal of the field school is to increase the quantity of qualified large wood restoration practitioners in the North Coast Region. The field school will include classroom presentations, hands-on demonstrations, and tours of recently implemented project sites.

Southern Steelhead Summit

Ventura, CA – Dates to be Announced Soon

Salmonid Restoration Federation's Mission Statement

Salmonid Restoration Federation was formed in 1986 to help stream restoration practitioners advance the art and science of restoration. Salmonid Restoration Federation promotes restoration, stewardship, and recovery of California native salmon, steelhead, and trout populations through education, collaboration, and advocacy.

SRF Goals & Objectives

1. To provide affordable technical education and best management practices trainings to the watershed restoration community.
2. Conduct outreach to constituents, landowners, and decision-makers to inform the public about the plight of endangered salmon and the need to preserve and restore habitat to recover salmonid populations.
3. Advocate for continued restoration funds, protection of habitat, enhanced instream flows, and recovery of imperiled salmonids.

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