Abstracts

Speed Talks

***** = student presenter

Evolution of Reproductive Strategies in Intertidal Sculpins

Thaddaeus Buser*****, Oregon State University, busert@oregonstate.edu

The cottoid fishes, commonly known as sculpins, are a diverse group of marine and freshwater species found throughout the northern hemisphere. This group contains a remarkable diversity of ecological and biological specialization. Particularly, sculpin species display a wide range of reproductive characters, ranging from spawning and external mixing of gametes, to a unique form of fertilization known as "internal game association." The evolution of these traits has been only lightly explored. Here, we show that copulation and associated characters are the ancestral condition in a group of intertidal sculpins, the subfamily Oligocottinae, and contrary to previous hypotheses, copulation and associated traits has likely being lost in one oligocottine lineage.

Life Stage Lexicon for Lamprey

Benjamin Clemens, Oregon Department of Fish and Wildlife, Ben.Clemens@oregonstate.edu

At least nine different terms are used interchangeably to describe life stages of lamprey. These terms may appear as esoteric jargon (e.g., 'ammocoetes'; 'macrophthalmia') to non-experts and are often used imprecisely across different life history stages and even species. Jargon and inconsistent terminology can confuse attempts to compare various datasets and publications. I compile a list of life stage terms and their explicit or implied definitions. Based upon simplicity and logical precedents set forth by the evolutionary and developmental biologist, E. K. Balon (1975 J. Fish. Res. Bd. Can.) and lamprey biologists M. F. Docker, J. Hume, and B. J. Clemens (2015 Ch. 1., Lamprey Conservation, Biology, and Control), I recommend the following three stages of post-hatch terminology be used for lampreys: a) Larvae (immature, non-sex determinant, filter-feeding larvae without eyes); b) juveniles (metamorphosed individuals with eyes); c) adults (non-feeding, upstream-migrating lamprey in various stages of sexual maturation). I recommend the use of other synonyms and pseudonyms be reduced: ammocoetes (larvae); macrophthalmia and transformers (juveniles). I also recommend that the following descriptors be used sparingly and with explicit qualifiers to render more precise meanings: 'eyed' lamprey, 'brown' lamprey, and 'silver' lamprey).

Cameroon's Crater Lakes - Biodiversity and Conservation

Joe Cutler*****, University of California Santa Cruz, jcutler@ucsc.edu
Brian Sidlauskas
Pius Oben
Benedicta Oben

Cameroon is home to 34 volcanic crater lakes. While these isolated ecosystems are often cited by evolutionary biologists as the most compelling examples of sympatric speciation, little to no fieldwork has been conducted at these sites in decades. Therefore the status of the native fish assemblages was unknown until 2015. With funding from National Geographic, I spend six months traveling through Cameroon and sampling ten of the volcanic crater lakes (Edib, Dissoni, Barombi Mbo, Barombi Kotto, Mboandong, Debundsha, Small Debundsha, Bermin, Muanenguba male and Muanenguba female). I will present data on the fish diversity within the lakes, introduced species, and forthcoming conservation efforts in the region.

Differentiating Mixed Stock Chinook Salmon to Distinct Life Histories Using Morphometric Analysis

Alexander Jensen*****, Oregon State University, alexander.jensen@oregonstate.edu
James Peterson
Carl Schreck

Management of mixed stock fisheries often requires estimates of stock-specific exploitation rates to conserve weaker, more vulnerable stocks, and the recreational fishery for fall-run Chinook salmon in the mouth of Columbia River, hereafter referred to as “Buoy 10”, is no exception. Early-fall “tules” and late-fall “brights” comprise two primary life history groups in the fishery, as defined by differences in spawning timing and location, which can be further split into region-specific management stocks. Novel methods to distinguish landed fish to management stock can complement the use of coded wire tags in this fishery system and improve estimates of stock-specific exploitation rates. We used standardized images captured from landed Chinook during the 2017 Buoy 10 fishery to evaluate the potential for morphometrics to distinguish between life history groups. In the absence of confirmed genetic identities, we used hierarchical and k-means cluster analysis with pre-specified body measurements to determine the presence of distinct groups of fish; measurements were generated using a truss-based approach. We subsequently applied logistic regressions to these new groups, in addition to groups defined by field observations, to identify length-based traits responsible for group differentiations. We identified several influential length measurements that offer promise for distinguishing between life history groups. These differences, which will be confirmed with future genetic identifications, will inform directed sampling during the 2018 fall-run fishery as well as our ongoing efforts to create a formal phenotypic identification guide.

Does More Wood Equal More Coho Smolts? Intensive Monitoring to Figure Out Where, When, and Why

Christopher Lorion, Oregon Department of Fish and Wildlife, chris.m.lorion@state.or.us
Erik Suring
Kara Anlauf-Dunn
Catalina Segura

Although wood placement projects have been a key component of Coho Salmon habitat restoration efforts, quantifying how these projects actually affect Coho Salmon smolt production remains challenging. Oregon Department of Fish and Wildlife salmonid life cycle monitoring sites provide exceptional opportunities for

investigating relationships between restoration measures and salmonid smolt production due to long-term intensive monitoring at these sites. A collaborative research project currently underway at the Mill Creek life cycle monitoring site in the Siletz River basin is examining stream habitat and Coho Salmon population responses to an extensive large wood placement project completed in 2016. With 20 years of pre-treatment monitoring of Coho Salmon spawners and smolts at Mill Creek, and multiple ODFW salmonid life cycle monitoring sites that can serve as controls, we have an unusually strong baseline for detecting project effects. Furthermore, the study is designed to make direct linkages between Coho smolt abundance, juvenile Coho overwinter survival, and stream habitat conditions. Local stream channel responses to the wood placement have been studied intensively at a number of wood placement sites, while basin-wide habitat surveys have also been conducted pre- and post-treatment. Initial results indicate significant changes in stream habitat in the first winter following wood placement, particularly in sites located in larger stream channels. Juvenile Coho Salmon overwinter survival also appeared to increase immediately after wood placement, although further monitoring will be needed to confirm this effect. Smolt abundance in the spring following the wood placement was well above the pre-treatment average, but still fell within the range observed before the wood placement. Continued intensive monitoring at Mill Creek over the next four years will allow us to assess short-term project effects on Coho Salmon overwinter survival and smolt production, and lay the groundwork for an integrative analysis that includes stream habitat and benthic macroinvertebrate responses to the wood placement.

National Fish Hatchery Production and the 2018-2027 U.S. v. Oregon Management Agreement

Doug Olson, U.S. Fish and Wildlife Service, doug_olson@fws.gov

The United States v. Oregon 2018-2027 Fisheries Management Agreement renews the previous 10-year framework to rebuild upriver fish runs and fairly share Treaty and Non-Treaty fisheries (along with obligated hatchery production) in the Columbia River. Parties to the Agreement include the States of Oregon, Washington, and Idaho, the Shoshone Bannock Tribes, the Confederated Tribes of the Warm Springs Reservation of Oregon, the Confederated Tribes of the Umatilla Reservation, the Nez Perce Tribe, the Confederated Tribes and Bands of the Yakama Nation, and the United States (Bureau of Indian Affairs, National Marine Fisheries Service, and the U.S. Fish and Wildlife Service). Treaties between the United States and Tribes signed in 1855 reserved the Tribes exclusive rights to fish in waters running through their reservations and at "all usual and accustomed places, in common with the citizens of the United States." U.S. v. Oregon (1969) is the on-going federal court case that enforces and implements the Treaty Tribes reserved fishing rights in the Columbia River. Along with the decisions in U.S. v. Washington (1968/1974), "in common with" has been defined as the 50% sharing of all harvestable fish in the Tribes traditional fishing places. In this presentation, an overview will be provided on National Fish Hatchery production, recent harvest allocation, and Endangered Species Act compliance associated with the renegotiated U.S. v. Oregon agreement.

The Role of Beaver in Stormwater Attenuation and Sediment Transport in Urban Streams of The Tualatin River Basin, Oregon

Erin Poor, U.S. Geological Survey, epoor@usgs.gov
Alexandria Costello

Micelis Doyle
Krista Jones
Jennifer Morse
Stewart Rounds

Beaver have a unique ability to alter landscapes to fit their needs. The establishment of beaver dams pushes stream water onto the floodplain, creating ponds that allow beaver to safely inhabit the streamscape, and alter the stream's hydrology. The change in hydrology causes a variety of stream responses, including stormwater attenuation and suspended sediment retention. The U.S. Geological Survey is working to quantify the benefits and limitations of beaver activity on urban streams in the Tualatin River basin in northwestern Oregon in order to inform local resource management decisions.
Stage data from beaver-populated stream reaches showed a decrease in the magnitude of storm peaks downstream, as well as a decrease in the intensity of the response to rain events, indicating a dampening of streamflow during periods of heavy rainfall. The effects of beaver activity on hydrologic variability was quantified using several modified indices of flashiness; results tended to reinforce the observation of attenuated streamflow variability during storms. During the study, the beaver dams were periodically notched by the local parks department to clear trails of ponded water. The dam notching was evident in the stage data as far as 0.45 miles upstream of the uppermost dam, suggesting that beaver dams created a backwater effect that extended well beyond the obvious area of floodplain ponding.

Fish Entrainment Evaluation Using a Custom Weir at a Municipal Pumping Facility on the Tualatin River, Oregon

Joshua Richards, Mount Hood Environmental, joshua.richards@mthoodenvironmental.com
Forrest Carpenter
Benjamin Briscoe
Ian Courter

Municipal and agricultural practices alter streams and impact the aquatic ecosystem through a variety of infrastructure projects, such as dams, pumping facilities, and water diversions. Therefore, regulations exist to prevent fish entrainment at water withdrawal facilities. For example, to prevent juvenile fish entry into pumping facilities, fish screens are required to meet particular mesh size criteria. To determine whether screen improvements are necessary for a large, municipal water pumping facility on the Tualatin River, Oregon, we estimated the rate of salmonid fry entrainment within the facility's pumping bays. Two 15-foot tall, weir-style aluminum fish traps were designed, fabricated, and installed between the fish screens and pump intakes. A 7x7 foot orifice in the center of each weir was equipped with a removable net bag (1/16 inch mesh) to collect entrained fish. In spring 2018, hatchery Coho Salmon fry were marked and released in the intake channel in front of the pumping facility to estimate the efficacy of the fish screens. This approach provided a cost-effective method of testing whether modification or replacement of existing fish screens was necessary. Further, data collected from such an approach quantifies pumping facility impacts to establish empirically based mitigation criteria.

Measurements of turbidity and suspended sediment showed that beaver ponds trapped large quantities of sediment during storm events. Concentrations of suspended sediment were consistently decreased downstream of beaver ponds, from fifteen to as much as ninety percent during storms. In contrast, beaver activity increased the baseline turbidity downstream of ponds during summertime baseflow conditions. In a large pond in Fanno Creek, measurements of sediment accumulation showed that more than 1200 cubic meters had been trapped over the course of only five years.

The effects of beaver activity on hydrology and suspended sediment flux in urban streams depends on the stream morphology and the degree of floodplain inundation, but the data collected in this study are proving valuable in assessing the degree of hydrologic alteration and the changes to the stream's suspended-sediment fluxes, results that will be useful to resource managers.

Assessment of Fish Biodiversity at Three Proposed Dam Sites in Gabon

Brian Sidlauskas, Oregon State University, brian.sidlauskas@oregonstate.edu
Joseph Cutler
Jean Hervé Mve Beh
Marie-Claire Paiz
Hans Mipounga
Marie-Louise Yedi
Edouard Nzengue
Franck Nzigou
Jean-Daniel Mbega

The planned construction of hydroelectric dams potentially threatens the biotic integrity of several rivers in the tropical African country of Gabon. Gabon harbors an incredibly rich freshwater biota, including more than 400 fish species, 10% of which have been discovered in the last 20 years, yet little baseline data exists about which of these species inhabit the sites proposed for hydropower development. Throughout the wet and dry seasons of 2017, we assembled the first comprehensive baseline for the fish biodiversity at proposed hydropower sites at Les Chûtes de l'Imperatrice on the Ngounié River, Dibwangui on the Louetsi River, and Ngoulmendjim on the Komo River. The collections yielded more than 10,000 fish specimens, hundreds of live photos, and nearly 2000 tissue samples representing approximately 150 species, several of which appear to be new to science. The assemblages at all three sites include large, channel-adapted fishes such as giant cyprinids (Labeobarbus) and frugivorous catfishes (Schilbe) whose movements might be blocked or fragmented by dam construction. Rivers near two of the dam sites yielded specimens of commercially important marine species, such as juvenile giant threadfins (*Polydactylus quadrifilis*) near Ngoumendjim and grunts (*Pomadasys perotaei*) near l'Imperatrice, indicating potential importance of access to freshwater habitats for the well-being of those species. The fauna of the Louetsi River did not contain marine derived species, but did differ substantially from that of the mainstem Ngounié River into which it flows. We are currently working to create a set of management recommendations for those mighty, biodiverse rivers, and to build scientific capacity among the team of Gabonese scientists who are assisting the collection, identification and curation of these critically important specimens in the permanent holdings of the Oregon State Ichthyology Collection.

Traditional Oral Presentations

Expanding the Portfolio: Increased Chinook Outmigrant Diversity through the North Fork Floating Surface Collector

Nick Ackerman, Portland General Electric, nick.ackerman@pgn.com
Garth Wyatt

Life-history diversity in Chinook has been shown to be an important factor in providing population resiliency. In the Willamette Basin, spring Chinook display a wide array of juvenile life history strategies (Schroeder et al. 2015). In 2015 Portland General Electric improved juvenile salmon collection capabilities at North Fork Dam on the Clackamas River by adding a 1,000 cfs floating surface collector (FSC). Since the FSC was put into operation, bypass system collections of juvenile Chinook have shown increased temporal diversity in outmigration. Most Chinook are collected in the fall as subyearlings with roughly equal numbers in the spring (yearlings) and summer (subyearlings). Additional subyearlings are collected in the winter in association with high flow events. PIT tag data reveal interesting seasonal and length dependent relationships with FSC recapture rates, a potential indicator of migratory motivation. This presentation will explore changes in temporal and size distributions of Chinook outmigrants at the Clackamas Project since the FSC was put into operation. We will also review results of spring, summer, and fall PIT tag releases of Chinook into North Fork Reservoir.

Warming Winter Climate Reduces Landscape-Scale Variability in Pacific Salmon Incubation Duration

Luca A. Adelfio, U.S. Forest Service, ladelfio@fs.fed.us
Steven M. Wondzell
Nathan J. Mantua
Gordon H. Reeves

Incubation duration for fall-spawning Pacific Salmon (*Oncorhynchus spp.*) is largely controlled by winter water temperature and may be impacted by climate change. We measured incubation period (October to May) water temperature at 12 Coho Salmon (*O. kisutch*) spawning sites on the Copper River Delta in southcentral Alaska. The 12 sites fell into 4 water source categories: groundwater, groundwater-mixed, precipitation, and precipitation with an upstream lake. We quantified the accumulation of thermal units and modeled incubation duration, contrasting years with historically-common snow-dominant conditions and years with anomalously warm rain-transitional conditions, a proxy for an anticipated future climate scenario. Our results showed that water source controlled the sensitivity of water temperature to changes in air temperature. At groundwater sites, seasonal and interannual temperature variations were strongly attenuated, leading to uniform incubation conditions within and among years. In contrast, incubation duration was reduced by 4 months during rain-transitional winters at precipitation-fed streams. The impacts of rain-transitional winters were particularly pronounced at sites with shallow lakes upstream, where a 1.6 °C increase in incubation period mean air temperature prevented ice formation and limited the accumulation of snow. Consequently, lakes were exposed to short-wave radiation with the onset of long subarctic spring days and increased solar heating contributed to

an 8 °C increase in mean May water temperature. Across all study sites, the coefficient of variation in incubation duration was significantly greater during snow-dominant winters than during rain-transitional winters, indicating landscape-scale variability in salmon life history event timing may be reduced by a warming winter climate. The relative frequency of snow-dominant versus rain-transitional winters has varied historically with large-scale patterns in climate variability, notably the Pacific Decadal Oscillation, indicating climate change impacts to winter water temperature are not likely to occur in a linear fashion, but may occur in non-uniform shifts that could have biologically significant impacts on Pacific salmon incubation. Based on these findings, we present three conclusions about climate change impacts to Pacific salmon: (1) Water source, impacted by geomorphology, can attenuate or accentuate variability in winter water temperature, with implications for incubation duration and life history expression; (2) landscape-scale variability in incubation duration may be reduced as the climate warms, impacting emergence or spawn timing and the availability of salmon to consumers; and (3) understanding how interactions between large-scale climate variations and the severity of winter conditions have impacted Pacific salmon life history expression in the past, as well as how climate variability may influence climate change impacts in the future, will be important.

Use of Small Unmanned Aircraft Systems (sUAS) for Fall Chinook Salmon Spawning Surveys in the Snake River

Brad Alcorn, Idaho Power Company, balcorn@idahopower.com

Redd counts of Snake River fall Chinook salmon are used to aid resource managers in monitoring this ESA listed population of fish. Both shallow-water (aerial - helicopter) and deep-water (remote underwater video) survey methods are used to conduct redd searches within the main Snake River. To facilitate the safety of biologists, we developed of a new method for conducting aerial redd surveys using small unmanned aircraft systems (sUAS). The sUAS are small, lightweight, multi-rotor platforms that are able to be pre-programmed to fly specific sets of waypoints. In 2011 we tested the application of collecting video at 17 index sites within the Snake River to survey redds across the eight week spawning period. Each site was able to be surveyed once per week over an eight week period. Data from the video was used to calculate an estimate of total shallow-water redds (1,922), and this compared favorably with what was reported by biologists using the traditional helicopter method (1,949). Continued development of this application led to a survey sampling method that estimates total shallow-water redd counts from a sample of sites chosen proportionate to their size. This approach has been used since 2015 and has resulted in an effective method for surveying shallow-water redds in the main Snake River which is ultimately safer than traditional helicopter methods.

Predicting Effects of Climate Change on Myxozoan Disease Dynamics Using an Epidemiological Model

Julie Alexander, Oregon State University, Alexanju@science.oregonstate.edu
Jerri Bartholomew
Patrick De Leenheer

Climate change has been linked with changes in the dynamics of infectious diseases in aquatic systems. Climate related shifts in water temperatures and precipitation patterns will have significant effects on the myxozoan disease dynamics, but predicting the magnitude and direction of specific responses is challenging. We present an overview of myxozoan disease dynamics illustrated with data from salmonid ceratomyxosis in the Klamath River CA, USA. Using an epidemiological model, we predicted host and parasite dynamics under future climate scenarios (hot/dry-cold/wet). We used data from hydraulic and water temperature models, predictive statistical models, and empirical data to parameterize the epidemiological model. Epidemiological model outputs were compared to observations from the Klamath River collected from 2006 to 2017. The majority of predictions were similar to values in years having high disease risk for salmonids. This result suggests C. shasta-induced mortality will likely remain high and could increase in Klamath River salmonids, making the recovery and management of salmon even more challenging.

A Status Update of Age-0 White Sturgeon Recruitment in the Lower Columbia River Basin

Eric Anderson, Oregon Department of Fish and Wildlife, eric.s.anderson@state.or.us
Colin Chapman
Peter Stevens

Our objective is to provide a status update of age-0 white sturgeon (*Acipenser transmontanus*) recruitment in the lower Columbia River basin, including the mainstem Columbia River from the mouth to McNary Dam and the Willamette River from the mouth to Willamette Falls. White sturgeon were collected using small mesh gill nets in John Day, The Dalles, and Bonneville reservoirs, the lower Columbia River (below Bonneville Dam), and the Willamette River. Gill nets were deployed overnight at predetermined, standard sites in each reach, with the exception of the Willamette River. Two metrics, the proportion of positive efforts (Ep; proportion of all gill net sets that captured at least one age-0 white sturgeon) and catch-per-unit-effort (CPUE; average number of age-0 white sturgeon caught per gill net set), were calculated to assess annual recruitment. From 2014 to 2016, both Ep and CPUE were higher in the Willamette River than the lower Columbia River. For the Columbia River reservoirs, Bonneville Reservoir generally had the highest Ep, followed by The Dalles Reservoir, and then John Day Reservoir. Years with strong recruitment were often associated with high discharge from McNary Dam. This work increases our understanding of white sturgeon population dynamics in the lower Columbia River basin by helping identify environmental conditions that are favorable for age-0 recruitment.

Multi-Species Rarity and Climate Vulnerability

Kara Anlauf-Dunn, Oregon Department of Fish and Wildlife, kara.anlauf-dunn@oregonstate.edu
Meryl Mims

There is a dearth of information known about the vulnerability of Oregon's native fish. Even for those that are well studied, the effects of future climate regime shifts is relatively unknown. We set out to understand the vulnerability of multiple species by exploring the degree to which the species is affected by a threat (sensitivity) and the extent to which the species' environment will change (exposure). We developed species distribution models using available occurrence data, exploring rarity-based and traits-based approaches to understand climate sensitivity. We identified prominent features in the species' environment that are both direct threats with respect to climate and threats related to water quantity and quality that will likely be exacerbated with

forecasted climate regime shifts. Several modeled approaches were evaluated given the inconsistency in available species occurrence data, and we modeled a range of plausible futures given the variability in climate projections. We are assessing proxies that can be incorporated to evaluate the relative capacities of fish species to adapt to environmental changes as this will influence future distributions. While the specific objective of these modeling efforts is to map the likelihood of species persistence to help categorize species conservation status, we are also learning how best convey uncertainty. Further, these analyses will provide needed information to support numerous management decisions related to land and water use and support prioritization of land and water resources for protection and restoration to support species resilience as climate change impacts are realized.

2018 State of Oregon Fish Passage Prioritization

Greg Apke, Oregon Department of Fish and Wildlife, greg.d.apke@state.or.us

Fish passage barriers are prevalent throughout the Oregon landscape. Over time, despite fish passage rules and regulations, access to native fish habitats has been blocked or impaired by the construction of impassable culverts, dams, tide gates, dikes, bridges, and other anthropogenic infrastructure. Providing passage at these artificial obstructions is vital to recovering Oregon's native migratory fish populations. With so many barriers spread across the landscape, and funding becoming scarce, it is paramount that we thoroughly prioritize fish passage, with inclusion of multiple parameters. This will allow for a focused effort to improving passage conditions and meeting a critical need of Oregon's native migratory fish. ODFW is initiating a new statewide fish passage prioritization in 2018 and we seek input from various stakeholders. This presentation will provide an overview of this statewide fish passage barrier prioritization effort.

Predicting Flow Permanence in Streams from Time Series of Stream Temperature

Ivan Arismendi, Oregon State University, ivan.arismendi@oregonstate.edu
Jason Dunham
Michael P. Heck
Luke D. Schultz
David Hockman-Wert

Intermittent and ephemeral streams represent more than half of the length of the global river network. Dryland systems are especially vulnerable to changes in human-related water uses as well as shifts in terrestrial climates. Here, we used existing stream temperature datasets in the northwest Great Basin desert, USA, to extract critical information on patterns of flow permanence. We used Hidden Markov Models (HMMs), to extract information from daily time series of stream temperature to diagnose patterns of stream drying. Specifically, we applied HMMs to time series of daily standard deviation (SD) of stream temperature between April and August (2015–2016). We used information from paired stream and air temperature data loggers as well as co-located stream temperature data loggers with electrical resistors as confirmatory sources of the timing of stream drying. We expanded our approach to an entire stream network to illustrate the utility of the method to detect patterns of flow permanence over a broader spatial extent.

Shifts in the US academic fisheries network over time

Ivan Arismendi, Oregon State University, Ivan.Arismendi@oregonstate.edu
Katherine McLaughlin
Brooke Penaluna

During the past few decades there has been a slight improvement in the inclusion of women and people of underrepresented race/ethnicity in science, including fisheries. Yet, the promotion and retention of this new workforce is challenging and requires the understanding of existing barriers related to the existing network structure. In some cases, the prevailing scientific ideas are constrained to geographical and cultural boundaries, often with biases against underrepresented groups. In this study, we asked how the performance of scientists is affected by the structure of their research social networks. It has been demonstrated that scientists connected to multiple distinct peers have a better citation-based performance than those with fewer connections, suggesting that the structure and connectivity of professional networks can be used to predict the performance of scientists. We characterize the structure of the US academic fisheries co-publication network using all articles published between 1970-2016 with at least one author in fisheries academia in the US. We provide information about trends in number of publications, mean number of authors per article, and the proportion of authors from within the fisheries network over time. We used network analysis to characterize potential shifts in the structure and connectivity of the network over time, and how this relates to gender, ethnicity and professorship categories. Our research will provide a better understanding about how the US academic fisheries co-publication network may shift over time by including underrepresented groups of women and minorities."

Not Always Nasty: Exploring the Conservation Significance of Seasonally Warm Habitats

Jonny Armstrong, Oregon State University, jonathan.armstrong@oregonstate.edu
Joe Ebersole
Aimee Fullerton
Ivan Arismendi
Brooke Penaluna

Climate change adaptation strategies often judge habitats based on their maximum summer temperatures, placing value on areas that remain cool and devaluing those that are seasonally warm. A key challenge is to understand how intermittently suitable habitats contribute to the production and resilience of coldwater fish. Can habitats that are hot in August be written off, or do these habitats have unique value at other times of the year? Here we review empirical studies that show how fish can exploit seasonally warm habitats and we present preliminary results from an individual-based energetics model exploring the potential contribution of seasonally warm habitats to the annual growth potential of salmonids.

Genome Wide Markers of Reproductive Success and Mate Choice in Coho Salmon

Heather Auld, Oregon State University, auldh@oregonstate.edu
Dave P. Jacobson
Michael A. Banks

Because individuals are limited in their ability to produce offspring by time, energy, and gamete availability, it is important for individuals to not mate randomly, but instead select sexually receptive, high quality and/or genetically compatible partners, in order to increase their likelihood of reproductive success. In nature, with the exception of instances of coercive or sneaky mating, individuals can choose their reproductive partners by strategically allocating mating effort towards and/or accepting copulation from specific individuals. This ability to choose mates and the natural variation in mate choice has important effects in the direction of evolution, including maintenance of genetic diversity within populations, and speciation. However, in instances where humans breed species either for resource use or conservation efforts, individual mate choice is often either absent or limited. This can be problematic for conservation or population recovery efforts since individuals who choose their mates often have greater mating success than those who do not. Humans are unlikely to be able to appropriately identify optimal mating pairs when the factors that affect mate choice and reproductive success in a given species are unknown or when we are incapable of utilizing the same sensory modalities. However, even when given the opportunity to choose a mate, reduced reproductive success has been observed in hatchery fish relative to their wild counterparts, suggesting a reduced ability of hatchery fish to either find, compete for, and/or select appropriate mates which could be the result of the parental generation of hatchery fish not being able to select their own mates and thus producing less sexually competitive offspring. Here, we use a previously established pedigree, including known reproductive partners and resultant reproductive success, of both hatchery and wild Coho Salmon (*Oncorhynchus kisutch*) from the Umpqua River in southern Oregon and genotyping-by-sequencing (GBS) to identify single nucleotide polymorphisms (SNPs) associated with variation in both individual and mate pair reproductive success. This genome wide approach allows us to evaluate a wide array of genes that affect an individual's ability to locate, compete for, and/or attract suitable partners for reproduction. Preliminary results suggest a significant relationship between multiple genes, including those related to mRNA processing, the cell cycle, carbohydrate metabolic processes, neurite growth, mucus production, and reproductive success. Our results further suggest potential differences between hatchery and wild fish in genes related to vision, embryonic morphogenesis, RNA, adult social behavior and male germ-line stem cell division. We will discuss potential implications of our findings on hatchery mating practices.

ODFW-ODOT Culvert Repair Programmatic Agreement

Pete Baki, Oregon Department of Fish And Wildlife, pete.a.baki@state.or.us

There are approximately 35,000 culverts under the State highway system; most were installed prior to 1970 and are nearing the end of their design life. ODOT began developing systematic information on culvert infrastructure and condition in 2013. The culvert inventory has revealed that approximately 30 %, or 10,500, of the inventoried ODOT culverts are in poor or critical condition and need to be repaired or replaced in the near term to maintain the safety and integrity of the State highway system. The cost to replace all of these culverts in kind would be well over one billion dollars. This cost would be substantially higher for installation of larger culverts or bridges to meet fish passage criteria.

The Oregon Department of Fish and Wildlife (ODFW) and Oregon Department of Transportation (ODOT) partnered together through a Culvert Repair Programmatic Agreement to make critical repairs and improve fish passage to some aging culverts in Western Oregon. The repairs do not meet full fish passage criteria, but passage is improved at each site. To offset the delay in providing full fish passage, ODOT paid into an ODFW managed account that will help fund providing passage at some of the highest priority fish passage projects in the state.

The work completed to date, the challenges present and the progress of the Culvert Repair Programmatic Agreement will be discussed.

Translocation of Lost River and Shortnose Suckers from Lake Ewauna to Augment Spawning Populations in Upper Klamath Lake, Oregon

Nathan Banet, U.S. Geological Survey, nbanet@usgs.govn
David Hewitt

Lost River (*Deltistes luxatus*) and shortnose (*Chasmistes brevirostris*) suckers, two federally endangered species endemic to the Klamath Basin, were translocated from Lake Ewauna to Upper Klamath Lake in each of four years (2014-2017) in an effort to augment existing spawning populations. Over the four years a total of 658 adult suckers were captured in Lake Ewauna, PIT-tagged, and translocated to the Williamson River, a spawning tributary that flows into Upper Klamath Lake. We monitored success of translocation efforts with encounters from remote PIT tag antennas and physical captures. Although most suckers were encountered at least once after relocation (83%), the proportion of the translocated cohorts that were encountered declined in each subsequent year following translocation. Restricting attention to data just from the spawning season (March – June), encounters of translocated suckers were highest in the year of translocation (51 – 76%) and declined in each subsequent year (30 – 51% in the second year; 30 – 41% in the third year). The vast majority of translocated suckers were encountered during the spawning season in the Williamson River, and few were encountered at other known spawning locations. Migration timing of translocated suckers largely coincided with the migration of resident suckers in the Williamson River. However, migration timing for translocated suckers was most similar to the timing of resident suckers in years following translocation. Results suggest that migration timing and spawning site fidelity are similar for translocated and resident individuals, but substantial declines in the proportions of translocated cohorts that are encountered in subsequent years are cause for concern in using translocation as a management strategy for recovery.

Hydrologic and Thermal Regime Relationships to Coho Salmon Spawning in the Smith River Watershed, Oregon

Mackenzie Baxter*, Oregon State University; Inter-Fluve, Inc., mackenzie.baxter@oregonstate.edu
Rebecca Flitcroft

Guillermo Giannico

Survival of Pacific Salmon in freshwater environments depends on suitable conditions of temperature and discharge. Relationships between temperature and discharge may provide important insight into life stage events such as spawning. Previous studies have focused on physiological thresholds that influence the initiation of migration; fewer studies have investigated the relationship between hydrologic and thermal conditions and spawning throughout the course of the spawning period. Understanding environmental drivers of spawn timing may allow for more efficient prioritization of preservation and enhancement activities that guard salmon populations against the unpredictable effects of climate change.

This study evaluates how Oregon coastal Coho Salmon (*Oncorhynchus kisutch*) returning to three small tributaries of the Smith River watershed (in the central Oregon Coast Range) respond to stream hydrology throughout the spawning period. Generalized linear mixed models were constructed to evaluate relationships between various stream discharge metrics, water temperature, physical basin characteristics, and annual Coho return data collected between 2010 and 2016. The results of the work indicate that water temperature, cumulative discharge, and daily discharge values prompt redd construction. Further, analysis shows synchrony in spawning time response to environmental cues across basins. Annual run size of the North Umpqua population of Coastal Coho Salmon appears to affect the level of influence stream hydrology and temperature has on timing of redd construction in these three basins.

A Historic, Regulatory and Scientific Review of Atlantic Salmon Net Pen Operations in Puget Sound

Kurt Beardslee, Wild Fish Conservancy, kurt@wildfishconservancy.org

The commercial culturing of Atlantic salmon in open-water net pens is a rapidly expanding industry around the world. Washington State is the only West Coast U.S. state currently practicing open-water Atlantic salmon aquaculture. Recent events have drawn increased attention to this industry; its environmental impacts, and their implications for concomitant ESA-listed species. In 2016, an international corporation owning Atlantic salmon net pen operations in Chile, Spain, Scotland and Maine purchased all the Atlantic salmon net pens and leases in Puget Sound, Washington. For nearly three decades, the net pens in Puget Sound had been owned and operated by much smaller local companies. Shortly after this acquisition was completed the industry announced its intent to substantially expand their operations into the Straits of Juan de Fuca. Then in August 2017, the structure of one of the Puget Sound net pens off the coast of Cypress Island collapsed, allowing the escape of an estimated 160,000 Atlantic salmon, attracting international attention. The presentation will cover the industry's west coast history, a summary of environmental impacts resulting from the industry, existing Washington State regulatory structure, as well as future alternatives.

Use of the Deschutes River by PIT Tagged Migrating Adult Snake River Steelhead

Blane Bellerud, NOAA Fisheries, Blane.Bellerud@noaa.gov

Regular monitoring for PIT tags in the Deschutes River was established at Sherars Falls (Deschutes Rm43), detectors were installed at the Deschutes River mouth in 2013. PIT tag detections at these sites indicate relatively large numbers of Snake River Steelhead are present in the Deschutes River as far upstream as river mile 43 from July-November. From 2013-2015 12.8-18.3% of the PIT tagged Snake River Steelhead detected at The Dalles Dam were detected at the Deschutes River mouth.
A range of 75-83% of Snake River Steelhead detected at the Deschutes River mouth and 25-64% detected further upstream at Sherars Falls were later detected upstream at McNary Dam. Thus the majority of SR Steelhead detected in the Deschutes River were not permanent strays.
Behavior of most (though not all) of the Snake River steelhead entering the Deschutes is similar what would be expected of fish using a thermal refugium. More Snake River steelhead were present in the months of high Columbia River water temperatures (July-August), exiting in September-November as Columbia River temperatures cooled.

Snake River Steelhead were more likely to enter the Deschutes River when Columbia River temperatures are high, the Deschutes River is cooler than the Columbia River, and if they were transported as juveniles. Wild fish were more likely to be detected at the mouth of the Deschutes River, but not further upstream at Sherars Falls.

Best Practices in Aquatic Restoration to Protect Declining Native Freshwater Mussels

Emilie Blevins, Xerces Society for Invertebrate Conservation, emilie.blevins@xerces.org
Laura McMullen
Sarina Jepsen
Michele Blackburn
Aimee Code
Scott Black

The Pacific Northwest is home to several species of native freshwater mussels, which inhabit creeks, rivers, lakes and ponds. Western mussels have declined from their historical distributions, including two species (the western ridged mussel and winged floater) that are Vulnerable to extinction and one species (the western pearlshell) that is Near Threatened according to categories and criteria of the International Union for Conservation of Nature's Red List. The decline of western freshwater mussels is important to river conservation and relevant to river restoration practitioners because mussels provide numerous ecosystem services that benefit salmon and other native aquatic species. Inhabiting the benthos and filtering water, freshwater mussels reduce turbidity, remove toxic substances, improve water quality, concentrate nutrients, provide habitat for other macroinvertebrates, and serve as an important food source for other species.

While aquatic restoration projects are designed to benefit native ecosystems and people, they also have the potential to impact freshwater mussels, which are sensitive to disturbance and dewatering. Unlike fish, mussels are unable to avoid areas where projects impact or alter the stream bed, banks, or flow. Even when impacts are temporary, mussels are less mobile than most species and are unable to avoid or escape from active restoration sites. Additionally, the timing of restoration activities has the potential to disrupt reproduction and recruitment of juveniles. When restoration projects and activities are implemented in areas where freshwater mussels occur, practitioners stand to lose existing site values, and mussel populations may take decades to recover from impacts. We have developed a set of Best Management Practices to assist restoration practitioners protect freshwater mussels including:

- Methods to determine mussel presence, including a review of mussel survey techniques;
- Methods to include mussels in project planning activities;
- Methods to reduce impacts to mussels; and
- Methods to salvage and relocate mussels.

BMPs are provided for multiple kinds of restoration practices, including construction, vegetation management, flow management, and sediment remediation. The BMPs provide useful guidance and flexibility, as well as an opportunity to maximize benefits of aquatic restoration projects where mussels are present. By incorporating freshwater mussels into restoration design, planning, and implementation using these BMPs, practitioners can protect existing populations of declining western mussels and improve conservation efforts for these and other aquatic species.

Cute, Cute, Cute, Until They Get BIG

Rick Boatner, Oregon Department of Fish & Wildlife, rick.j.boatner@state.or.us

In 1996, Oregon Dept. of Fish and Wildlife developed and implemented the "Wildlife Integrity" rules in Oregon Administrative Rules Division 56. In part, these rules were developed to allow private ownership of some non-native wildlife species and prohibited the private ownership of other wildlife species. Some of the criteria used to determine how to classify a species were: potential to introduce disease or parasites, potential to interbreed or hybridize, potential for competition with native wildlife and whether they could survive in Oregon. If a species was a high risk for any of the 12 criteria than that animal was classified as prohibited and where not allowed in Oregon, Unfortunately, many individuals never think that a state might have laws in place that prohibited ownership of some animals or they know about the law and chose to ignore them. With the use and ease of on-line shopping this makes thing more problematic with people making the assumption that "if I can get it on-line it must be legal to own" and most on-line company will not inform the person about their state laws or life history of their purchase. Therefore, many people do not understand the responsibility of pet ownership or have knowledge of the life history of their new pet.
After a few days, months or years a person realizes that their silver dollar size hatchling turtle that was so cute is now growing up and requires a bigger tank, better filtering system, more time, etc.... and the children are now bored with it. So the options are to try to sell it and find out it was illegal to have or release it into the wild were it will be happy and be able to frolic in the fields with all their friends or my one turtle or other critter wouldn't hurt anything.   Whatever their reasoning or rational may be, people often choose the releasing option. Due to this option we now have reproducing population of prohibited species in Oregon.

For this talk we will look at some of the more common prohibited species that are found in Oregon. Learn how to identify these species and how you can help remove these species from Oregon

Beyond Borders: Working As a Natural Resource Professional in a Foreign Country

Justin Bohling, US Fish and Wildlife Service, justin_bohling@fws.gov

The demand for natural resource professionals is not limited to North America: there is ample opportunity to pursue fish and wildlife conservation opportunities internationally. Fish and wildlife management is performed differently in other countries and I firmly believe there are lessons to be learned that can benefit practices in the USA. Students from the United States increasingly have an interest in working in foreign countries and the Internet facilitates identifying opportunities in far-flung places. These are alluring, but there are challenges associated with working internationally. I will discuss my own experiences and provide general advice that would be relevant to early career professionals. Along with participating in field courses in the Neotropics, I spent a year working in France as a fisheries scientist. I will emphasize working as a professional in another country as opposed to study-abroad courses, but much of the material will be relevant to both situations. There are the obvious roadblocks that people anticipate: language barriers can significantly impact the experience as can cultural differences. Professional expectations, both in terms of day-to-day work and general productivity, can be different in other countries. Logistical administrative challenges can severely impact the experience, especially for professionals with families. Working internationally can also be a tremendously rewarding experience and facilitate professional growth. This includes not only learning new skills, but growing as an individual and learning new worldviews. International opportunities can be exciting and offer novel career experiences, but it is important to perform background research and understand the demands that accompany them.

Genetic Monitoring of Bull Trout Populations in the Upper Willamette River Basin

Justin Bohling, US Fish and Wildlife Service, justin_bohling@fws.gov
Patrick DeHaan
Nik Zymonas
Upper Willamette Bull Trout Working Group

Since the 1990s the Upper Willamette Bull Trout Working Group has been monitoring bull trout populations in the upper Willamette River basin. One aspect of the monitoring program has included a genetic component: since 2005 genetic samples have been collected and genotyped for bull trout in this system. Sampling across a decade provided a time series to track changes in the genetic attributes of these populations. Measures of genetic diversity have remained stable over time but some populations have low levels that could threaten viability. Translocations from Anderson Creek, a healthy spawning population, to other tributaries appeared to contribute to patterns of genetic diversity and population structure across the entire region. Genetics has also been used to assess the distinctiveness of spawning populations, along with estimating genetic connectivity between them. The spawning population in the South Fork McKenzie River is highly unique genetically and received no gene flow from other populations. Assessing the origin of bull trout captured at fish passage facilities has also been possible with genetic data. Reintroduction of bull trout into the Middle Fork Willamette River included the collection of genetic samples, providing a genetic perspective on the outcome of the project. This population was founded with a mix of individuals from multiple populations and had among the highest genetic diversity of any population. Incorporating genetic monitoring into this program has provided a wealth of information about these populations, enhancing management and guiding assessments of viability.

An Evaluation of Fitness and Return Timing of Reintroduced Spring Chinook Salmon in Fall Creek, Oregon

Sandra Bohn, Oregon State University, sandra.bohn@oregonstate.edu
Kathleen O'Malley

On Fall Creek, a tributary of the Middle Fork Willamette River, recovery of spring Chinook salmon (*Oncorhynchus tshawytscha*) is hindered by Fall Creek Dam, which blocks access to historical spawning habitat for this species. Beginning in 1998, primarily hatchery-origin (HOR) spring Chinook salmon were released above Fall Creek Dam with the aim of re-establishing natural production on historical spawning and rearing grounds. Since 2010, only unmarked, natural-origin (NOR), spring Chinook salmon have been reintroduced above the dam. We evaluated the efficacy of the reintroduction program by reconstructing a genetic pedigree and assigning the 2014 and 2015 adult recruits to salmon previously reintroduced in 2011 and 2012. Interestingly, there has been a marked shift toward earlier return timing in 2011-2015. To investigate whether the shift in return timing is genetically based and represents an adaptation of NOR salmon in Fall Creek, we evaluated allele frequency differences at genes influencing migration timing (i.e. circadian clock genes).

We assigned 10% of the 2014 and 87% of the 2015 adult returns to salmon previously released in 2011 and 2012. Preliminary fitness for the 2011 cohort averaged less than one progeny and preliminary replacement rates were 0.32 for males and 0.46 for females; however, our estimates did not include age-5 progeny. Notably, the proportion of age-3 males returning to Fall Creek Dam tripled from 2014 to 2015.

We found no evidence for potentially adaptive differentiation between early- and late-returning spring Chinook salmon in Fall Creek based on circadian clock gene data from only one year (2011). However, male and female salmon were genetically differentiated at two circadian clock genes (Omy1009UW and Ots515NWFSC) and 11 neutral microsatellite markers in two years (2013 and 2015), when males returned later and were shorter than females from the same respective year. When examining across years, we found that early-returning salmon in 2011 and 2015 were genetically differentiated at one clock gene (Ots515NWFSC), when the date of first return and median return date was 22 days and 29 days earlier for salmon in 2015 compared to 2011, respectively. We also found evidence for potentially adaptive genetic differentiation within each sex across years. Males in 2015 were significantly differentiated from males in both 2011 and 2012 based on variation at two circadian clock genes (Ots515NWFSC and Omy1009UW, respectively). Similarly, females returning in 2013, 2014, and 2015 were genetically differentiated from females in 2011 based on variation at the same two circadian clock genes.

Resilience Thinking in Salmon Management

Daniel Bottom, Oregon State University (courtesy faculty), dan.bottom@gmail.com
Kim Jones

Charles Simenstad
Matthew Sloat

Traditionally, Pacific salmon management has been defined as a production problem requiring prediction and control of aquatic ecosystems to reduce fish mortality, increase smolt abundance, and achieve the "optimum" adult escapement. From a production perspective, management success is defined by the numbers: survival rates, recruits per spawner, adult returns. Recent case studies of the "portfolio effect" in salmon highlight other qualities of populations—e.g., genetic, life history, and geographic variations—that determine their ability to persist in unpredictable environments. Resilience thinking has been proposed as an alternative framework to account for ecological uncertainties, including the risks of a rapidly changing climate. Yet the practical application of these ideas requires new indicators of the adaptive capacities of salmon populations and their ecosystems. This presentation will explore life history variations and other attributes of resilient salmon populations, the relationship between the physical environment and life history expression in salmon, and the human or environmental factors that strengthen or undermine salmonid "response diversity". Through these examples, we will describe indicators to incorporate resilience thinking in salmon management.

The Stored Water Volume Required to Meet Willamette BiOp Minimum Flows Using a Reservoir Simulation Model

Cindy Bowline, U.S. Army Corps of Engineers, Cindy.M.Bowline@usace.army.mil

The program ResSim was used to calculate the total water volume from the Willamette Basin projects that is used to meet the minimum flow targets at Salem and Albany on the Willamette River mainstem and the minimum tributary flows downstream of the USACE dams in the basin. These targets were defined in a 2008 Biological Opinion from NOAA. This was a detailed water volume accounting study, with the total volume calculations parsed into different flow components: the water that comes from reservoir storage, the water that was passed through the projects without being stored to meet the flow targets, the volume shortages in meeting the flow needs, and the other incidental water volumes that were released for other purposes. These water volumes were calculated for 79 years of flow data for the Basin by using the program ResSim to model current reservoir operations and then processing the simulation output data. The water volume computations were made for all years in the dataset analyzed, which show wide variability based on the water year.
These calculations were made for each individual USACE storage reservoir in the Willamette Basin, and then the individual project results were summed to obtain a total use of stored water in the basin to meet BiOp targets.

The modeling process used a set of rules within ResSim that represents the way that the projects are operated by the Corps as of 2017 and a flow dataset from the 2010 Level Modified Streamflows. A continuous simulation from October 1928 through September 2008 used a daily time step and operation rule sets that incorporate all current reservoir operations year-round. This continuous simulation is not a reproduction of what happened over those years; rather, it is a representation of what would happen now in a water year similar to each of these historical water years with the current operations of the Willamette reservoirs.

Calculated water volume components are summed to define a BiOp Need, which is any water released from the dams to meet BiOp minimum flow targets. In all years, this volume of water needed to meet the targets in the basin (stored water + passed inflow + shortages) is always greater than the maximum conservation storage of the system. The water volume component that passed through the reservoirs to meet flow targets without being stored is larger than the component of stored water released to meet flow targets.

Forecasting Salmon and Tuna Abundances and Marine Habitat Quality Based on Climatic and Oceanographic Drivers

Stephen Brandt, Oregon State University, stephen.brandt@oregonstate.edu
Cynthia Sellinger
Cassandra Glaspie

Pacific-coast, Chinook salmon have important economic and cultural value to the entire northwest region. Recent declines in abundances have been attributed, in part, to changes in climate, but the impact of changing climate and ocean current structure on habitat for Chinook salmon is not fully understood because marine habitat quality for salmon has yet to be quantitatively and mechanistically defined. The marine stage of the salmon life cycle not well understood, yet is critical to salmon production, survival and reproductive potential. We used a well-tested, spatially-explicit bioenergetics modeling approach to quantify essential fish habitat (EFH) for Chinook salmon in ocean and coastal waters and examine shifts in EFH over time and space. We examined the impact of past climate shifts (e.g. El Niño events, Pacific Decadal Oscillation) and coastal upwelling on salmon growth rate potential (a measure of habitat quality) using all of NOAA's World Ocean Database for the N. Pacific and detailed data from the Newport Line. Measures of habitat quality correlated well with observed regime shifts, upwelling events and annual commercial/recreational landings. Similar analyses for Albacore Tuna are underway. We contend that an integrated, dynamic definition of habitat quality, such as Growth Rate Potential, is necessary to understand the impacts of climate oscillations on fishery production. Ultimately, our goal is to develop a predictive framework to incorporate habitat quality to forecast Chinook salmon and tuna distribution, production and returns in the short- (1-3 years) and long- (20-50 years) term, and provide maps of species-specific habitat quality across the Pacific to local and regional fisheries managers.

Willamette River Floodplain Restoration – Reconnecting Overwintering Habitats for Juvenile Salmonids

Troy Brandt, River Design Group, Inc., tbrandt@riverdesigngroup.net
Pete Gruendike
Russell Bartlett
Chris Smith

The Willamette River floodplain formed under a historical hydrogeomorphic regime considerably different than the contemporary regime that is controlled by thirteen high head dams comprising the Willamette Project. In addition to the modified flow regime, the Willamette River floodplain has been developed over the past nearly 200 years to improve economic productivity, facilitate human habitation, and reduce flood impacts to floodplain infrastructure. Interior floodplain features including side channels, alcoves, and remnant channel segments, historically provided overwintering habitat for Upper Willamette River (UWR) spring Chinook salmon, UWR winter steelhead, and other native fish species. Overwintering habitats provide lower water velocities, more complex cover, more productive food resources, and warmer water temperatures relative to in-channel conditions. The combination of the regulated flow regime and floodplain modifications have reduced the connectivity and availability of these habitats for winter fish use.

River Design Group, Inc. (RDG) has collaborated with conservation organizations and fish and wildlife agencies over the past 10 years to improve the connectivity between the Willamette River and the adjacent floodplain. RDG works with partners to identify qualifying properties, assess floodplain habitat conditions, and determine river-floodplain connectivity constraints. Hydrologic and hydraulic modeling are completed to determine frequency and duration of river-floodplain connectivity based on flood hydrology. Engineering designs account for system hydrology, site conditions, and land use and site constraints. Habitat and channel stability designs are prepared to enhance habitat and minimize project area erosion potential.

Projects completed on both private and publicly-owned properties in the Eugene to Salem reach of the upper Willamette River have included floodplain road crossing improvements, floodplain grading to reconnect interior habitat features, gravel pit pond modification, extensive reforestation, and other aquatic habitat enhancement. Project partners are engaged in post-project monitoring to assess hydrologic connectivity, riparian reforestation success, and fish use.

Changes in Native Salmonid Production Potential in Response to Forest Fire

Benjamin Briscoe, Mount Hood Environmental, Benjamin.Briscoe@mthoodenvironmental.com
Christopher J. Fisher
Ian Courter
Forrest Carpenter
Kevin Ceder
Sonya Schaller
Dennis L. Papa

Fire suppression can have a significant influence on flow conditions and salmonid habitat availability in streams by increasing tree stand density and water loss due to evapotranspiration. To quantify the impact of fire suppression on flows in the Omak Creek basin, Washington, stream discharge, physical stream habitat types (cascade, glide, pool, or riffle), and fish densities were measured in two tributaries to Omak Creek, Stapaloop and Swimptkin Creeks between 2014 and 2017. A wildfire burned 76% of the Stapaloop Creek watershed in 2015 while the Swimptkin Creek watershed remained intact. Base stream flows measured in Stapaloop Creek in 2014 were 19% higher compared to Swimptkin Creek, and 118% higher in 2017 indicating that reduced stand density may have substantially increased base stream flows in Stapaloop Creek relative to Swimptkin Creek. Additionally, fish assemblages in Stapaloop Creek changed from predominantly invasive Eastern brook trout (*Salvelinus fontinalis*) to a higher relative abundance of native rainbow trout (*Oncorhynchus mykiss*). Wetted stream channel width and maximum pool depth also increased from 2014 to 2017 in Stapaloop Creek. Our

preliminary results corroborate the theory that reintroduction of a historical fire regime increases stream flow and may also increase native salmonid production and habitat quality.

Past, Present and Future Willamette Tributary Temperatures

Norman Buccola, U.S. Army Corps of Engineers, norman.buccola@usace.army.mil

In recent years, several dams in Willamette River tributaries owned by the U.S. Army Corps of Engineers have been operated with the intent of achieving more normative temperatures downstream in support of restoring threatened and endangered Upper Willamette River (UWR) Chinook salmon (*Oncorhynchus tshawytscha*) and UWR winter steelhead (O. mykiss) fisheries. These changes include the construction of a selective withdrawal temperature tower at Cougar Dam on the McKenzie River (completed in 2005), interim temperature operations at Detroit Dam on the North Santiam River (since 2007), and plans to build a selective withdrawal structure at Detroit Dam (2023). The Corps is currently studying the relative thermal impacts from dam operations, potential structures, and environmental conditions at selected points downstream of Cougar, Big Cliff, and Foster dams on the McKenzie, North Santiam, and South Santiam Rivers respectively. This presentation will illustrate the effects of past and present temperature operations (based on monitoring data) and compare them to predicted temperatures achieved with proposed and hypothetical selective withdrawal structures at Detroit, Green Peter, and Foster Dams (based on simulations). The results will be focused on discovering the effects of year-to-year variation of downstream heat exchange as expressed in thermal accumulation experienced by Chinook salmon and steelhead during fall and spring. Results will be compared with estimates of pre-dam conditions to assess the system potential of each project.

Willamette River Environmental Flows

Christine M. Budai, U.S. Army Corps of Engineers, christine.m.budai@usace.army.mil

The U.S. Army Corps of Engineers Portland District (Corps) operates 13 dams in the Willamette Basin that provide a range of human benefits, including flood risk management, hydropower, irrigation, and recreation. However, operation of these dams has changed the volume and timing of water flow in the river, resulting in reduced peak flows, lower spring flows, increased summer low flows, and infrequent bankfull events. Alterations to the natural flow regime affect the health and viability of the freshwater ecosystems and the aquatic and terrestrial species and communities they sustain. To address this issue, the Corps and the Nature Conservancy (The Conservancy) have worked together to determine environmental flow requirements downstream of the dams, and to identify opportunities to restore key aspects of the flow regime.
The Corps partnered with The Conservancy to produce an implementation plan for environmental flows at multiple projects within the Willamette Basin. The goal was to operationalize the environmental flow recommendations into acceptable guidance and recommendations for Willamette reservoir regulators and project operators for implementation.
Environmental flows have been successfully conducted on the Middle Fork Willamette, North Santiam, and South Fork McKenzie, all major subbasins within the Willamette Basin. The Willamette's flows are essential for fish species downstream, lateral movement into floodplains that creates off channel habitat, gravel bar

migration, and dispersal/recruitment of vegetation. Preliminary monitoring of Willamette environmental flows show positive trends.

Modeling Resilience: Prospects for Quantitatively Assessing Salmon Habitats Under Uncertain Futures

Kate Buenau, Pacific Northwest National Laboratory, kate.buenau@pnnl.gov
Nichole Sather
Amy Borde
Gary Johnson

Protection and restoration of salmon populations is challenged by broad spatial and temporal variability in habitats and their environmental drivers. This challenge is only increased by uncertainty in climate-driven environmental trends and the feedbacks they produce. An approach to assessing these uncertainties—and the resilience of habitats and populations to variability and systematic change—is through quantitative information synthesis and predictive modeling of salmon-habitat relationships. While quantitative modeling is often used as a tool for planning restoration and measuring project or program success, it is also highly valuable for the identification of gaps in conceptual models and information availability. Initial attempts at building such models for the Lower Columbia River and estuary identified several challenges: 1) information gaps, particularly regarding primary and secondary productivity, 2) the focus of prior research and monitoring on states, not processes, and 3) high variability in conditions, communities, and salmonid responses across relatively small spatial scales, which may make functional relationships difficult to detect. If these obstacles can be addressed through focused research and monitoring, there is high potential for such models to not only aid in short- to medium-term management planning but also to address long-term management for resilience to climate or land use threats. Other important considerations for assessing resilience with models include using an iterative approach: i.e., building and testing a model and using it to identify specific research needs, then using new findings to improve successive iterations of the model to inform decision-making processes of the effects of uncertainty throughout the process. Scenario-based assessments are helpful for evaluating the potential effects of changes in drivers, such as climate-driven trends, and in weighing the costs and benefits of management alternatives. Finally, it is crucial that resource managers and stakeholders be involved with scenario development and the identification of decision-relevant metrics to ensure the model applications are understood and accessible to those who require the information. While model development often requires multiple iterations and levels of engagement before the model is mature enough to address planning questions, the process itself is valuable for understanding and synthesizing factors leading to resilient habitats and populations, and for improving the state of the science itself.

Tracking Northern Pike Invasions in the Columbia River Basin

Kellie Carim, U.S. Forest Service, kelliejcarim@fs.fed.us
Lisa Eby
Virgil Dupuis
Loren Miller
Michael Young

Michael Schwartz

Northern pike are native to Holarctic waters in Russia, Europe, Canada, Alaska, and the eastern U.S., where they are considered a keystone predator and are prized as a sport fish. Their popularity among anglers has led to many illegal introductions outside their native range, particularly in western North America where they are regarded as a threat to many native species. Recent and rapid expansions of northern pike into the mainstem of the Columbia River have led to extensive suppression efforts. Identifying upstream source populations of northern pike contributing to this expansion could help thwart reinvasions and continued expansion of northern pike in the Columbia River basin. We are using genetic assignment to identify the most likely source populations contributing to the expansion of northern pike in the Columbia River Basin. If recent invasion of northern pike in the Columbia River was caused by downstream immigration, we expect their population structure to exhibit isolation by distance, with established populations in eastern Washington being the most likely source of downstream invaders. If this invasion is primarily the result of illegal introductions, however, the most likely source population of the recent invasion may not be the nearest neighboring population on the landscape. To evaluate these hypotheses, we analyzed 11 microsatellite loci to examine genetic relationships between northern pike in Lake Roosevelt and five established populations in western Montana, northern Idaho, and eastern Washington. These laboratory results are pending and will be reported in this presentation.

What's for Lunch? An Assessment of Piscivorous Fish Diets in the Columbia River Related to Targeted Northern Pikeminnow Removals

Andrea Carpenter, Oregon Department of Fish and Wildlife, andrea.l.carpenter@state.or.us
C. Mac Barr
Eric Tinus

The Northern Pikeminnow Management Program (NPMP) has applied targeted removal fisheries in the Columbia and lower Snake rivers since 1990 to reduce predation on out-migrating juvenile Pacific salmon and steelhead (*Oncorhynchus spp.*) by restructuring the size distribution of Northern Pikeminnow (*Ptychocheilus oregonensis*). Since 1990, the Oregon Department of Fish & Wildlife (ODFW) collected biological data via electrofishing from Northern Pikeminnow, Smallmouth Bass (*Micropterus dolomieu*), and Walleye (*Sander vitreus*) to assess consumption of salmonids and determine potential compensatory mechanisms that may dampen the presumed benefits of the NPMP. Additionally, ODFW sampled Northern Pikeminnow removed via hook-and-line at The Dalles and John Day dams annually from 2006-2017 for similar purposes of evaluation. We examined the contents of digestive tracts collected from both methods to quantify relative consumption of juvenile salmon. Contents were analyzed in the laboratory and sorted into general prey categories. Samples containing fish hard structures were chemically digested to clean bones to allow identification to the lowest taxonomic level and conservatively enumerated to arrive at counts of a given taxon in a diet sample. We analyzed data from our time series to characterize diets of piscivorous fish species, consumption of salmonids, and to evaluate any changes over time. Though targeted removals of larger individual Northern Pikeminnow may increase survival of migrating juvenile salmonids, remaining Northern Pikeminnow or other piscivorous fishes could potentially offset the net benefit of Northern Pikeminnow removals due to reduced competition or other compensatory mechanisms.

Salmon and Steelhead Hooking Mortality in the Lower Cowlitz River

Forrest Carpenter, Mount Hood Environmental, forrest.carpenter@mthoodenvironmental.com
Ian Courter
Thomas Buehrens
Benjamin Briscoe
Joshua Richards
Scott Gibson
Jamie Murphy
Missy Baier

Salmon and steelhead hooking mortality rates affect both the quantity and duration of sport fisheries in the Columbia Basin where Endangered Species Act (ESA) listed stocks are impacted by angling. In most cases, ESA-listed wild stocks are hooked and released by anglers targeting hatchery salmon and steelhead. Angling impacts associated with these fisheries are typically calculated using an estimate of the number of wild salmon or steelhead captured combined with simple assumptions about hooking mortality. Limited empirical data exists to inform these assumptions and current mortality estimates do not account for specific aspects of the fisheries that may significantly alter hooking mortality rates (i.e. water temperature, angling gear/methods, species, or run type). To improve the accuracy and regional specificity of hooking mortality estimates used to manage salmon and steelhead sport fisheries in the Columbia Basin, we initiated a three-year angling evaluation on the Lower Cowlitz River in southwest Washington in May 2017. We intend to further the development of an empirical model relating salmon and steelhead mortality to catch and release angling practices as well as environmental conditions. Between May and November 2017, 315 hatchery salmon and steelhead have been angled and tagged. Angled tagged fish are reported recaptured by recreational anglers, creel surveyors, or by operators at the Cowlitz Salmon Hatchery adult fish separator. Due to well below average returns of summer steelhead and fall Chinook to the Lower Cowlitz River in 2017, Coho Salmon make up the majority of tagged treatment (angled) fish thus far. Twenty-nine control fish releases of non-angled summer steelhead and Coho Salmon occurred in 2017 and provide an avenue to directly compare treatment fish recapture rates to control groups. Initial results indicate that recapture rates vary between control and treatment groups, by gear types (bait, lures, bait/lure, jigs, or flies), and by angling methods (bobber, gear, fly, back troll, etc.).

Estimating and Correcting For Size Selectivity of Longline Sampling Gear Targeting White Sturgeon in the Lower Columbia River

Colin Chapman, Oregon Department of Fish and Wildlife, colin.g.chapman@state.or.us

The ideal sampling methodology would provide a representative sample of a population by collecting animals in proportion to their actual abundance in the environment. However, all fishing gear is, to varying degrees, selective for certain attributes. Therefore, quantifying the selectivity of a given sampling gear and correcting for that selectivity can lead to improved stock assessments. The most direct method for estimating size selectivity of a sampling gear is to mark a large number of fish and determine the proportion of marked fish caught by the sampling gear in different size categories. Here we present proportional recapture data from 18 unique mark-recapture experiments conducted from 1999 to 2017 and estimate size selectivity of longline sampling gear targeting White Sturgeon in the lower Columbia River. Results indicated a dome-shaped selectivity curve, with selectivity changing over time. Maximum selectivity from 1999-2008 occurred at ~100 cm fork length (FL), while maximum selectivity from 2009-2017 occurred at ~112 cm FL. Across all years selectivity was lowest for fish <60 cm FL and >150 cm FL. These results can be used to improve stock assessments by correcting length frequency data of white sturgeon captured with longlines in the lower Columbia River, and potentially other areas as well.

Writing for the Record: Lessons Learned On Why and How to Publish Your Work

Benjamin Clemens, Oregon Department of Fish and Wildlife, Ben.Clemens@oregonstate.edu

I present my experience in research, writing, reviewing, and editing, including publishing papers in 15 different scientific outlets; serving as a peer reviewer of manuscripts for 16 different scientific journals; and serving as an Associate Editor for North American Journal of Fisheries Management. This experience includes input from a former graduate advisor on the importance of publishing: "The tax payers are paying for this. If you don't write it up, it's like it never existed". This ignited my interest in effective communication of science early in my career, including documenting my work through publishing. I believe that engaging in the publication and review process is an important part of being a practitioner of fisheries science, and while some work is not publishable, with the right outlet, other work is. I explore some consistent missteps that can be addressed to improve chances for publication and present some examples of pitfalls in attempting to publish (i.e., what not to do). I conclude that publication is not always a desirable end goal, but is attainable for the intrepid and persevering person. Publishing is fundamental for promoting learning and progress in our profession, and it has the added benefits of helping to advance careers and solidify collaborations.

The Effect of Rearing Environment on Spatial Learning Ability in Juvenile Chinook Salmon

Karen Cogliati, Oregon State University, karen.cogliati@oregonstate.edu
Julia Unrein
Carl Schreck
David Noakes

Environmental factors may promote behavioural flexibility and cognition. There is a commonly held hypothesis that rearing animals in more complex ("enriched") environments will produce greater behavioural complexity and flexibility. We tested the prediction that a more complex physical rearing environment would enhance fish cognition as assessed by learning ability in a spatial navigation task in juvenile Chinook Salmon, *Oncorhynchus tshawytscha*. We reared fish in two treatments: bare fiberglass tanks or tanks with physical structure. Additionally, we compared fish from both our rearing treatments to conventionally reared hatchery fish. We tested individually marked fish for seven consecutive days and recorded movement and time to exit a testing maze. Stimulus conspecific fish outside the exit of the maze provided positive reinforcement for test fish. There

were no significant behavioral differences between experimental fish reared with and without structure. However, our experimentally reared fish made significantly fewer mistakes but took longer to exit the maze compared to hatchery fish. Hatchery fish showed the greatest degree of learning over time, but the number of mistakes and time to exit the maze were both significantly greater on the first day of trials. Increasing habitat complexity with structure may not promote spatial learning ability, but differences between groups in density and motivation to be near conspecifics likely led to observed behavioral differences.

Enhancing Fish Detection with Newly Developed Electrofishers, eDNA Detection Devices, and Automated Data Collection

Patrick Cooney, Smith-Root, pcooney@smith-root.com

The presentation will discuss how newly developed field rugged eDNA detection technology paired with georeferenced electrofishing equipment is improving crew efficiency and increasing confidence in the results of fish surveys.

Timing and Environmental Cues for Downstream Migrating Juvenile Lamprey in the Clackamas River

Dan Cramer, Portland General Electric, dan.cramer@pgn.com

In 2006 Portland General Electric finished construction of a lamprey friendly fish ladder bypassing River Mill Dam, replacing a fish ladder that had been a significant passage impediment to Pacific lamprey for nearly 100 years. Shortly after completion of the new ladder a two year adult lamprey trap and haul program was implemented to bypass the three dam hydroelectric complex on the Clackamas River and help restore lamprey populations in the upper Clackamas River. Additional fish passage improvements were made that included construction of downstream migrant collection facilities at River Mill Dam in 2012 and the North Fork Dam in 2015. Though these collectors were designed for salmon and steelhead passage they have shown success in collecting downstream migrating juvenile lamprey. With year round operation of these collection facilities annual increases in the number of downstream migrating lamprey ammocoetes and macropthalmia have been observed at both locations. Continuous operation of these facilities has also given insight into timing and environmental cues for lamprey movement. This presentation will discuss trends in captures of juvenile lamprey at downstream collection facilities, length distributions of juveniles sampled by season and life stage, and associations between environmental cues and migration timing.

Historical Abundance of Oregon Coho: It's Not What We Thought

Steve Cramer, Cramer Fish Sciences, steve@fishsciences.net

It has become a frequent practice when describing the status of salmon populations at risk to compare historic and present estimates of abundance. We investigated historic data on Oregon Coast Coho fisheries as an example for the reliability of historic population estimates. We found that coastwide, from California to Alaska, broad-scale monitoring of salmon spawner escapement did not begin until the 1950's. Regional estimates of salmon populations before 1950 are based entirely on harvest data, combined with assumptions about what fraction of the population those catches represented. For Oregon Coast Coho, we tested the prevailing assumption that in-river landings represented a constant 40% of the population extending back to 1892. Data on license sales and harvest restrictions, as well as accounts by fisheries managers all established that populations were being over-fished prior to 1945, and harvesting was sharply curtailed by regulatory action after 1947. Fin-mark studies at Oregon hatcheries beginning in the 1940s also provide a basis to estimate harvest rates in the late 1940s and 1950s, as do mark-recapture studies with adult Coho tagged as they entered freshwater in the 1950's. These early data collected by the Oregon Fish Commission and Oregon Game Commission indicate historic harvest rates were roughly double those of prevailing assumptions, which means the fraction that escaped to spawn was much lower than prevailing assumptions. The earliest surveys of OCN Coho also show low numbers of spawners that began increasing, not decreasing, into the mid 1950's. Revised harvest rate assumptions consistent with these historic data indicate spawner abundance of OCN Coho during 1892-1956 was not greater than today, but varied within a similar range to that in recent decades. The OCN example illustrates the danger of placing faith in historic population estimates that depend on speculation about historic harvest rates.

Update: Science and Applications of Biotic Tools to Assess Sediment Regime in Streams

Robert Danehy, Catchment Aquatic Ecology, danehy@catchmentae.com
Patrick Edwards

Water quality is important. Fine sediment naturally travels down streams as long-term erosional processes occur accentuated by disturbance events. Tools to measure sediment regime in streams include physical (turbidity or pebble counts) and biological (fish, invertebrates, periphyton). Biological stress to fine sediment is species specific resulting from the duration and magnitude of exposure to suspended sediment events or (and) alteration of bed conditions (substrate infilling, pool deposition).
Macroinvertebrate indices to assess stream assemblages of this species rich community (typical reach richness > 300 populations) recently have been developed in PNW. The indices used PNW data sets to identify substrate habitat preferences for regional macroinvertebrates. In one of the first applications a fine sediment biotic tool found populations sensitive to fine sediment declined as road density increased. More recent examples and ongoing research includes applications in disturbance impacts and rates of recovery, paired watershed study treatment comparisons, and ongoing bioassessment in the region. Tools provide biological measures by assessing populations which integrate impacts more broadly than physical measures.

Adult Spring Chinook Migratory Response to Passage Improvements at the Clackamas River Hydroelectric Project

Maggie David, Portland General Electric, margaret.david@pgn.com
Nick Ackerman
Garth Wyatt
Dan Cramer

Cory Starr

PGE owns and operates a hydroelectric project on the Clackamas River in northwest Oregon. The Project is over 100 years old and consists of three dams with two fish ladders. Under the terms of the License issued in 2010, PGE built, replaced, or modified most of the upstream migrant fish facilities, and modified operations to improve fish passage conditions. Using radio telemetry, spring Chinook migration behavior within the Project was used to evaluate passage improvements and to identify potential existing problems, as well as, potential cumulative effects from the Project on subsequent upper basin migrations. Marked improvements were seen in passage rate and passage time within the Project. Above the Project, there was no negative effect on migratory behavior of fish that migrated through the Project compared to fish bypassed around the Project. This presentation will briefly cover passage improvements but will focus mainly on results from the telemetry evaluation.

Resource Selection by Winter Steelhead on the West Fork Smith River, Oregon

Morgan Davies, Oregon Department Fish and Wildlife, davies.morgan@gmail.com

Due to mismanagement, over-harvest, and habitat loss anadromous fish populations in the Pacific Northwest region of the United States suffered severe declines throughout the 1900s (Noakes et al. 2000, NOAA 2005, Heard et al. 2007). Better management practices and temporary closures of commercial and recreational fishing have reversed the downward trend (NOAA 2005, Heard et al. 2007). Along with this, habitat recovery programs have been implemented throughout the area to improve spawning and rearing habitat as well as overall water quality (NOAA 2005). Current monitoring of habitat done by the Oregon Department of Fish and Wildlife (ODFW) measures at a unit scale (e.g. pool, riffle, pool) along a 1,000m segment. Data that is collected at each unit includes depth, width, length, slope, substrate, shade cover, and presence of habitat structures. These unit data are then lumped together to give an overall picture of the 1,000m segment. During steelhead spawning season Global Positioning System (GPS) locations are taken at each redd found.

The way the data are currently analyzed shows how much utilization a particular segment may achieve, but does not analyze patterns at a finer scale. I propose that by taking the unit data and mapping it spatially along the 1,000m segments using Dynamic Segmentation in ArcGIS and combining this with the redd locations I can create a habitat utilization model. This model could be used to analyze utilization of natural gravel beds versus those created by habitat structures as well as utilization of different substrate makeup (e.g. percent cobble, gravel, and sand).

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Water in the Willamette: Identifying Environmental Flows for the Ecosystem and Listed Salmonids

J. Tyrell DeWeber, Oregon Cooperative Fish and Wildlife Research Unit, Oregon State University, jtdeweber@gmail.com
James T. Peterson

Sustaining the ecological integrity of lotic ecosystems, while providing needed water resources for human needs is a major challenge facing society. The Willamette River ecosystem is a prime example these challenges. The Willamette River ecosystem has been altered by impoundments, flow regulation, and human land development, which has negatively affected fluvial-dependent biota such as federally threatened Chinook salmon *Oncorhynchus tshawytscha* and steelhead O. mykiss. We describe a science-based decision support process to evaluate tradeoffs in management objectives and identify environmental flows that can sustain and help restore the Willamette River ecosystem. The primary steps of this process were to identify ecosystem objectives, review existing information linking flows to ecosystem objectives, identify key knowledge gaps, prioritize new analyses to address key knowledge gaps, and summarize information to help evaluate environmental flow needs. To enable this project to address diverse aspects of the river ecosystem, we worked with the Science of Willamette Instream Flows Team (SWIFT), an interdisciplinary team of scientists and managers with knowledge and experience in the Willamette River. The information review process revealed significant knowledge gaps in our understanding of how flow affects the river ecosystem, and the SWIFT identified several analyses to help address these knowledge gaps. We discuss the results of analyses in relation to expected ecological responses to alternative environmental flows, and ongoing efforts to develop science to support instream flow decisions for the Willamette River system.

Climate, Drought, and Streams in the Western United States

Jason Dunham, U.S. Geological Survey, jdunham@usgs.gov

Stream flows and temperatures are changing across the western United States as climates warm and the probability of drought increases. At a regional extent, the PRediction Of Streamflow PERmanence or PROSPER model has been built with over 20,000 crowd-sourced point observations of wet/dry conditions in streams. PROSPER has the capability to predict probability of perennial flows in streams and to track changes associated with climate. Within Oregon and to the south in the northwest Great Basin, instrument networks are tracking stream flows and temperatures on a year-round basis. Instrumental data provide much higher resolution information, but cover fewer points and smaller extents. Preliminary results to date highlight the sensitivity of Great Basin streams to drought, including wildfires, the extent to which existing classifications correctly characterize flow permanence, and new methods to extract information on drying regimes based on daily records of temperature. These models and instrument networks are providing new and powerful capabilities to better understand changing streamflow permanence and thermal regimes across the region.

The OBGP: Genomic Data Assembly for the Development of Enhanced Molecular Monitoring Tools

Emily Dziedzic, Oregon State University, emily.dziedzic@oregonstate.edu
Taal Levi

Rapid technological advancements and decreasing DNA sequencing costs have led to a genomics revolution enabling the development of molecular applications to monitor biodiversity and assess management policies. The Oregon Biodiversity Genome Project (OBGP) was established to develop novel genetic tools to quantify the distribution and ecology of fish, wildlife, and invertebrates to understand how ecosystems function and respond to management intervention. Such tools allow the rapid evaluation of policy impacts on fish and wildlife. Traditional methods to measure biodiversity are inefficient and strides have been made to enhance our ability to monitor wildlife using molecular detection tools with environmental DNA (eDNA). Assays can detect target taxa in eDNA at various levels. Species-general primers can identify a range of species while species-specific primers can be used to identify the presence of individual species. To develop these tools we need comprehensive genomic data, and data for these applications are generally collected piecemeal for individual genes and applications. This frustrates researchers' ability to fine-tune tools to discern single species or targeted groups of species from eDNA. The OBGP will create a comprehensive georeferenced reference sequence database including full mitogenomic data for Oregon's animal species. We will make these data publicly available to facilitate molecular tool development for wildlife monitoring and management. We are currently working with ODFW, OSU, and the USFS to develop these resources and are interested in forging collaborations to expand the taxonomic scope of the OBGB, which will require georeferenced animal tissues of species throughout Oregon.

Application of Portfolio Theory in Recovery Planning for Pacific Salmon

Joseph Ebersole, U.S. EPA, ebersole.joe@epa.gov
Marcía Snyder
Matthew Sloat
Jonathan Armstrong

Ecological applications of portfolio theory demonstrate the utility of this analytical framework for understanding the stability of commercial and indigenous Pacific Salmon fisheries. Portfolio theory also has the potential to aid in recovery planning for threatened and endangered Pacific salmon but it has not been applied in this context. This study applies portfolio theory to recovery planning for the Oregon Coastal Coho Salmon (*Oncorhynchus kisutch*) Evolutionary Significant Unit (ESU). This ESU includes 21 independent populations organized into five geographically and genetically cohesive strata. We apply portfolio theory to time series of spawner abundance to identify stability properties of populations within and among ESU strata. We also correlate population stability properties with watershed-scale habitat features to explore landscape controls on Coho Salmon population dynamics. Our work identified high variation among five ESU strata in the temporal stability of Coho Salmon populations. Variation among strata was associated with watershed-scale habitat features. In particular, the stratum with highest levels of temporal population stability (lowest coefficient of variation [CV] in population abundance) is notable for the presence of coastal lakes that are known to relax winter habitat survival bottlenecks for juvenile Coho Salmon. We observed low temporal coherence in population abundance within other strata, suggesting considerable response diversity of populations in close proximity. These results reflect an important analytical framework for designing conservation strategies for population aggregations such as Pacific Salmon ESUs.

The Future's So Bright (or) How Do You Become What You Decided You Wanted To Be When You Grew Up?

Demian Ebert, Pacific Power, demian.ebert@pacificorp.com

The transition from school to a professional career in a non-academic setting is a period of massive change and uncertainty. You've been soaking up information for years and now are being asked to apply that knowledge. What decisions do you need to make and how do you make sure they are the most informed decisions? What steps should you take to ensure the transition is as successful as it can be? Wouldn't you like to know what you don't know that would help you to be successful? Expect to receive helpful information on network development, decision making, self-valuation, and work-life balance. We are going to crowd-source some answers to a short, but to-the-point set of questions that focus on desirable attributes in job candidates, advanced degrees, important skill sets, and other factors that influence success. By using networks of established professionals we'll be able to provide specific and helpful information.

Zis a ba Estuary Restoration for Salmon Habitat and Climate Resilience

Daniel Elefant, Cardno Restoration Engineering & Geomorphology, daniel.elefant@cardno.com
Sky Miller

Tidal data and the inundation characteristics of tidal wetlands are affected by changes in global sea level. Global average eustatic sea level has risen 0.6 feet in the past century and is predicted to rise an additional 0.6 to 1.9 feet in the century ahead (Intergovernmental Panel on Climate Change 2007). The National Wildlife Foundation (2007) modeled potential impacts of sea level rise on coastal habitats in the Pacific Northwest and estimated a 25% loss of freshwater marsh and 31% loss of tidal swamp habitats in the Columbia River Estuary for the 1.9-foot-rise scenario. Actual impacts to the distribution of tidal wetland habitats at the project site (adjacent to Stanwood, WA along the Old Stillaguamish River Channel) will depend on not only the rate of sea level rise but the rate of sediment accretion as well. Cardno estimates the relative sea level rise (accounting for vertical land movement and eustatic sea level rise) at the zis a ba site for 2050 and 2100 to be 6 inches and 13 inches, respectively, for the moderate scenario defined by the University of Washington Climate Impact Group's 2008 report titled "Sea Level Rise in the Coastal Waters of Washington State" (Mote 2008).

The Old Stillaguamish River channel will experience deposition into the future due to sea level rise, reduced fluvial flows, and reduced tidal flows (net reduced tidal prism). However, the zis a ba estuary will act as a net sediment sink. Thus, the project will reduce risk of long-term sedimentation to the City's infrastructure, but it cannot eliminate the long-term drivers of this trend. Tidal marshes are well known for trapping suspended sediments and aggrading vertically to keep up with sea level rise adding to a community's climate resilience.

Furthermore, the project was designed to maximize post-construction and future evolution of salmon habitat. Construction was completed fall 2017 and Stillaguamish fish biologists have already documented salmon access on the newly restored estuary site.

Hydraulics, Geomorphology, Wetlands, Design, and Construction for the 3 Crabs Restoration Project, Olympic Peninsula

Daniel Elefant, Cardno Restoration Engineering & Geomorphology, daniel.elefant@cardno.com
Jack Bjork

The project is located near the mouth of Meadowbrook Creek and the Dungeness River on the Olympic Peninsula. Historically hydraulically connected to the Dungeness River, the 3 Crabs estuary was cut off in the 1960s when a levee was constructed to protect the Town of Dungeness. The estuary has also been impacted by filling and associated re-grading as well as the construction of roadways and residential development, and an undersized crossing. The site includes property owned by Washington Department of Fish and Wildlife, Clallam County and Dungeness Farms and project planning and design involved a close working relationship with them as well as local residents. In addition to restoration of the tidal lagoon system to improve vital estuarine salmonid rearing habitat, this project set back an old Clallam County roadway and utilities and replaced an undersized county bridge. Cardno's work included a site geomorphic analysis, tidal hydrology analysis, hydrodynamic modelling, community and stakeholder facilitation, and engineering design plans, specifications, and construction cost estimates. Cardno provided bid support with construction completed in 2016.

Detecting the Effects of Management Regime Shifts in Dynamic Environments Using Multi-Population State-Space Models

Matt Falcy, Oregon Department of Fish And Wildlife, matt.falcy@oregonstate.edu
Erik Suring

Detecting the effectiveness of management actions intended to increase the abundance of threatened or exploited species can help resolve uncertainties about cost-effective management tactics intended to meet societal values. However, the complexity of ecological systems can make it difficult to identify important factors causing change in population abundance. This difficulty extends from detecting naturally-caused ecosystem regime shifts to management-induced regime shifts. The adult abundance of naturally-produced Coho Salmon (*Oncorhynchus kisutch*) on the Oregon Coast generally declined until these fish were listed as threatened under the Endangered Species Act in 1998. The subsequent rebuilding of Oregon coastal Coho adult abundance is coincident with increased habitat restoration, reduced hatchery production, and reduced harvest. Importantly, ocean survival also improved, thereby complicating the assessment of management effectiveness at the adult life stage. Our objective was to assess change in the freshwater production of juveniles (smolts) through time in order to determine if recent increases in adult abundance could be related to management affecting the freshwater juvenile production. We combined 46 years of data associated with 18 populations of Oregon coastal Coho. Spawner-to-smolt relationships were modeled with Bayesian hierarchical state-space implementations of the logistic hockey stick recruitment function. Our models estimated the relative reproductive success of hatchery spawners. We found more evidence for decline than increase in productivity in the spawner-to-smolt life stage, suggesting that changes in physical oceanographic conditions are responsible for recent increases in adult abundance. The reproductive success of hatchery-origin fish relative to natural-origin fish was 0.51 with a 95% credible interval from 0.19 to 0.89. While some management effects may unfold on longer time-scales than we observed, the analysis nonetheless provides a framework for evaluating the effects of management in a manner that is analogous to detecting natural regime shifts.

Catherine Creek and Grande Ronde River Spring Chinook Salmon Reach-Specific Survival During Spring Emigration

Scott Favrot, Oregon Department of Fish and Wildlife, scott.d.favrot@state.or.us
Brian Jonasson

During 2011−2013 and 2015–2017, we estimated reach-specific survival for radio-tagged Catherine Creek and Grande Ronde River spring Chinook salmon *Oncorhynchus tshawytscha* smolts emigrating through the Grande Ronde Valley, northeast Oregon, respectively. For all years, we detected no relationship between condition and travel time when successful and unsuccessful naturally-produced smolts were compared. For naturally-produced Catherine Creek smolts, reach-specific survival ranged from 0.59 (SE = 0.10) to 0.95 (SE = 0.03), whereas survival within most Grande Ronde River reaches was typically 1.00. For naturally-produced Grande Ronde River smolts, reach-specific survival ranged from 0.81 (SE = 0.10) to 0.96 (SE = 0.03) from the release site to the Wallowa River confluence, where reach-specific survival estimates typically were considerably higher. For Catherine Creek naturally-produced smolts, slow emigration rates and high mortalities were documented throughout Catherine Creek, while fast emigration rates and low mortalities occurred within the Grande Ronde River. For Grande Ronde River naturally-produced smolts, slow emigration rates and high mortalities were documented from the release site to the Wallowa River confluence, while fast emigration rates and low mortalities occurred downstream from the mouth of the Wallowa River. Both Catherine Creek and Grande Ronde River naturally-produced smolts initially exhibited slow seaward migration rates coupled with low survival rates, which transitioned to fast emigration rates associated with high survival rates upon reaching downstream large river confluences. In 1869, the Grande Ronde River State Ditch was constructed to alleviate spring flooding of agriculture land within the lower Grand Ronde Valley. The Grande Ronde River State Ditch has considerably altered hydrology characteristics within the Grande Ronde Valley, and these altered hydrology characteristics may have deleteriously changed critical migrations cues. Our research results have improved our understanding of Catherine Creek and Grande Ronde River smolt behavior and mortality within the Grande Ronde Valley during seaward migration, suggest critical issues potentially vital to the restoration of these populations, and can guide holistic management particularly relevant to improving survival of emigrating smolts upstream from the Snake and Columbia River hydrosystem.

Alternatives and Design of Cougar Downstream Fish Passage

Scott Fielding, U.S. Army Corps of Engineers, scott.d.fielding@usace.army.mil
Jeremy Britton
Chris Budai

In its 2008 Biological Opinion (BiOp), the National Marine Fisheries Service (NMFS) concluded that the Proposed Action for continued operation and maintenance of the U.S. Army Corps of Engineers' (Corps) Willamette Valley Project (WVP) is likely to jeopardize the continued existence of Upper Willamette River (UWR) Chinook salmon (*Oncorhynchus tshawytscha*) and UWR steelhead (O. mykiss), which are listed as threatened under the Endangered Species Act (ESA), and to adversely modify or destroy designated critical habitat for these species (NMFS 2008). NMFS provided the Action Agencies (Corps, Bonneville Power Administration (BPA), and Bureau of Reclamation (USBR)) with Reasonable and Prudent Alternative (RPA) to supplement the Proposed Action. The RPA is a package of measures that allows for the survival of these species with an adequate potential for their recovery. The RPA contains categories of substantive measures for fish passage, water quality, flows, water contracts, habitat, and hatcheries.

The BiOp provides specific priority RPA measures that are required, such as investigations of the feasibility of improving downstream fish passage at Cougar Dam through structural or operational alternatives. RPA 4.12.1 Cougar Dam Downstream Passage states that the Action Agencies will investigate the feasibility of improving downstream fish passage at Cougar Dam through structural modifications as well as with operational alternatives, and if found feasible they will construct and operate the downstream fish passage facility. The Corps has worked through the Engineering Documentation Report process and the Floating Screen Structure with truck transport was the alternative carried forward to the Design Documentation Report (DDR) phase.

Behavior, Distribution and Passage Metrics of Juvenile Chinook Salmon Above and Below Lookout Point Dam

Eric Fischer, Pacific Northwest National Lab, eric.fischer@pnnl.gov
Eric Fischer
James Hughes
Scott Titzler
Kenneth Ham
Fenton Khan
Gary Johnson

The goal of this study was to provide biologists, engineers, resource managers, and regional decision-makers with information about the behavior, distribution, and passage of juvenile Chinook Salmon (*Oncorhynchus tshawytscha*) through the Lookout Point reservoir and tailwaters, Middle Fork Willamette River, Oregon. The results of this study are intended to inform decision-making about long-term structural and operational measures to help rebuild populations of Upper Willamette River Spring Chinook Salmon listed as threatened under the Endangered Species Act.

The study addressed two life-history patterns for Spring Chinook Salmon: reservoir-rearing with outmigration past Lookout Point Dam (Lookout Point) in fall (subyearling Chinook Salmon) and natal-stream rearing with outmigration in spring (yearling Chinook Salmon). The study area stretched from the upper Lookout Point reservoir to below Dexter Dam (Dexter). An active acoustic telemetry study of tagged fish migration and passage was conducted to meet study objectives. During the fall period (October 3, 2016–December 30, 2016), a total of 520 fish were tagged and released and 549 fish were tagged and released during spring (March 6–June 30, 2017). Detection data were used to estimate migration and passage metrics for each of the study periods.

Overall numbers of fish detected in the reservoir peaked days after release at all reservoir receiver arrays in both fall and spring; however, detections slowly decreased as the study season progressed. This indicated a lack of movement within the reservoir for both age classes of fish. Of the 520 subyearling Chinook Salmon released into the reservoir in fall, 53% (n= 276) migrated downstream to Lookout Point. In spring, 87% (n=475) of the 549 study fish that migrated down to Lookout Point were detected at the dam. The majority of both age classes that first approached Lookout Point did so from the southern, earthen portion of the dam in both fall (87%) and spring (83%). Diel patterns of the arrival of fish in the forebay was generally evenly distributed between day and night, indicating age classes entered the forebay at all hours of the day. Low numbers of subyearling Chinook Salmon passed Lookout Point and Dexter during the fall study period (31 and 16, respectively), whereas during the spring study, fish passed Lookout Point and Dexter in relatively high numbers (299 and 188, respectively). Increased flows and the use of the spillway in spring (March to June) may have contributed to the increased passage numbers in spring compared to the fall study period. Additional research of spill operations as a surface outlet for downstream fish passage could inform management decisions for improving Chinook Salmon passage and survival at Lookout Point Dam.

Temporally Dynamic Spatial Distributions of American Plaice (*Hippoglossoides platessoides*) and Yellowtail Flounder (*Limanda ferruginea*)

Devin Flawd*****, Marine Institute of Memorial University of Newfoundland, Devin.Flawd@mi.mun.ca
J. A. D Fisher

American plaice and yellowtail flounder are two commercially important flatfish species found on the Grand Banks, NL in the Northwest Atlantic Ocean. Due to overexploitation during a critical period of oceanographic changes, both species suffered severe population declines in the early 1990's resulting in commercial fishing moratoria. The yellowtail flounder stock recovered quickly (~5 years) and is now a Marine Stewardship Council (MSC) certified sustainable fishery. In contrast, 25 years later, the American plaice stock remains below the minimum spawning biomass threshold to allow a directed fishery. Working with a long-term government trawling survey dataset, the goal of this study was to assess how both species' spatial distributions changed before (1985-1992) and after (1993-2015) population collapses, and their associations with environmental parameters such as temperature and depth. Nonlinear presence/absence and abundance models show significant changes in spatial distribution for both species across spatial and temporal scales. We demonstrate that analyzing multiscale patch distributions during periods of low vs. high abundance are dependent on the chosen spatial scale (local vs. regional), and can be useful in identifying archetypes of density-distribution

relationships. Key findings from this project reveal how flatfish stocks respond to population fluctuations at multiple spatial scales with an emphasis on spatially overlapping species with similar life histories yet different population trajectories. Our findings address a key knowledge gap in fisheries science to inform management.

Opportunities and Limitations of Using LiDAR to Model Sea-Level Rise on the Oregon Coast

Rebecca Flitcroft, U.S. Forest Service, rflitcroft@fs.fed.us
Mary Santelmann
Brett Boisjolie

In estuaries, land-surface and tidal elevations influence the amount of salt-water inundation in a specific location, ultimately affecting the distribution of estuary vegetation and associated aquatic habitats. Species of Pacific salmon are known to use estuary channel habitats for juvenile rearing, particularly Coho (*Oncorhynchus kisutch*) and Chinook (*Oncorhynchus tshawytscha*) salmon. The diversity of residence times exhibited by juvenile salmonids corresponds with different life histories, thereby contributing to the portfolio of behaviors that may confer resilience at population-scales. Effective habitat restoration in the face of climate uncertainty is critical to the sustainable production of seafood and maintenance of ecosystem functions. Further, restoration of estuary habitats has been identified as a tool to mediate some anticipated effects of climate change, including flooding from sea-level rise, changes to precipitation regimes, and increased storm surges. Understanding even small changes in land-surface elevation at a site scale provides relevant information to managers seeking to design effective long-term restoration projects designed to enhance salt marsh communities and recreate tidal channels. Currently, there are some simple methods available to link tidal elevations to land-surface topography using lidar data in particular, allowing managers to determine where tidal inundation may occur. However, lidar that is not flown at low tide or at consistent tidal heights poses significant challenges in the interpretation of both land-surface and tidal elevations. Where lidar is consistently collected at low tide, linking tidal datums to land-surface topography provides a useful construct for understanding coastal topo-bathymetry. Along with locally-specific information, the types of map products that can be developed using this method could identify places that may be vulnerable to salt-water inundation, along with effective migration corridors for marshes and other habitats. These tools provide an important link in determining options for conservation and restoration of threatened salt marsh habitat and associated tidal channels.

What Do You Want To Do With Your Life? Career Trajectories and Transitions

Rebecca Flitcroft, U.S. Forest Service, rflitcroft@fs.fed.us
Kara Anlauf-Dunn

Congratulations! You've just finished your bachelors, or masters, or even PhD! Now what? In this talk, we will share our own less than direct career paths and offer some suggestions as you approach important career decisions or transitions. Thinking through what's next in a way that leverages your strengths will help you achieve your next goal. Or, if you are less linear in your career goals and ambitions, thinking through what sounds most interesting or appealing for the next step in your journey may help you decide on your path forward. Becky will share some of her experiences in her non-linear academic and research path through state and federal agencies. Kara will speak to her fisheries career path, commenting on the value of advice, self-reflection, and finding balance between the two. In the end, we hope to be able to share some stories, highlight some things that might be helpful to do before you make a big transition, and provide suggestions as you advance your career in fisheries science and management.

Resilient Responses by Pacific Salmon to Climate Change Require Diverse Thermal Landscape

Aimee H. Fullerton, NOAA Northwest Fisheries Science Center, aimee.fullerton@noaa.gov
E. Ashley Steel
Christian E. Torgersen
Se-Yeun Lee

Spatiotemporal variability is prevalent in natural thermal regimes within and among Pacific Northwest rivers, and salmon and steelhead are adapted to these diverse freshwater thermal landscapes. Projections about suitable freshwater habitats in the future are grim. Water temperature is expected to increase, summer flows to decrease, and there remains considerable uncertainty about how these changes will affect fish. We use a combination of spatially-explicit empirical and modeled water temperature, predicted changes in thermal and flow regimes, and simulated fish response to evaluate risks for salmon posed by climate change. We illustrate that (1) observed water temperature patterns are diverse at multiple spatiotemporal scales, (2) that multiple methods of forecasting future thermal regimes yield more robust understanding, and (3) that salmon may respond in unexpected ways to new thermal landscapes. We conclude that salmon populations most likely to be resilient to climate change will be those that have diverse thermal habitats available to them.

Willamette River Tributary Instream Flow Study: Determining Habitat-Flow Relationships in the North and South Fork Santiam Rivers

Michael Gagner, R2 Resource Consultants, mgagner@r2usa.com
Dudley Reiser
Chiming Huang
Tim Sullivan
Mary Louise Keefe

In response to a requirement in the 2008 Willamette River Biological Opinion (2008 BiOp), the Corp of Engineers (COE) commissioned R2 Resource Consultants to conduct the Willamette Tributary Instream Flow Study. The study was designed to evaluate instream flow objectives described in the 2008 BiOp as compared to the fish habitat needs for the target ESA-listed species of spring Chinook Salmon (*Oncorhynchus tshawytscha*) and winter steelhead (*Oncorhynchus mykiss*). The study focused on identifying relationships between river flow and habitat needs for adult passage, adult holding, spawning/incubation, and juvenile rearing in the North Fork Santiam River (NFS) below Detroit Dam and the South Fork Santiam River (SFS) below Foster Dam. Technical studies included instream flow data collection and analysis utilizing standard 1-D PHABSIM methods, development of Habitat Suitability Criteria curves, review of previous adult upstream passage surveys, and monitoring changes in water temperature and adult holding areas in large pools.

Habitat-flow relationships were developed for each of the target species and life stages utilizing site-specific hydraulic data collected from 40 transects (23 transects in NFS and 17 transects in SFS) distributed between seven study reaches at sampled flows ranging from 600-5,800 cubic feet per second. This presentation describes the methods and results of the study leading to the development of habitat-flow relationships for the target species and the application of time series analysis to compare the quantity of habitat under existing operations and pre-project conditions.

The Impact of Different Hatchery Rearing Environments on Smolt-To-Adult-Survival of Spring Chinook Salmon

Ryan Gerstenberger, Confederated Tribes of Warm Springs, ryan.gerstenberger@ctwsbnr.org
Brian Beckman
Deb Harstad
Dina Spangenberg
Donald Larsen
Chris Brun

We studied environmental effects on smolt physiology, smolt migration, and smolt to adult return (SAR) of Hood River stock spring Chinook salmon *Oncorhynchus tshawytscha* reared at three different hatchery facilities across three brood years (2008-2010). We compared the measured physiological attributes for fish reared among the sites in each year with migration pace and SAR to determine relative performance of each of the rearing groups. We also compared SARs of Hood River release groups with PIT tag derived SARs of other nearby hatchery spring Chinook programs in the Mid-Columbia region. We found that the rearing groups had significantly different migration rates and SARs and that the differences in physiological attributes among the rearing groups effectively predicted the relative SAR among these groups. Using the results of the initial three brood year study we have made changes to our Chinook production program which include improved facilities and development of a “wild fish” rearing template to better represent natural juvenile growth patterns. Initial adult returns suggest we may in fact be improving SARs following the adoption of these hatchery rearing reforms relative to other spring chinook programs in the region.

Does Freshwater Life History Affect Marine Survival Rate of Coho Salmon?

Grace Ghrist*****, Humboldt State University, gkg47@humboldt.edu
Darren Ward

Juvenile Coho Salmon (*Oncorhynchus kisutch*) in coastal California streams exhibit various life history strategies during their freshwater development. One strategy of interest to managers and conservationists is the early emigrant. This juvenile type migrates from natal habitat into lower parts of the watershed or estuary during the winter, where it rears before migration to the ocean in spring. By contrast, the more prevalent life-history type resides in natal reaches over the winter and emigrates the following spring. Salmon monitoring programs generally estimate juvenile production and demographic rates using only spring emigrants. In a Northern California stream, we PIT tagged juvenile Coho Salmon in the fall and detected their movements throughout

the stream and estuary over their first winter, and then as they returned to spawn as adults. With the use of a multistate mark recapture model, we tested for distinct marine survival rates between these emigration periods. Our model allowed us to incorporate multiple life history strategies onto a single platform which can be used to report unbiased survival estimates of juvenile Coho Salmon.

Coquille Working Landscapes Projects--"Beef in the Summer and Fish in the Winter"

Michael Gray, Oregon Department of Fish & Wildlife, michael.e.gray@state.or.us

The Coquille River Valley historically contained an estimated 9,000 to 12,000 acres of tidal and freshwater marshes connected to the river. Most of these marshes were converted to farmland by 1870, and less than 400 acres (3 to 4%) were still in existence by 1990. In the last ten to fifteen years, efforts by local landowners, watershed councils, and agencies have partnered to implement multiple projects to restore tidal and freshwater wetlands, while recognizing the economic importance of agriculture in the local community. “Coquille Working Landscapes” is a collaborative process comprising the China Camp Creek Project (C3P) of the Beaver Slough Drainage District (BSDD) and the Winter Lake Restoration Project (WLRP) of the Oregon Department of Fish and Wildlife (ODFW) and The Nature Conservancy (TNC). Failing tidegate infrastructure and ODFW’s acquisition of lands within the drainage district brought together the agricultural and ecological interests into a partnership. The BSDD’s tidegates and berms that protected pasture lands from twice-daily inundation were deteriorating, jeopardizing the agricultural economy of the mid-Coquille Valley. ODFW acquired lands from willing sellers with goals of habitat restoration to enhance populations of Coho Salmon and other native fish species, to enhance waterfowl habitat, and to create public recreational opportunity on a “Coquille Valley Wildlife Area”. The two projects were developed and designed to meet multiple land and water management objectives in a non-exclusive manner. The overall design isolates the projects into three units, where water can be managed to meet individual landowner goals. A bank of seven “state of the art” tidegates was constructed in the summer of 2017 (C3P), with tidal restoration channels in the (WLRP) planned for excavation in the summer of 2018. Numerous partners and funding entities have contributed to this large-scale effort which impacts over 1,700 acres in the BSDD. Progress to date and future phases will be presented.

Stay the course--navigating a career through the ever-shifting currents of priorities, leadership, public interest, and politics

Michael Gray, Oregon Department of Fish and Wildlife, michael.e.gray@state.or.us

In addition to the global weather patterns, the changing “climate” can pertain to our careers as fisheries professionals as well. During your career you may work for multiple agencies or entities with different priorities, and even within one agency your career may span several changes in leadership. Changing politics, administrations, and public interest can result in paradigm shifts that affect your work. Finally, as new revelations emerge from science or our own self-interests change, our careers may take unexpected turns as a result. Maintaining a path forward in your career, while adapting to a changing “climate” will be discussed.

Finding Your Niche in the Private World

Rich Grost, Pacific Power, rich.grost@pacificorp.com

Rich's career has been dominated by non-agency employment at an engineering firm, his own 1-man company, and now with Pacific Power. He will share his insights derived along this path as he describes a sometimes strange migration from Michigan through Alaska, Wyoming, and Washington to Oregon, and from confused college kid to focused fish specialist. He'll also describe his job and what it's like to be a full-time Hydropower Biologist, with an opportunity for questions.

Oregon's Bull Trout Recovery Strategy: Accounting for a Changing Climate

Stephanie Gunckel, Oregon Department of Fish And Wildlife; U.S. Fish and Wildlife Service, stephanie.gunckel@oregonstate.edu
Chris Allen
Shaun Clements

To provide direction for on-the-ground implementation of the Bull Trout recovery plan (2015) ODFW, USFWS, and USFS have developed an overarching strategy to guide and prioritize recovery actions and monitoring across Oregon. Our goal is to link management actions with research and monitoring information, data organization and analyses to most efficiently achieve recovery in an accessible and transparent manner. The technical foundation of our strategy is the Bull Trout Vulnerability Assessment (BTVA) developed by USGS (Dunham 2015). This model synthesizes range-wide data on presence/absence of bull trout and nonnative fish, landscape features, and threats to assess vulnerability of Oregon's bull trout populations to a changing environment. Monitoring activities that support the BTVA will focus on threats and delisting criteria identified in the recovery plan and understanding how the presence of bull trout can be managed in the context of future scenarios of development, restoration, climate change and other factors. Insights generated from the BTVA will be used in concert with other factors (social, economic, etc.) to develop a state-wide decision support model for prioritizing statewide investment for recovery, monitoring and evaluation. Data employed by the strategy, along with continually updated status assessments, will be available on a recovery tracker website allowing for greater transparency, fewer data requests, and shared progress. Overall, the strategy for implementing recovery of bull trout in Oregon is based on an adaptable set of quantitative models that can be integrated with decision support tools, and that allows for information to be easily accessed and continually updated for direct application to range-wide and local management actions to benefit bull trout.

Temperature Constraints on Redband Trout Life History in Klamath Lake: Seasonal Patterns and Climate Change Implications

Nick Hahlbeck*****, Oregon State University, nicholas.hahlbeck@oregonstate.edu
William Tinniswood
Jordan Ortega
Matthew Wyatt

Matthew Sloat
Jonathan Armstrong

Our ability to measure and model variation in stream temperature across space and time is ever increasing, but our understanding of how fish life histories are adapted to this variation is often limited. Temperatures in Upper Klamath Lake range from near freezing in winter to higher than 25 C in summer. In contrast to the lake, the comparatively small, groundwater-dominated tributaries offer more stable and intermediate temperatures. We are studying how the life history of redband rainbow trout depends on these distinct habitats across the year. In 2016, we used temperature-transmitting radio tags to demonstrate that adult fish occupy two different areas of tributary habitats during summer and winter, using the first as a thermal refuge to escape high lake temperatures and the second for spawning. In spring and fall, we observed most fish returning to the hypereutrophic lake habitat, which we hypothesize provides the high prey abundance needed to fuel net energy consumption in summer and winter. To test this hypothesis, in 2017 we compared aspects of fish energetic condition in tributary and lake habitats using length-weight indices, gut content analysis and novel bioimpedance methods. We also tagged and measured energetic condition of 14 additional fish from the Keno Reach of the Klamath River, an area without access to thermal refuge, for comparison against fish with thermal refuge access. Finally, we expanded our original tagging study from 40 to 95 fish and added visual surveys of thermal refuges to more precisely understand the timing and spatial extent of thermal refuge use. Preliminary results indicate that most migration to thermal refuges occurs within a short 2-3 week period that varies annually, while the return migration to the lake is more variable within years but less variable between years. Additionally, energetic condition and visual survey data support our hypothesized roles of lake and tributary habitats in redband trout life history, and suggest that areas of cool water across the watershed differ widely in their utility as thermal refuge habitats. These results demonstrate that interpreting the conservation value of fish habitats from temperature predictions in a warming world requires a detailed knowledge of life history adaptations.

Putting Time Back in Space-for-Time Mark Recapture to Estimate Survival, Collection and Travel Time for Migrating Fish

Dalton Hance, U.S. Geological Survey, dhance@usgs.gov
Russell Perry
John Plumb
Adam Pope

Juvenile salmon migrating past hydroelectric projects experience differential probabilities of survival and detection based on environmental conditions and dam operations at their time of passage. Accurate and precise estimates of these parameters are essential tools for aiding management and recovery of these species. However, estimation of these parameters is complicated by the fact that the time of passage is unknown for fish that are not detected. We address this problem with a novel mark-recapture model to efficiently estimate time-varying survival and detection in relation to covariates based on a semi-parametric travel-time process. In this talk, we describe both the mathematical derivation of our model and the results of a simulation study demonstrating the capacity of the model to successfully estimate parameter values of the simulated data. We present preliminary results applying the model to estimate survival, detection, and travel-time of subyearling fall Chinook salmon migrating down the Snake River past four hydroelectric projects.

Middle Fork John Day River Intensively Monitored Watershed: Lessons Learned From 10 Years of Monitoring Steelhead and Chinook

Kirk Handley, Oregon Department of Fish and Wildlife, kirk.a.handley@state.or.us
James Ruzycki

Effectiveness monitoring at the watershed scale is considered an effective means of assessing a population level response to restoration actions and is being done at several intensively monitored watersheds (IMWs) throughout the Pacific Northwest. We evaluated seasonal distribution, productivity, survival, growth, and abundance of spring Chinook salmon *Oncorhynchus tshawytscha* and summer steelhead *Oncorhynchus mykiss gairdnerii* throughout the Middle Fork John Day River Basin to help understand the effects of ongoing restoration actions. We compared watershed productivity (smolts per adult) estimates for Middle Fork John Day River Basin to those from the Mainstem John Day River Basin for Chinook, and South Fork John Day River Basin for steelhead. Site and reach level monitoring of seasonal distribution, abundance, survival, and growth was conducted throughout the Middle Fork John Day River IMW at control and treatment reaches for Chinook and steelhead parr. We did not detect a positive response at the watershed scale to restoration activities during our 2008 through 2017 monitoring. Although no immediate fish response to restoration actions was detected, this monitoring provided a greater understanding of factors limiting and influencing smolt production, seasonal parr distribution, parr abundance, parr survival, and parr growth for these two anadromous fish species throughout the Middle Fork John Day River IMW. Our research suggests that restoration actions that are effective at reducing summer water temperatures will have the greatest potential benefit to salmonids in the Middle Fork John Day River Basin.

Synthesis of Downstream Fish Passage Information at Dams in the Willamette River Basin, Oregon

Amy Hansen, U.S. Geological Survey, achansen@usgs.gov
Tobias Kock
Gabriel Hansen

The U.S. Army Corps of Engineers (USACE) operates the Willamette Valley Project (Project) in northwestern Oregon, which includes a series of dams, reservoirs, revetments, and fish hatcheries. Project dams were constructed during the 1950s and 1960s on rivers that supported populations of spring Chinook salmon (*Oncorhynchus tshawytscha*), winter steelhead (O. mykiss), and other anadromous fish species in the Willamette River Basin. These dams, and the reservoirs they created, negatively affected anadromous fish populations. Efforts are currently underway to improve passage conditions within the Project and enhance populations of anadromous fish species. Research on downstream fish passage within the Project has occurred since 1960 and these efforts are documented in numerous reports and publications. These studies are important resources to managers in the Project, so the USACE requested a synthesis of existing literature that could serve as a resource for future decision-making processes. In 2016, we reviewed all literature that currently exists on downstream fish passage studies within the Project and synthesized this information into a single document. This presentation will provide an overview of the results that we obtained and summarize key areas of known and unknown information.

Behavior and Passage of Juvenile Salmon and Steelhead at Detroit and Cougar Dams, Oregon

Amy Hansen, U.S. Geological Survey, achansen@usgs.gov
John Beeman
Tobias Kock

During 2011–2015, the U.S. Geological Survey conducted a series of biotelemetry studies to evaluate the behavior and passage of juvenile Chinook salmon and steelhead at Detroit and Cougar Dams in the Willamette River Basin, Oregon. During these studies a total of 6,494 juvenile Chinook salmon were tagged and released in Detroit and Cougar Reservoirs. Additionally, 700 juvenile steelhead were tagged and released into Detroit Reservoir. Biotelemetry arrays located in dam forebays and along the face of each dam monitored fish behavior patterns. Collected data were used to describe passage routes and timing at each dam. At both locations, tagged fish had long reservoir and forebay residence times prior to passage. Patterns in passage rate and timing varied seasonally and by diel period. We found that diel period, reservoir elevation, and discharge were strong predictors of dam passage. This presentation will summarize important findings from each study and describe factors that were found to be important predictors of passage success.

Assessing Climate Vulnerability of Columbia River Basin Steelhead: A 3-Step Decision Process Framework for Management Actions

Jill Hardiman, U.S. Geological Survey, jhardiman@usgs.gov
Steve Waste

Ameliorating the impacts of climate change to a species and habitats requires an articulation of key existing and projected vulnerability stressors. A substantial amount of science is available on identifying existing species' vulnerabilities and management adaptation strategies and actions. However, a consistent framework, that can be applied at a variety of landscape scales and can be used for prioritizing management actions and limited resources for focal species has been lacking. The Columbia Basin Partner Forum and Great Northern Landscape Conservation Cooperative are working with partners throughout the interior Columbia River Basin to synthesize a series of vulnerability assessments for priority species and habitats and develop parallel, integrated decision support frameworks that guide and coordinate species and system-level resource management approaches and actions. A case study of steelhead vulnerability to climate change within the Columbia River basin will be presented highlighting this process. The vulnerability assessment and 3-step decision process will assist natural resource managers by 1) identifying key vulnerabilities of climate change for Columbia River basin steelhead through existing scientific literature, expertise, and data; 2) characterizing the potential range of climate vulnerabilities from most to least significant; 3) identifying appropriate management actions for climate adaptation; and 4) provide a consistent and transparent framework for information synthesis and decision support, which is being used to assess vulnerabilities of other species and habitats in the Columbia

River basin. Attendees will benefit from learning about a structured approach to transfer knowledge gained from vulnerability assessments, expert scientific opinion, and adaptation strategies to multi-jurisdictional conservation decision making. We will also provide information on where to find other species and habitats vulnerability assessments being completed by partners within the Columbia Basin Partner Forum.

Pacific lamprey recolonization of a Pacific Northwest river following dam removal

Julianne Harris, U.S. Fish and Wildlife Service, julianne_harris@fws.gov
Jeffrey Jolley
Gregory Silver
Timothy Whitesel

Recolonization of Pacific lampreys Entosphenus tridentatus into historically used freshwater habitats in the United States Pacific Northwest was evaluated in the White Salmon River basin after removal of Condit Dam. Pacific lamprey population declines are of concern and passage barrier removal is often recommended for conservation. Condit Dam on the White Salmon River in Washington was a complete barrier to fish migrating upstream for nearly 100 years, was breached in 2011, and was removed by 2012. Distribution of larval Pacific lampreys was estimated before and after removal of Condit Dam using either backpack or deepwater electrofishing. Larval detection probabilities were calculated for the basin and sample efforts were refined to ensure at least 80% confidence that larvae were absent when not detected. Pacific lampreys were not present upstream of Condit Dam before it was removed but were present in areas downstream of the dam. After dam removal, Pacific lamprey larvae were collected upstream of the former dam site from four reaches of the mainstem White Salmon River, indicating a recent recolonization event. Pacific lampreys were absent from the river mouth area before the dam was removed, but were found in newly created habitat at the mouth after dam removal. Pacific lampreys naturally recolonized the White Salmon River basin within a few years after dam removal. Removing dams and providing passage opportunity can allow Pacific lampreys to distribute into vacant areas and may help reverse population declines.

USACE Water Management - Willamette River System

Salina Hart, U.S. Army Corps of Engineers, Salina.N.Hart@usace.army.mil

The Willamette River basin is located entirely within the state of Oregon, beginning south of Cottage Grove, and extending approximately 187 miles to the north where the Willamette River flows into the Columbia River. The basin is more than 11,200 square miles, averages 75 miles in width, and encompasses approximately 12 percent of the total area of the state. Within the watershed are most of the state’s population (nearly 70 percent), larger cities, and major industries. The basin also contains some of Oregon’s most productive agricultural lands and supports nationally and regionally important fish and wildlife species. Through a series of Flood Control Acts the U.S. Congress authorized the U.S. Army Corps of Engineers (Corps) to construct, operate, and maintain thirteen major dams1 in the Willamette River basin. Collectively, these dams, reservoirs and associated infrastructure are known as the Willamette Valley Project (WVP). From 2000 through 2003, the Corps worked with other federal and state agencies to develop a WVP flow management strategy. This strategy established a continuing framework for meeting both mainstem and tributary flow objectives that relies on monthly meetings and regular coordination. Minimum flow objectives for the mainstem and effected tributaries were then included in a 2008 Biological Opinion from the National Marine Fisheries Service. With a combined conservation storage capacity of approximately 1,590,000 acre-feet, the WVP is capable of providing important benefits for flood risk management, hydropower, navigation, irrigation, municipal and industrial water supply, flow augmentation for pollution abatement and improved conditions for fish and wildlife, and recreation. This presentation will review pre- and post-project hydrology of the Willamette River, and how well current management objectives are being achieved.

Deciphering the Signal: How Quantitative, Accurate and Sensitive is eDNA Metabarcoding?

Laura Hauck, Pacific Northwest Research Station, USFS, lhauck@fs.fed.us
Brooke Penaluna
Kevin Weitemier
Tiffany Garcia
Rich Cronn

As aquatic biodiversity declines worldwide, there is an urgent need for rapid, accurate, and standardized assessment methods to identify diverse aquatic taxa. Many agencies are incorporating environmental DNA (eDNA) screening into their assessment protocols for species of interest. These methods show enormous promise in tracking the distribution of specific taxa and populations, but 'single-species' methods do not allow for broader biodiversity or ecosystem health assessments. We are developing a multi-species biodiversity assay that uses integrated fluidic circuits (IFCs) and massively parallel sequencing to identify 48 gene targets from a single eDNA sample. By combining taxon specific targets (e.g., cytochrome oxidase) and conserved metabarcoding targets (e.g., ribosomal DNA), 48 primer sets have the potential to reveal hundreds of organisms at a range of taxonomic ranks and abundances from aquatic communities. Our targets include all ray-finned bony fish and select chondrostei fish, amphibians like ranid frogs and salamanders, and a wide range of aquatic invertebrates and pathogens. Important questions with this approach are "How quantitative, accurate and sensitive is eDNA metabarcoding?" To address these questions, we collected replicate water samples from the Fall Creek, OR watershed for DNA analysis in 2016 and 2017, and directly compared eDNA data (presence; relative rank abundance) with estimates of abundance obtained by traditional electrofishing in the 2017 field season. Our results allow us to evaluate the reproducibility of the multiplexing method, and to make recommendations for improving and expanding this assay to other target taxa and aquatic systems.

Regime Shifts and Resilience Thinking For Salmon in the Sacramento/San Joaquin Delta

Michael Healey, University of British Columbia, healey@mail.ubc.ca

The Sacramento/San Joaquin Rivers were once one of the great salmonid producing systems of the world, with large and productive populations of Chinook salmon and steelhead/rainbow trout. Historic populations are not well known but Chinook probably numbered in the several millions and Steelhead in the tens of thousands. Chinook also had high diversity illustrated by four distinct run timings (fall, late fall, winter, and spring runs).

Populations have declined dramatically to a few hundred thousand for Chinook and a few thousand for steelhead. Winter and spring run Chinook and steelhead are all listed as threatened or endangered under the Endangered Species Act. Habitat alteration and destruction, dam construction, hydrological and water quality change, hatchery propagation, and alien species are all implicated in the species' decline. Now climate change is imposing further stress on these species. Recent analysis suggests that the Sacramento/San Joaquin Delta, a critical transitional habitat for adults and juveniles and (possibly) an important historic juvenile nursery, has gone through an ecological regime shift that is negative for native species. In this paper I will consider the extent to which resilience theory can help understand the socio-ecological forces that have kept this system on the path to near extinction of valued native species, why concerted efforts to sustain ecological function and productivity since passage of the Central Valley Project Improvement Act have been unsuccessful, and what the way forward might be.

Descending Rockfish: Incorporating the Science into Fisheries Management

Christian Heath, Oregon Department of Fish and Wildlife, christian.t.heath@state.or.us
Lynn Mattes
Patrick Mirick

Non-retention of US West Coast rockfish species in fisheries, due to overfishing status or harvest caps, has led to increasing use of descending devices in recreational fisheries for fish which cannot overcome the capture effects of an overinflated swimbladder, and may not be able to descend to depth without assistance. Researchers have produced a significant body of work on the effects of barotrauma, and the use of descending devices to release back to depth and recompress captured rockfish species. Fisheries managers have been tasked with incorporating that research into management analyses to more accurately account for discard mortality when anglers use descending devices. To complete this task, species-specific mortality rates which incorporate the use of descending devices had to be developed, and then approved by the Pacific Fishery Management Council. Once rates were approved, the states could proceed to (1) incorporate into tracking and management of fisheries, the estimations of discard mortality when descending devices are used, and (2) conduct public outreach on the importance of using descending devices. This talk will describe this process, using Yelloweye Rockfish (*Sebastes ruberrimus*) and Canary Rockfish (*Sebastes pinniger*) in Oregon recreational fisheries as an example. We will also discuss how the increased usage of descender devices has contributed to an increase in recreational angling opportunities on Oregon's rocky reefs.

Fivemile Bell Restoration Project Aquatic Organism Relocation: What to Do When You Are Up to Your Ankles in Lamprey Ammocetes

Ana Hernandez, U.S. Forest Service, anashernandez@fs.fed.us
Paul Burns

Fivemile 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).

The Fivemile 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. 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.

In the last 2 field seasons over 100,000 organisms were relocated from the old downcut stream channels prior to filling. Methods used predominately in the relocation efforts included extensive seining, hoop nets, minnow traps, dip netting, hand picking, and even snorkeling. Using methods such as electrofishing proved ineffective with the existing site conditions, as well as a higher mortality risk for ESA listed Coho. The addition of high capacity dewatering pumps in 2017 increased our efficiency in collecting organisms especially for removing the majority of lamprey ammocetes from the sandy substrates present in this extremely low gradient system. These relocation efforts also included help from various groups and organization including local tribes. We hope to share information on the different techniques we used to accomplish fish relocation for large restoration projects and hopefully allow other practitioners to be more aware about how to plan for relocation efforts on their projects.

Structure in Hatchery Tanks Appears To Moderate Handling and Crowding Stress Response in Juvenile Chinook Salmon

Crystal Herron, Oregon State University, crystal.herron@oregonstate.edu
Karen M. Cogliati
David L.G. Noakes
Carl B. Schreck

We tested the influence of structure in rearing tanks on the stress response of juvenile Chinook Salmon (*Oncorhynchus tshawytscha*). Structure consisted of PVC pipe and strips of black plastic suspended throughout the water column. Fish were subjected to a three-hour stressor characterized by lowered water levels in novel tanks and were then moved to novel tanks similar to their rearing tanks. Plasma was collected before the start of the stressor and throughout 20 hours post stressor for cortisol analysis. For fish that were in the stress treatment, those reared on structure had elevated plasma cortisol over resting cortisol (control treatment), but their physiologic stress response was not as severe as the stress response of fish reared without structure in their tanks. Additionally, we observed that plasma cortisol levels in structure-reared fish had returned to baseline by 20 hours post stress while fish reared without structure had not fully recovered. Our findings suggest that by increasing the complexity of their rearing environment, juvenile Chinook Salmon would not experience an unnecessarily exaggerated response to stressful management protocols, ultimately leading to better fish quality and survival.

A Fearless Approach to Stage 0 Floodplain Restoration at Deer Creek, McKenzie River, Oregon

Johan Hogervorst, U.S. Forest Service, jhogervorst@fs.fed.us
Kate Meyer

Past land management practices had impaired watershed processes and contributed to poor habitat conditions in lower Deer Creek, a tributary to the upper McKenzie River on the Willamette National Forest. Riparian logging, the flood of 1964, in-stream wood salvage and berm construction led to severely reduced channel and floodplain roughness and increased the transport capacity of the channel, meaning that much of the wood, gravel, and fine sediment in Deer Creek were frequently transported out of this high energy system.

The recovery of large wood had been slow to non-existent (less than 20 pieces of large wood per mile), the substrate was too large for spawning, and most of the flow was confined to an incised, single-thread channel that was no longer connected to its floodplain. These conditions were severely impacting habitat for native species, including ESA-Threatened spring Chinook salmon and bull trout. No spawning of spring Chinook salmon had been observed since 1994. Major limiting factors for all fish species included: lack of spawning gravel, lack of off-channel habitat and high flow refuge, lack of deep pools, lack of cover, lack of large wood, and high summer stream temperatures.

The project was designed to restore floodplain connectivity and channel complexity and enhance habitat for native fish and wildlife in the lower 1.6 miles and 42 acres of floodplain. Techniques used to accomplish the project focused on process-based Stage 0 restoration (Cluer and Thorne, 2013) as opposed to a form-based, channel-centric approach. In the summer of 2016, 200 whole trees (24-36”dbh) were pushed over with rootwad intact from upland units, broken in half, transported to the stream and placed in Deer Creek with an excavator. Berm material was pushed into the main stem channel with a dozer to raise the elevation of the incised channel (Randy Haley, Haley Construction Company, Lebanon, OR). In both fall 2016 and fall 2017, 23 additional large (38-63”dbh) streamside trees were pulled over into the floodplain by truck-mounted yarder to act as key pieces (Mark Villars, Blue Ridge Timber Cutting, Inc., Coos Bay, Oregon).

Because an aggressive approach was taken, results and benefits were immediate. A bankfull storm event in October 2016 re-activated the entire floodplain at low velocities and deposited abundant spawning-sized gravel. Instead of a single-thread channel, there are now multiple channels and slow off-channel habitat. Deep pools have already formed and fresh beaver cuttings have been observed. Ecological function and habitat condition has already been vastly improved. In the fall of 2017, spring Chinook salmon returned to spawn in the newly restored gravels of Deer Creek for the first time in 24 years (3 new redds). Partners include: McKenzie Watershed Council, Willamette NF, Oregon Department of Fish and Wildlife, Eugene Water and Electric Board and U of O. Funders include: OWEB, National Fish and Wildlife Foundation and PayCo.

Development and Application of a Molecular Quantification Method for *Ichthyophthirius multifiliis* In the Lower Klamath River, CA

Claire Howell, Oregon State University, howellcl@oregonstate.edu
Sascha Hallett
Stephen Atkinson
Jerri Bartholomew

Ichthyophthirius multifiliis (Ich) is a globally distributed freshwater parasite that infects wild and cultured fishes. Its direct, temperature dependent life cycle enables rapid multiplication when hosts are plentiful and environmental conditions are favorable. Early detection is central to the control of infections and prevention of mortality, particularly in wild systems where chemical treatments are not feasible. In the Klamath River, CA, Ich infections are a serious threat to pre-spawning adult salmon. Currently, Ich is monitored via lethal sampling of fish hosts and visual quantification of parasite load. This method is time intensive, imprecise and often limited to advanced infections. In contrast, direct detection of Ich DNA in river water samples using a specific quantitative polymerase chain reaction has the potential to identify areas with elevated infection risk to fish, and as a less labor-intensive method for routine monitoring. We developed and validated a qPCR assay that targets Ich small-subunit ribosomal DNA demonstrating strong linearity, efficiency and repeatability. Ich can be detected in 1L water samples with a sensitivity of 1 infective theront/liter. When applied to environmental water samples, the assay provides a more rapid and labor-saving Ich detection method than sampling fish. Ich levels in environmental water samples collected from the lower Klamath River from July to October in 2014 through 2016 relate to observed parasite load on salmon sampled concurrently. Initial detection in the mainstem related to salmon migratory behavior, and were highest in 2014, the year with the most severe Ich infections observed on migrating Chinook salmon. In addition, analysis of water samples collected in and around a partially isolated, cool water refugium in the lower Klamath River when adult Chinook salmon (*Oncorhynchus tshawytscha*) were congregated revealed that Ich levels were significantly elevated in the refugium compared with both upstream and adjacent mainstem sites. This indicates that conditions in the refugium can promote higher densities of waterborne stages, an important consideration for managing Ich in the Klamath River. Additionally, we detected horizontal and vertical stratification of Ich within the refugium. Future work is needed to determine the relationship between the levels of Ich detected and disease risk to migrating salmon in the Klamath River, but our initial efforts indicate that the qPCR assay could be a useful monitoring tool for Ich in the Klamath River, with application throughout the region. This work was undertaken in collaboration with Yurok tribal biologists and the CA-NV Fish Health Center, USFWS.

Pathogen-related health impacts on Chinook salmon in the Deschutes River Basin with a focus on *Ceratonova shasta*

Kalyn Hubbard*, Oregon State University, hubbakal@oregonstate.edu
Sascha Hallett
Stephen Atkinson
Cyndi Baker
Jerri Bartholomew

Ceratonova shasta is a myxozoan parasite with a two spore, two host life cycle, which can cause intestinal hemorrhaging and enteronecrosis in salmonids of the Pacific Northwest. The parasite has three distinct genotypes, each having preferences for specific salmonid hosts, and different pathogenicity. *C. shasta* abundance is positively correlated with some of the effects of climate change including warmer water temperatures and low water flow. The timing of spring Chinook salmon migration, which occurs late June through late August in the lower Deschutes River (Oregon), makes them especially vulnerable to the effects of *C. shasta*. Initial sentinel fish studies indicated that *C. shasta* was a primary factor leading to juvenile mortality in these fish and may also contribute to pre-spawn mortality. Primary detection of *C. shasta* is through water sample filtration, DNA extraction, and qPCR analysis. We collect water samples every two weeks at Pelton Round Butte, Oak Springs and Warm Springs Hatcheries March through October, and have conducted longitudinal surveys twice a year during adult salmon migration (in June and August). These water sampling surveys span the confluence of the Deschutes River with the Columbia River to Cline Falls (~198 river kilometers upstream) and occur within 12-hour periods to serve as snapshots of *C. shasta* spatial abundance. Once we determine the spatial distribution and abundance of *C. shasta* and identify trends, we will genotype selected water samples and wild and hatchery fish tissue samples. We have also included non-target pathogen screening of the adult fish, through histology of key organs including kidney, liver, spleen, pyloric caeca, and lower intestine. Tissue samples were collected from the Pelton Round Butte hatchery during spawning on August 30th, 2017. Since all salmon migration is halted at the Pelton Dam, these samples provide information about the different pathogens that adult salmon may encounter in the lower Deschutes River during migration. The histological and genetic data we collect will eventually be used to inform management decisions and biological models with the intent of improving salmon health and abundance in the system.

Funding for this study is provided by the Confederated Tribes of the Warm Springs River (CRITFC-PCSRF) and an Oregon Department of Fish and Wildlife Graduate Fellowship to Kalyn Hubbard.

Effective Population Size, Connectivity, and Occupancy of Bull Trout: Tools to Assist in Recovery

Michael Hudson, U.S. Fish and Wildlife Service, michael_hudson@fws.gov
Brook Silver
Justin Cook
Timothy Whitesel

Achieving recovery of bull trout throughout their range will require a variety of actions targeting limiting factors in an effort to achieve minimum viable population sizes that can persist into the future. This project evaluated empirical information in an effort to relate effective population size theory to absolute abundance and population genetic variability, addressing potential limiting factors, and, ultimately, providing information toward defining minimum viable population requirements for bull trout. The objectives of the project were: 1) Determine abundance of bull trout populations above the Wallowa Valley Irrigation Canal (WVIC) as well as an area of reference unaffected by the WVIC; 2) Determine if there is connectivity (movement) between bull trout populations; 3) Determine within and among population genetic variability for five local populations of the Imnaha River core area; 4) Determine effective population size for potentially isolated populations above the WVIC as well as within a reference areas; 5) Determine bull trout occupancy throughout the Imnaha River core area using the patch analysis approach; and, 6) Determine if there is congruence between local populations identified by genetic means and patch analysis. To achieve these objectives, abundance was estimated in three local populations, connectivity evaluated using PIT technology, genetic analysis was conducted and occupancy assessed in habitat predicted to support bull trout in the Imnaha River core area. The three populations investigated appear to be stable in abundance and have varying degrees of connectivity with each other and additional populations in the core area. The genetic analysis supported the connectivity results and the identification of discrete local populations through a bull trout patch identification process using habitat metrics known to support bull trout populations. Despite low effective population size, two populations that are potentially isolated or where migratory corridors are obstructed, have persisted for over a century. The findings indicate that relatively small bull trout populations can persist with no significant evidence of genetic drift, even when potentially isolated, raising questions on interpretation of the "50/500" rule relative to recovery of this species. However, recovery actions to improve connectivity among populations will likely make populations more demographically stable and less vulnerable to stochastic events.

Tidal Exchange Through a MTR Tide Gate: Do Passage Windows and Seasonal Water Management Strategies Mimic Natural Tidal Dynamics?

Edward Hughes, Coos Watershed Association, ehughes@cooswatershed.org
Freelin Reasor

Tide gates are unique water control structures that intrinsically delineate a distinct ecotone, and alter lowland tidal systems and the dynamic aquatic resources that thrive in these productive environments. Muted Tide Regulated (MTR) tide gates integrate a float and lever system that pushes open the side gate earlier in the tidal cycle. Tidal inundation rises to a set upstream water level triggering release, allowing tidal pressure to close the door. The Coos Watershed Association in collaboration with several key partners monitored the operation of and environmental variables around an MTR tide gate at the mouth of Willanch Creek in Coos Bay, Oregon for a full annual cycle in 2016. A uniquely comprehensive in situ sensor array, with real-time networking, captured continuous datasets that were rectified in time series software. These data were then queried and analyzed for operational parameters and metrics based on select explicit ODFW fish passage criteria outlined in Oregon Administrative Rule 635-412-0035. In addition, several key ecological and operational parameters which remain uncertain for fisheries scientists, regulatory agencies and landowners were defined and modeled. These include upstream juvenile passage windows, conditional variability of MTR set point activation, and the

adaptive range of the MTR for seasonal water management planning. Future analysis of fish passage data concurrently captured via PIT tag antenna will allow a full assessment of the concordance between fish behavior in relation to model assumptions of fish passage windows.

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

Chuck Huntington, Clearwater BioStudies, cwbio7@gmail.com
Mark Hereford
Alex Gonyaw
Ted Wise

The goal of the Upper Klamath Basin Anadromous 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 hydropower dams on the Klamath River. Approaches proposed for reintroducing fall and spring-run Chinook Salmon, Coho Salmon, Steelhead, and Pacific Lamprey to upper basin habitats will vary. The specific approach taken for each species will depend on the availability of source populations in the lower Klamath Basin, the ability of those populations to recolonize accessible habitat following the availability of fish passage, and on the need for active interventions if or when local source populations are unable to recolonize historically occupied and still-suitable habitat. We will present an update on development of this plan, including an overview of habitat conditions above the dams, the key factors and uncertainties that will affect anadromous fish reintroduction, and how efforts following dam removal will monitor natural recolonization and guide active fish reintroduction efforts.

Aspects of the Parasite Fauna of Juvenile Fishes in Upper Klamath Lake

Andrew Janik*****, Oregon State University, janika@oregonsate.edu
Vasyl Tkach
AnindoChoudhury
Douglas Markle
James Peterson
Michael Kent

Shortnose Sucker (*Chasimistes brevirostris*) and Lost River Sucker (*Deltistes luxatus*) are endemic to the Upper Klamath Basin of Southern Oregon and Northern California. Populations of these fishes have been dwindling since the 1960's, particularly in their first year of life, and both species where listed as endangered in 1988. The effects parasitic infections have on underyearling suckers from Upper Klamath Lake was examined. Histopathological and wet mount examinations on 390 suckers caught during the summers of 2015 and 2016 was conducted. In addition, 1,355 juvenile suckers from a 2006-2013 collection from Upper Klamath Lake were also examined. Based on the 1,745 fish we examined, the most prevalent parasite infections were the copepod *Lernaea cyprinacea* and skin and muscle metacercariae (black spot), and all were associated with prominent lesions. The metacarciae were identified as a *Bolbophorus sp*. based on rDNA sequencing. However, the most severe lesion based on histology was caused by a larval *Contracaecum sp*. nematode, which caused massive dilation of the atrium and overall enlargement of the heart. The prevalence of this heart infection in the suckers was low (about 1-5% depending on the year). We also examined three cyprinid fishes from the lake, Tui Chub (*Gila bicolor*), Blue Chub (*Gila coerulea*) and Fathead Minnow (*Pimephales promelas*), all of which were infected with the heart *Contracaecum sp*. based on comparisons of the ITS-1 region of the rRNA gene. The adult stage of the same worm species (based on ITS sequence) was found in a pelican. Our worm is most closely related to *Contracaecum multipapillatum*, which has been documented to infect pelicans and other fish-eating birds. Completing the lifecycle of the trematodes infecting fishes in the lake was also attempted. The 28s gene array of 21 species of cercariae from 8 different species of snails from Upper Klamath Lake were sequenced. Ten of these cercariae species were known to infect fish, but none were a precise match to the 28s gene array sequenced from metacercariae obtained from fishes in Upper Klamath Lake.

We attempted to determine the parasite associated mortality (PAM) in the suckers at a population level using various methods commonly used with wild populations. Dr. D. Markle, Oregon State University, previously showed that the black spot was associated with reduced survival in these suckers using catch curve analysis. Application of the Crofton analysis and observing the frequency of dual infections with the calculated probability of their occurrence did not demonstrate PAM with the three major parasites. Other, possibly more direct and powerful methods, require examination of fish over time, but we were not able to apply these as we did not have suckers > 1 year of age. Nevertheless, given the severity and prevalence of parasite infections in underyearling suckers, these still should be considered to play a role in the overall survival of these endangered species.

Application of the Stream Salmonid Simulator (S3) for Chinook Salmon in the Trinity River, CA

Edward Jones, U.S. Geological Service, ejones@usgs.gov
Russell Perry
John Plumb
Nicholas Som

Life-cycle models can be an important decision support system (DSS) tool for resource managers who seek to protect and enhance fish populations. Life-cycle models can shed light on important demographic parameters that are otherwise difficult to estimate by conventional fisheries techniques. Through life-cycle simulation, emergent model properties may also lead to insights about population dynamics that are not obvious or intuitive. Using the framework of the Stream Salmonid Simulator (S3), we developed a model for juvenile life-stages of Chinook Salmon in the Trinity River, Northern California. This 1-D spatio-temporal model operates on a daily time-step, and is currently constructed for the upper 64-km section of river below Lewiston Dam. Spatially explicit estimates of daily redd, fry, and parr capacity drive processes such as redd superimposition, juvenile fish movement, and survival. The model relies on two physical inputs: time series of (1) daily streamflow, and (2) water temperature. Empirical redd survey data are used to initialize the population, and unique source populations can be tracked separately. Eggs, fry, and parr develop and grow as a function of water temperature. Fish movement and survival processes are assessed on a daily basis, and these parameters are estimated via calibration to empirical abundance estimates obtained from a rotary screw-trap at the downstream end of the model domain. As a DSS tool to facilitate the restoration of Trinity River Chinook Salmon to historical abundance levels, the S3 model will be instrumental for evaluating alternative dam operation scenarios, and to help prioritize restoration actions for greatest impact.

Mixed-Effect Models to Estimate Angler Tag-Reporting Rates Applied to the Oregon Tag-Reward Program

Michelle Jones, Oregon Department of Fisheries and Wildlife, Michelle.K.jones@state.or.us

In recent years, tagging programs have become a cost-effective method for estimating angler exploitation rates in recreational fisheries. Angler exploitation is estimated using the proportion of tags returned after being adjusted by a tag-reporting rate. The tag-reporting rate is estimated by releasing small numbers of high-reward tags (e.g., worth $50) simultaneous to standard tags (no monetary value), then comparing the reporting rates of both under the assumption that all reward tags are reported. Typically, the high-reward tagging system is only implemented for one to two years, after which the tag-reporting rate is assumed known and only standard tags are released. However, tag-reporting rates are often highly variable across two levels. First, tag-reporting rates at the same location often vary across different tagging events, which is likely due to small sample sizes when multiple tag releases are used throughout a fishing season. For example, in a few cases event-specific tag-reporting rates in Idaho have been estimated to be higher than reward tags, which unlikely reflects reality and makes event-specific exploitation rates impossible to determine (Meyer et al. 2012). Event-specific exploitation rates could be useful for determining short-duration exploitation rates to see how fishing varies throughout a season. On the second level, tag-reporting rates vary across locations. While this may be expected due to differences in the demographics of each angling community, the ability to use tag-reporting rates across similar locations would be beneficial. The current site-specificity of tag-reporting rates requires new high-reward tags to be released whenever new tagging programs are introduced. Here, we address the variability of tag-reporting rates at both levels by presenting mixed-effect models that may stabilize estimates of tag-reporting rates across tagging-events and locations, respectively. In our first series of models, tag-reporting rates for each location are considered random effects. In our second series of models, tag-reporting rates are considered site-specific random effects. We test both series of models on simulated data, then apply them to tagging data collected from Oregon recreational fisheries.

How to Train Your Fish: Olfactory Learning and Conditioning to Assess Potential Imprinting Odorants for Chinook Salmon

Maryam Kamran, Oregon State University, Maryam.kamran@oregonstate.edu
Andrew Dittman
Amanda Pollock
David Noakes

Olfactory cues play a critical role within an aquatic environment, with animals utilizing these cues for a suite of behaviors ranging from kin recognition to predator avoidance. Moreover, the role of olfactory cues in habitat recognition and site fidelity has been highlighted across a number of species. The spawning migrations of anadromous salmonids are one such example where, despite movements occurring over significant spatial and temporal scales, adults are able to return to their natal streams. Their ability to utilize olfactory cues is critical for successful homing, particularly during the freshwater phase of these spawning migrations.

Previous research has demonstrated that olfactory imprinting to odors occurs at specific developmental stages and this appears to be the mechanism through which juvenile salmonids learn site specific odors of their natal tributaries.

Although, salmonids can readily detect various classes of compounds within freshwater ecosystems, odorants which may be present within the environment that could potentially serve as migratory cues remain to be identified. Our goal is to improve olfactory imprinting of hatchery Chinook by introducing the selected odor compounds at the hatchery, which may reduce straying of hatchery fish and minimize negative interactions between hatchery and wild salmonid populations. We selected candidate odorants that could not only be used for successful olfactory imprinting but are also cost-effective compounds for application in hatchery management. To test the efficacy of select odorants as migratory cues, we conducted a series of odor conditioning behavioral assays to determine the olfactory learning abilities of juvenile fall Chinook salmon (*Oncorhynchus tshawytscha*). We evaluated whether juveniles successfully learned an odor after three days of conditioning, and then compared differences in learning abilities between the selected odorants.

Effects of Carcass Additions on Stream Food Webs Along a Temperature and Fish Assemblage Gradient in NE Oregon

Matthew Kaylor*****, Oregon State University, matthew.kaylor@oregonstate.edu
Seth White
Ted Sedell
Dana Warren

Over the last century, human impacts mediated by harvest, dam construction, and habitat degradation has led to a marked decline of naturally spawning salmon within the interior Columbia River basin. This loss of spawning salmon has reduced contributions of marine derived nutrient and carbon subsidies, potentially decreasing stream productivity. To evaluate how the loss of these subsidies may be affecting stream food webs, we added carcasses to three locations along a thermal gradient and with varying species composition in the upper Grande Ronde River of NE Oregon. Carcasses were added in August and sampling was conducted before and after the addition of carcasses in both control and treatment reaches. We evaluated responses of primary producers, growth rates of juvenile salmonids (Chinook salmon, *Oncorhynchus tshawytscha*, and steelhead and rainbow trout, O. mykiss), and diets of juvenile salmonids. We found limited evidence for local increases in biofilm chlorophyll a and ash free dry mass in the two warmer carcass treatment reaches soon after carcass addition, but these effects did not manifest in whole ecosystem primary production rates. Colder stream temperatures and scavenging of carcasses by bears likely contributed to the lack of a biofilm response in the third pair of sites, which was farthest upstream. Growth rates of juvenile O. mykiss were substantially greater in carcass addition reaches compared to control reaches one month after addition at all three sites. Juvenile Chinook were present in the two upstream reach pairs and also exhibited greater growth rates one month after

carcass addition. Diet samples indicated that both Chinook and O. mykiss were consuming substantial amounts of carcass tissue and eggs from carcasses. Our results suggest that the addition of carcasses impacted juvenile salmonids through direct consumption pathways. The reduction of naturally spawning salmon in the Grande Ronde basin may be limiting summer production of juvenile salmonids.

Foster Dam Improvements for Upstream and Downstream Fish Passage

Fenton Khan, U.S. Army Corps of Engineers, fenton.o.khan@usace.army.mil

Foster Dam (Foster), located on the South Santiam River in the Willamette River Basin, Oregon, is owned and operated by the U.S. Army Corps of Engineers (USACE). This 221-m tall dam went into operation in 1968 and is managed for multi-purpose use, including flood risk management, navigation, consumptive water, and power production. Foster also serves as a re-regulating dam (regulates water flow in the South Santiam River) for Green Peter Dam, located 11 kilometers upstream of Foster. A National Marine Fisheries Service 2008 Biological Opinion Reasonable and Prudent Alternative (RPA) included measures for improving up and downstream fish passage for threatened Spring Chinook salmon and winter steelhead in the South Santiam River. The RPA measures required an improvement to the Foster Adult Fish Facility (AFF) for upstream passage and evaluating the fish weir at the spillway for improvements to facilitate juvenile downstream passage.

The USACE rebuilt the Foster AFF in 2013 to improve collection and transport of adult Spring Chinook salmon and winter steelhead. These fish are transported and released upstream of Foster into the South Santiam River, considered a wild fish sanctuary. Studies to evaluate downstream fish passage at the fish weir and other routes at Foster began in 2013 and the results informed design for a new fish weir to improve juvenile downstream passage. This presentation will provide an overview of the USACE process of developing and designing fish passage solutions at Foster Dam.

Evaluation of Chinook Salmon Fry Survival in Lookout Point Reservoir, Oregon

Tobias Kock, U.S. Geological Survey, tkock@usgs.gov
Russell Perry
Gabriel Hansen
Philip Haner
Amy Hansen

An innovative study design was developed and tested in 2017 to estimate survival of Chinook salmon fry in Lookout Point Reservoir, Oregon. The reservoir supports abundant populations of piscivorous fish species, which are believed to prey heavily on juvenile Chinook salmon that move downstream and enter the reservoir during spring each year. Resource managers are interested in improving fish passage at Lookout Point Dam, but these efforts may not positively influence the population if reservoir mortality rates are high and limit the number of fish that survive to pass the dam. Therefore, our study was designed to estimate reservoir survival to inform decisions aimed at protecting juvenile salmon in the system. The study included the release of three groups of juvenile Chinook salmon (April, May and June) that were marked using parentage-based tagging methods. Monthly reservoir sampling (May–October) was conducted to recapture fish from each release group, and analyses were performed to estimate reservoir mortality that occurred between each release period. More than 3,500 juvenile Chinook salmon were recovered during reservoir sampling events. This presentation will summarize important lessons learned during this evaluation and present survival estimates obtained using the newly developed method.

Hooks, Slime, and Sinkers: Life after Barotrauma, Lessons Learned in the Field

Kelly Lawrence, Oregon Department of Fish and Wildlife, Kelly.a.lawrence@state.or.us
Polly Rankin
Michele Ottmar

A significant amount of waste or "discard" is generated in fisheries, from non-selectivity of gear, overlap of species occurrences, and high-grading catch. The Magnuson Steven's Act requires fisheries agencies to study methods to reduce fishery discard and to decrease mortality of bycatch and incidentally impacted species, which has resulted the generation of a significant body of work in the last few decades. This presentation will summarize some key points and lessons learned on the topics of fish handling, retention and holding, and reducing mortality for the purposes of scientific research such as mark-recapture, barotrauma, and telemetry studies. We will discuss the effects of, and some remedies for common injuries from hook-and-line capture such as: external wounding, stress, and barotrauma injuries, as well as cover the use of behavioral indices such as RAMP to quantify the short and longer term impacts to fish.

Evaluation to Determine the Effects of Foster Dam Fish Weir on Juvenile Salmonid Passage and Behavior

Stephanie Liss, Pacific Northwest National Laboratory, stephanie.liss@pnnl.gov
James Hughes
Eric Fischer
Brian Bellgraph
Fenton Khan
Ryan Flaherty
Gary Johnson

We evaluated downstream passage at a fish weir at Foster Dam (Oregon) and its efficacy as a non-turbine passage route for yearling and subyearling Chinook salmon (*Oncorhynchus tshawytscha*) and juvenile steelhead (O. mykiss) during October–December and March–June in 2015 and 2016. The objective was to estimate downstream passage over a decades old fish weir, which is a modified spill bay stop log, by estimating route-specific fish passage distributions, passage effectiveness, and survival rates. The overall goal was to support decisions on long-term measures and operations to improve passage conditions at the dam. Passage data for juvenile salmonids will ensure biological risks to downstream-migrating fish are minimized.

During 2015 and 2016, passage and survival of juvenile Chinook salmon and steelhead was evaluated at two reservoir elevations — 613 ft (low pool) and 635 ft (high pool). A total of 1260 yearling Chinook salmon, 2627 subyearling Chinook salmon, and 1597 juvenile steelhead were double-tagged with radio (RT) and Passive Integrated Transponder (PIT) tags. Fish were released equally at mid- and head-of-reservoir (2 km and 4 km upstream of Foster Dam, respectively). Randomization occurred between release locations, frequencies, codes, and burst rates to minimize the probability of code collision at the at the dam-face telemetry array. Direct-mounted underwater balanced loop-vee radio antennas were deployed at the spillway, the fish weir, and on the trash racks of the turbine penstock intakes. Downstream arrays consisted of an egress, primary, and secondary array (2.5, 19, and 23 km downstream of Foster Dam, respectively).

In both study years over half (50–67%) of the yearling and subyearling Chinook salmon passed over the spillway regardless of season or forebay elevation. In contrast, steelhead used the fish weir in higher proportions than other routes during both study years (43–97%), especially at high pool where 97% of steelhead passed. Survival estimates fluctuated for yearling and subyearling Chinook salmon at low pool (63–90%) for all routes, and were similar for weir and spillway passed fish. However, at high pool yearling Chinook salmon survival was higher for spillway passed fish (89–92%) than for weir passed fish (52–78%). The survival rate for steelhead was similar at spring low pool for weir and spillway passed fish (47–67%), and was higher at high pool (62–78%). We concluded the fish weir would not be suitable as a long-term passage solution at Foster Dam, considering the 33–50% of Chinook salmon that do not utilize this passage route. The findings are relevant to hydropower and fisheries managers working to provide safe downstream fish passage at Foster Dam, and will also be useful at other hydropower projects where spillways could be modified with surface-flow weirs as a downstream fish passage route. The results of this study informed the design of a new fish weir, which will be installed and tested in spring 2018.

The Importance of Diversity in Focused Internships and Mentoring

Siena Lopez-Johnston, Bonneville Power Administration, smlopez@bpa.gov

Many Tribal Fisheries and Natural Resource departments are run and permanently staffed primarily by non-American Indian/Alaska Native (AI/AN) employees. The need to further develop programs that encourage and foster AI/AN involvement in these disciplines is apparent. A few organizations and partnerships exist which provide dedicated programming. These organizations and partnerships have shown success in mentoring students in natural resource fields. In order to achieve and accomplish their goals these students needed the opportunity to grow within these programs and were able to use their experiences within these programs to continue on and thrive as students and professionally.

An example of this success is the partnership between the American Indian Science and Engineering Society and Bonneville Power Administration. Their partnership includes an internship for Fish & Wildlife students. For the last 6 years this internship has provided invaluable experience in a 10 week practice based internship that provides mentorship and encourages students to excel in the fields of wildlife and fisheries science. The importance of these partnerships and opportunities to address the needs of Tribal Natural Resource Programs cannot be understated. Developing internships to foster AI/AN interest and experiences in these professions and fields will increase the number of tribal members working at/with Tribal Natural Resource Programs. This generation of AI/AN professionals hold not only scientific but traditional and intrinsic knowledge. This group provides a glimmer of hope for the future of AI/AN students interested in these areas of study.

Fish-Driven Restoration: Strategies for incorporating science into restoration projects

Greer Maier, Upper Columbia Salmon Recovery Board, greer.maier@ucsrb.org

How do you incorporate important monitoring and modeling tools into restoration project development and design? Restoration practitioners often focus much of the design process on reducing risks and maximizing function but struggle with the best way to incorporate science into the process to ensure the work we do benefits the specific species and life stage(s) we are trying to benefit. Oftentimes we end up fixing the most obvious problems and assume it will fix habitat. However, there are cases where that may not work if there is a disconnect between the true limiting factor causing a survival bottleneck for a population and the function or habitat impairment you are addressing. Another issue is that projects addressing river function have more uncertainty and can take decades to provide habitat benefits while the needs of some species are certain and immediate. Given the data and tools we now have at our fingertips as fisheries scientists, there is a huge opportunity to develop better projects that will meet both the short-term and long-term needs of our species considering changing climate and other immediate threats. This talk will explore various examples of projects, tools, and strategies that scientists, sponsors, and designers can use to maximize benefits through a balance of natural process and goals for fish and habitat.

Climate Contributions to Hard Times in US West Coast Salmon Fisheries

Nate Mantua, NOAA/NMFS Southwest Fisheries Science Center, nate.mantua@noaa.gov

Sustained hard times for modern US west coast salmon fisheries arguably began in the early 1990s, with eleven of the past twenty-five years marked by federal disaster declarations. Eight additional petitions are now pending for federal fishery disaster declarations for U.S. west coast salmon fisheries in 2015, 2016 and 2017. Chinook salmon catches in 2016 were the 5th lowest since 1971, harvest quotas were not met, and spawning escapements to the Klamath and Sacramento River basins were very low. For 2017, the Klamath River Chinook salmon abundance forecast was the lowest on record, and 2017 salmon fisheries were sharply restricted from southern Oregon to southern California. Here I argue that the "warm blob" of 2014-2016, the California drought of 2012-2015, and western snow drought of 2015, are just the latest of multiple cases where climate extremes have had severe negative impacts on west coast salmon fisheries. Using a framework for a fishery being composed of an integrated system linking nature, law, and economy, I evaluate the role that climate extremes, resource management policies, and the evolving salmon production system played in federal fishery disaster determinations and the late 20th Century decline in US west coast Chinook salmon fisheries. I evaluate a 3 part hypothesis that (1) declining resilience in the West Coast salmon production system, and (2) increased variability in aspects of Pacific climate are increasing the variance in salmon abundance; and (3) because ocean troll fisheries operate on mixed stocks, the increased variance in salmon abundance and an increasing emphasis on "weak stock" management has reduced the reliability of harvest opportunities, landings, and landed value.

Under this hypothesis, the already degraded resilience in West Coast salmon fisheries is threatened by future trends towards increasing climate stressors on West Coast salmon production systems due to anthropogenic climate change. Restoring resilience in these fisheries in a warming climate will require some combination of rapidly increasing resilience in the salmon production system, the management system, and the fishing economy.

The Influence of Geologic Events Upon the Distribution of Westslope Cutthroat Trout in Eastern Oregon

Jason D. McClaughry, Oregon Department of Geology and Mineral Industries, Jason.McClaughry@oregon.gov

The Pleistocene glacial cycles profoundly influenced the distribution of Westslope Cutthroat Trout. The geologic past helps explain the existence of a population of Westslope Cutthroat Trout in the John Day River drainage, a significant distance from the primary concentration of populations in Montana, Idaho, and British Columbia.

Relative Abundance and Isotopic Characteristics of Fishes in the Odell Lake Food Web

Michael Meeuwig, Oregon Department of Fish and Wildlife, michael.meeuwig@oregonstate.edu Elizabeth Bailey
Shaun Clements

The Odell Lake fish assemblage historically included Bull Trout, Redband Trout, and Mountain Whitefish. However, populations of Lake Trout, Kokanee, and Tui Chub have been intentionally or inadvertently established in Odell Lake. These nonnative fishes may negatively affect populations of native fishes in Odell Lake through competitive or predatory interactions. For example, declines in Bull Trout populations have been observed following the establishment of Lake Trout in many lacustrine systems. We used data collected during gill net and trap net surveys and stable isotope data (▪13C and ▪15N) to evaluate general characteristics and potential interactions among fishes in the Odell Lake food web. Bull Trout and Lake Trout are both top-level predators in Odell Lake; however, Lake Trout outnumbered Bull Trout by about 27 to 1 in our net surveys. The majority of Lake Trout were sufficiently large to prey on most forage fishes in Odell Lake (i.e., Mountain Whitefish, Redband Trout, Kokanee, and Tui Chub). Substantial overlap in isotopic characteristics were observed between Rainbow Trout and Tui Chub. Isotopic values of Mountain Whitefish varied considerably with individual length and almost completely encompassed those of Rainbow Trout, Tui Chub, and large Kokanee. The low abundance of Bull Trout in Odell Lake coupled with the relatively high abundance of Lake Trout and similarity in trophic position between Bull Trout and Lake Trout suggest that Bull Trout may no longer provide a functional role in the Odell Lake food web. Additionally, substantial overlap in isotopic characteristics among native and nonnative forage fishes suggest competitive interactions may occur at lower trophic levels.

Use of Functions and Values Assessments to Achieve Compensatory Mitigation of Aquatic Resources in Oregon

Eric Metz, Oregon Department of State Lands, eric.metz@state.or.us

Dana Hicks
Charlotte Trowbridge
Bill Ryan
Tracie-Lynn Nadeau
Nicole Maness
Tom Taylor

To meet the goals of the U.S. federal Clean Water Act (CWA) and Oregon's Removal-Fill (R-F) Law, unavoidable impacts to jurisdictional waters must be compensated for through compensatory mitigation under the CWA Section 404 and Oregon R-F permitting programs. Both federal and state mitigation rules require functional replacement of impacts, however while many rapid assessment methods exist in the U.S., few attempt to evaluate function, defined for our project as the ecological characteristics and processes associated with a water of the state.
Program partners have made advances in assessment methods that will provide a more function-based evaluation of wetlands and streams for regulatory purposes. We will provide information on these methods and their status.

Program partners are incorporating these assessment methods in development of Oregon's Aquatic Resource Mitigation Program. This is a statewide mitigation approach to cover all jurisdictional aquatic resources that defines a watershed approach and uses function-based assessment methods to quantify compensatory mitigation requirements. We will provide information on the status of Program development, and highlight policy options and challenges associated with function-based credit quantification.

Diversifying the Profession: Unwrapping Economic Barriers

Christine Moffitt, AFS Hutton Committee; University of Idaho Emerita Professor, cmoffitt@uidaho.edu

Recent presentations of the demographics of our profession document the lack of diversity, including representation of women. Several efforts in AFS are underway to increase awareness of un-intention bias and cultural differences, mentoring efforts, and structural access for newly recruited professionals. However, outside of the aspect of racial and cultural diversity looms a far greater challenge, that of economic access to professional training. Since the recession, many state sponsored educational institutions programs have increased the costs that students must pay for their education. In Oregon alone, the inflation adjusted increases in tuition and fees for higher education have averaged more than 75% over the costs in 2006. Recent studies also show that incoming students are poorly prepared to understand college selection process, debt structure, and loan decisions. These surveys note a gap between male and female, and between white and African American and Hispanic students in financial literacy as well as capability. In our efforts to recruit and retain diverse candidates for the profession, we need to be more proactive in addressing these needs. Opportunities for economic and higher educational planning could be included in high school mentoring programs such as those for Hutton scholars.

Downstream Movement and Foster Dam Passage of Juvenile Winter Steelhead in the South Santiam River

Fred Monzyk, Oregon Department of Fish And Wildlife, fred.monzyk@oregonstate.edu
Jeremy Romer
Ryan Emig

Specific objectives of this study were to: 1) summarize the downstream movement patterns by age of wild juvenile steelhead entering Foster Reservoir; 2) determine the timing and age that juvenile steelhead pass Foster Dam, and 3) recommend the best operation window for the new weir at the dam to optimize passage utilization.

We monitored seasonal movement of juvenile steelhead into Foster Reservoir from 2011-2016 using a 1.5-m diameter rotary screw trap located upstream of Foster Reservoir. Juvenile steelhead ≥65 mm fork length (FL) were PIT-tagged at the screw trap and at various additional locations above Foster Dam from 2014-2017. We used boat electrofishing and Oneida Lake traps in Foster Reservoir to collect fish. We used a variety of techniques to collect and tag juveniles rearing throughout the South Santiam River and tributaries (Moose, Canyon and Soda Fork creeks) upstream of the reservoir. All tagged fish were measured and age was estimated based on length-frequency. Tagged fish detected at PIT antennas located in the weir at Foster Dam and at several locations downstream of the dam were used to calculate Foster dam passage timing, age at passage, and travel time to the Columbia River estuary.

The age of fish entering the reservoir was variable among years. Age-2 fish were only captured in the spring and were rare in some years (2011, 2012, and 2014). Age-1 fish were caught in both spring and fall and demonstrated highly variable peak timing in downstream movement among years. Fall peaks were observed in 2011 and 2014 and spring peaks observed in 2013, 2015, and 2016. The first age-0 juveniles began entering Foster Reservoir in late June each year, soon after emergence. This age-class continued to enter the reservoir throughout the rest of the year, and were generally the most abundant age class captured in the trap each year.

Overall, we tagged 5,778 juvenile steelhead upstream of Foster Dam from 2014-2017 to monitor dam passage. Age structure was comprised of 33% age-0, 50% age-1, 17% age-2, and <1% age-3 fish (age-1 fish were tagged in greater proportion to their abundance because they could be captured in all locations throughout the year and were >65 mm FL).

Age-2 fish comprised the majority of fish passing the dam. Overall age structure of juveniles at dam passage was 0% age 0, 13% age 1, 84% age 2, and 2% age 3. Most tagged age-0 and age-1 fish reared for at least one additional year before migrating past the dam.

Passage at Foster Dam occurred primarily from March through June (>97%). No fish passed in the summer and <3% of the tagged fish passed the dam in the fall. Variability in spring (March-June) passage timing was evident among years, with a later migration in 2015 compared to other years. Within the spring, 30-68% of the fish passed prior to 15 May and 98-100% passed prior to 07 June during the three years of the study.

Resilience and Vulnerability in Salmon Watersheds

Jonathan Moore, Simon Fraser University, jwmoore@sfu.ca

The resilience of salmon and their fisheries or other ecosystem services are enabled by a series of processes that include life-history diversity, compensatory capacity, meta-population dynamics, and watershed structure. This talk will synthesize recent findings on these resilience processes from salmon watersheds in British Columbia (Canada). For these different resilience processes I will address three questions: Resilience of what? Resilience to what? And, what human activities may disrupt the resilience? For example, connectivity, diversity, and the natural tree-like structure of rivers means that rivers are more than a sum or their parts. This watershed stability can stabilize flows, temperatures, and salmon catches and attenuate long-term climate change. Yet, these connections also mean that environmental risk may be propagated both upstream and downstream. Thus, maintaining and benefitting from processes that contribute to the resilience of salmon poses challenges for management and may demand shifts in environmental decision making.

Bioenergetic Modelling Shows That Climate Change Could Reduce Growth of Reservoir Rearing Juvenile Chinook Salmon

Christina Murphy*****, Oregon State University, christina.murphy@oregonstate.edu
Brent Johnson
Ivan Arismendi
Sherri Johnson

In the Pacific Northwest, juvenile Chinook Salmon that rear in reservoirs during summer are currently reaching much larger sizes as sub-yearlings than their stream-dwelling counterparts, which appears to improve their long-term survival and return rates. These differences, and the potential for behavioral regulation of growth in a vertically stratified environment, are of special concern in managing these fish under novel regimes and climate change. Here, we use a linked foraging and bioenergetics model to explore predictions of reservoir rearing juvenile spring Chinook Salmon growth potential and optimal rearing capacity with increasing water temperatures.

To model potential responses to changing climate, we use observed data collected from three Willamette Basin Reservoirs with rearing juvenile spring Chinook Salmon: Fall Creek, Lookout Point and Hills Creek Reservoirs. We added a uniform 3°C temperature increase throughout the water column, as the reservoirs thermally mix during turnover in fall. We then compared these results to predicted growth under typical conditions as well as to a combined warming and increased stratification scenario for Lookout Point Reservoir that normally has weak stratification patterns.

We predict that water column warming would decrease growth potential but would increase the number of fish that can grow optimally before density dependent interactions. Warming resulted in a 40% decline in total predicted growth in Hills Creek and Fall Creek Reservoirs. However, even with warming throughout the water column, Hills Creek and Fall Creek Reservoirs retained cool water thermal refugia; most of the decline in growth potential related to a combination of increased metabolism from increased temperatures and reduced access to food. Growth of juvenile Chinook Salmon in Lookout Point Reservoir was predicted to decline more dramatically (up to 80% decrease) than in Hills Creek or Fall Creek Reservoirs. This was attributed to a lack of comparable thermal refugia resulting from weak stratification patterns.

The projected reduced growth under warmer temperatures, in general, allowed higher numbers of smaller juvenile Chinook Salmon to persist without density dependent effects in competing for prey. Combining the climate change scenario in Lookout Point with increased stratification lessened the projective negative impacts to growth potential but had little effect on the optimal rearing capacity. It appears that stratified reservoirs can provide thermal refugia under climate change warming, and suitable rearing habitats (compared to warming non-stratified waters such as stream or shallow lake habitats), but that growth rates are likely to decline.

A web-based graphic user interface for the model is available: http://cas-web0.biossys.oregonstate.edu/"

Developing Reintroduction Strategies and Monitoring of Chinook Salmon and Steelhead Populations in the Upper Willamette River

James Myers, NOAA Northwest Fisheries Science Center, jim.myers@noaa.gov
Richard Zabel

Dams currently block volitional fish passage to historical spawning and rearing habitat for a number of populations of spring-run Chinook salmon and winter-run steelhead in the Upper Willamette River. These species were listed as Threatened under the U.S. Endangered Species Act (ESA) in 1999 and included in a National Marine Fisheries Service Jeopardy determination in 2008 for 13 dams operated by the U.S. Army Corps of Engineers. Under the terms of the Biological Opinion and as part of the overall recovery plan for the Basin, passage alternatives at Federally-operated dams and reintroduction programs for the basins above those dams are being considered for four populations of Chinook salmon and two populations of winter steelhead in four tributaries to the Willamette River: North Santiam, South Santiam, McKenzie, and Middle Fork Willamette rivers.

The reintroduction process as defined by Peters et al. can be broken down into four sequential phases: Preservation, Recolonization, Local Adaptation, and Population Viability. The transition through each phase is primarily dependent on reaching sequential benchmarks in reproductive success and productivity. Improvements in juvenile and adult collection and passage efficiency, temperature control, as well as longer-term improvements in habitat and local-adaptation will likely be the primary drivers for improving reproductive success. Natural selection will gradually make the population more locally-adapted and overall fitness should improve. Longer-term efforts to improve habitat will play a major role in restoring naturally-adapted populations.

The reintroduction program for each population needs to be tailored to the biological status of available founder populations, habitat conditions in the subbasin, both above and below the dams, and the specifics of the passage and collection structures or operational protocols for juvenile and adult migration. Circumstances vary considerably for the six populations.

Short term research monitoring be critical for identifying limiting factors and developing/improving fish passage systems. During the later restoration phases monitoring efforts will transition to longer-term population status monitoring. A diverse suite of monitoring techniques and strategies are available. Although the immediate questions to be addressed by monitoring may change over the course of reintroduction, it is important to gather basic data relevant to population status in a consistent manner.

Reintroduction strategies and monitoring approaches will be discussed for each of the six populations emphasizing the specific biological, geographical, and infrastructural differences.

If the suite of reintroduction efforts are successful the population will reach the final phase, Population Viability. The criteria for viable status were established by the Lower Columbia River/Upper Willamette River Technical Recovery Team (McElhany et al. 2006).

Suction Dredge Mining Post 2017 Legislative Prohibition in Essential Indigenous Salmonid Habitat

Richard Nawa, Klamath- Siskiyou Wildlands Center, rich@kswild.org

A suction dredge uses a motor, pump and sluice box mounted on a floating device to suck up streambed sediments to recover gold. In 2017 Oregon Senate Bill 3 permanently prohibited motorized suction dredge mining in Essential Indigenous Salmonid Habitat. Oregon AFS provided the legislature with timely scientific analysis that supported the prohibition. ESH is mapped by Department of State Lands with input by ODFW. DSL is currently developing regulations to allow an unlimited number of general authorization permits for dredging of up to 25 cubic yards of sediment in ESH via non-motorized techniques. Egg-to-fry survival of fall spawning salmonids and bull trout are reduced when the fish spawn in gravels disturbed by dredging. Fine sediment from dredge mining waste discharge substantially increases fine sediment in streambeds below the dredge. Annual impacts to fish and water quality from the new DSL regulations are likely to be minimal because non-motorized dredges have limited application to high gradient streams generally not used by fall spawning salmon. Although there has been voluntary compliance by the majority of the mining community with the motorized prohibition, illegal motorized suction dredging continues in remote streams. Mapping errors in DSL ESH maps also allow motorized dredging in winter steelhead spawning/rearing habitat.

The Oregon Hatchery Research Center in A Changing Environment: of What Use is Research?

David Noakes, Oregon State University, david.noakes@oregonstate.edu

I will suppose for the purposes of this talk that I am an intelligent but uniformed observer – consider me an alien, say a Thinking Radish. Peter Medawar's "Advice to a Young Scientist" is required reading. A distinction is often made between basic and applied research, or fundamental and applicable research. As the environment for fisheries management and research changes it is important to consider what motivates research. I use the term motivation with two distinctly different meanings, to illustrate my perspective. Motivation is used in a colloquial sense for many years to suggest the driving force causing something to happen. Coaches of basketball or football teams talk of their next game. The players have to be motivated, give 110%, let the chips fall where they may and take one game at a time. Players are encouraged to become more enthusiastic, to work themselves into a kind of frenzy, to win one for the home school, the old coach or the fans. In that sense motivation for research would consist of such things as sources of funding, new departments at universities, or new initiatives to get more people working on a research topic – perhaps to solve an important question that affects public health. For animals, we think of motivation as what causes an individual fish to behave in a particular way, causation. The other sense in which the term motivation has been used is to consider what it is that individuals should do in particular circumstances, a functional question. The distinction between these definitions of motivation appears to be subtle, but it is important and I think that it helps us to a better understanding of how research reflects our environment. Examples abound: funding becomes available for ocean acidification and everyone rushes to proclaim their expertise in that area and their ability to deal with the promised funding. Choose your favorite example, in a changing environment there will be many. I present this as a perspective based on motivation in the sense of causation – if you create the funding, or the infrastructure the researchers and the research will come. A functional consideration is that individuals decide on what research they should conduct from their individual perspective. We can, and should, attempt to identify research questions that are key to particular areas. The efforts to determine the structure of the DNA molecule clearly are an example. We can, and will, identify the need for our own research to obtain funding or infrastructure support. The results from the two definitions of motivation would appear to be the same to an intelligent but uninformed observer. Everyone rushes to win the DNA structure game, numbers of bright young people dedicate their efforts to consideration of climate change, or ocean survival of steelhead. I will conclude by claiming that the distinction between basic and applied research is mostly a relic of history that should not bind, nor blind, young researchers.

Wild Surrogate Chinook and Steelhead for Dam Passage Studies

David Noakes, Oregon State University, david.noakes@oregonstate.edu
Karen Cogliati
Cam Sharpe
Carl Schreck

Our Wild Surrogate Project produces juvenile Chinook and steelhead with desired behavior, morphology and physiology for research collaborators to evaluate dam passage efficiency. We provide a downstream migrating juvenile phenotype during the requested timeframe (fall and spring migrants) for our research collaborators. In the Willamette River, Oregon there is considerable temporal variation in the downstream-movement life history patterns, but it is unclear if juvenile migratory phenotypes are determined in response to environmental stimuli or if they are established naturally much earlier in life. We determine experimentally what alternative rearing strategies are best to rear and hold those fish so that they satisfy the requirements for those field research projects. We are using alternative rearing strategies to produce juvenile spring Chinook salmon and winter steelhead trout to be used as wild fish surrogates that reflect the migratory and fitness phenotypes of their wild counterparts. We must rear large numbers of fish from specified genetic and geographic origins for different research projects. We have delivered as many as 135,000 fish from each brood year of juvenile Chinook salmon and steelhead trout to researchers for evaluation of reservoir behavior and dam passage in the Upper Willamette River. We will present data to evaluate whether phenotypic traits expressed early in life are correlated with juvenile downstream migration patterns expressed later in life. We measure results on caudal fin quality of natural, hatchery, and surrogate reared fish during the juvenile migration window, as well as total body lipid content of hatchery fish and wild fish, collected at various locations throughout the Willamette River Basin. Condition factor and lipid content are correlated with the probability of downstream juvenile migration. Wild fish have significantly lower lipid content than hatchery fish, but much greater variation of lipid compared to hatchery and surrogate fish. By targeting the fin quality and lipid content of juvenile wild fish in the Wild Fish Surrogate Project, we are able to produce fish that are more phenotypically accurate and likely congruent with wild fish behaviors, including migration. All evidence from field studies of our wild surrogate fish suggested that they were smolting; therefore their movement patterns have met the requirements of the studies. Our current rearing protocols includes rearing at low density, feeding a low lipid diet, including structure in rearing tanks, and using natural growth feeding patterns.

Genetic Tools to Inform Fisheries Management and Conservation in Oregon

Kathleen O'Malley, Oregon State University, kathleen.omalley@oregonstate.edu

Genetic information is routinely incorporated into management and conservation strategies for marine and freshwater fishes worldwide. The four primary themes that encompass the ways in which genetic analyses can contribute to fisheries management include: 1) fisheries stock structure, 2) mixed stock fisheries, 3) genetic tagging and monitoring, and 4) species identification. To illustrate the application of genetic methodology to fishery resources in Oregon, I will provide examples within each theme and discuss future research opportunities.

Stream Transport and Retention of Environmental DNA Pulse Releases in Relation to Hydrogeomorphic Scaling Factors

Joseph Parzych, Inter-Fluve, jparzych@interfluve.com
Alexander Fremier
Katherine Strickler
Stephen Powers
Caren Goldberg

Aquatic organisms shed DNA into the environment which can be identified in water samples and used to detect species presence downstream or away from the organism. This method, called environmental DNA (eDNA), is highly sensitive and considered a viable complementary method to traditional field sampling of hard to locate species. However, because eDNA methods confirm species presence by proxy of DNA in water, the processes influencing eDNA transport and removal from water become critical to the methods' efficacy.

Therefore, we need a clear understanding of the fate and transport of DNA in aquatic systems. To begin to quantify factors controlling the transport times and loss of eDNA to detection, we performed the tracer experiment in five 200-meter reaches on a small 4th order stream using water retrieved from tanks with white sturgeon. We correlated stream hydrogeomorphic characteristics with the areal retention of the injected sturgeon eDNA to the benthos. We found significant differences in areal uptake and spiraling length between reaches ($p < 0.001$) and potential correlations with stream slope ($R\ 2 = 0.76$, $p < 0.052$). Results suggests that reach scale geomorphic metrics can help explain eDNA retention in lotic systems. This adds to our fundamental understanding eDNA transport and retention in streams and has direct implications for sampling protocols across reaches with varying channel complexity. Specifically, sampling frequency might be increased in areas with lower slopes due to the increase in eDNA retention in the benthic zone. Importantly, our study highlights a general incomplete understanding of the fate and transport of eDNA in aquatic systems.

Comparing Multispecies eDNA to Traditional Approaches to Evaluate Species-Level Aquatic Biodiversity in a Stream Network

Brooke Penaluna, PNW Research Station, USFS, bepenaluna@fs.fed.us
Tiffany Garcia
Laura Hauck
Kevin Weitmier
Rich Cronn

Aquatic biodiversity has long-been a proxy for assessing environmental change. Traditional approaches for measuring aquatic biodiversity, however, have not been very comprehensive or standardized, and they can be time-consuming, expensive, and limited to certain taxa and habitats. Alternatively, environmental DNA is revolutionizing how we can survey biodiversity in streams by offering a rapid, accurate, and standard assessment of multiple aquatic species from various taxa. Here, we compare detection of multiple aquatic species using eDNA metabarcoding of taxon-general and taxon-specific primers using microfluidic multiplexed PCR and high-throughput sequencing to traditional approaches of electrofishing to understand the utility of multiplexed eDNA counts as a qualitative and semi-quantitative proxy for species-level identification of aquatic biodiversity. We evaluate the detection of multiple aquatic species of fish, amphibians, invertebrates, and pathogens in four neighboring stream networks below and above where fish reside in the network in the Trask Watershed in northern Coastal Oregon. In this study, we are able to assess whether streams that are hotspots in productivity of fish are also hotspots in their upstream tributaries for amphibians. Our study also allows us to examine questions about assay performance, such as reproducibility, minimum detection limits, and the ability to estimate global aquatic biodiversity at individual sites and the global network. Our work broadens the scope of eDNA research by allowing for data-driven prioritization of conservation actions for multiple aquatic species.

Above the Mud: Using UAS to Visualize Small Features for Estuary Monitoring in Oregon

Elizabeth Perotti, Oregon Department of Fish and Wildlife, elizabeth.a.perotti@state.or.us
Anthony D'Andrea
Timothy Lawes

Skyler Elmstrom
Steven Rumrill

Unmanned aircraft systems (UAS) can support and complement scientific field research and natural resource monitoring by enabling more frequent sampling, access to unsafe or inaccessible areas, and greater aerial coverage. It can also serve as a quick response tool when the need for information is paramount. The Oregon Department of Fish & Wildlife's Shellfish and Estuarine Assessment of Coastal Oregon (SEACOR) Project is tasked with assessing shellfish populations and their habitats in Oregon's estuaries, and responding to information requests by other agencies on the distribution or status of these resources. Estuarine assessments take more than one year and are evaluated on a decadal scale; UAS is a potential tool for more frequent monitoring. Presented here are initial efforts evaluating the utility of UAS for quantifying and visualizing small features requiring sub-centimeter resolution. We provide lessons learned from these efforts, recommendations for mitigating common pitfalls, and examples of how to quantify these data and apply them to monitoring and management.

Evaluating Factors Affecting the Performance of Surface Collectors to Inform Future Developments at High Head Dams

Russell Perry, U.S. Geological Survey, rperry@usgs.gov
Tobias Kock

Developing successful structures for downstream fish passage is challenging at high head dams. During the 1950s and 1960s several forebay collectors were constructed and operated at high head dams to collect juvenile salmon and steelhead. These devices were termed "gulpers", operated using attraction flows of 150 ft3/sec or less, and were largely unsuccessful. Few alternatives were developed in subsequent decades until a second generation of forebay collectors began appearing at high head dams by the 2000s. In the Pacific Northwest, eight forebay collectors were constructed from 2008 to 2015, and several more are currently being developed. The new collectors generally are operated using inflows from 250 to 1,000 ft3/sec, and several have been successful at collection large numbers of outmigrants. In 2017, we conducted a review of the eight collectors and conducted an analysis of several physical and operational features to determine which factors were important predictors of collection success. This presentation will briefly review these physical and operational characteristics and present findings from our analysis, which included the development of a model than can be used to estimate collection success at new locations.

Planning and Implementation of Fish Passage at High-Head Dams in the Willamette River Basin, OR

Richard Piaskowski, U.S. Army Corps of Engineers, richard.m.piaskowski@usace.army.mil
Ian Chane
Brad Eppard

The Willamette System (WS), operated by the U.S. Army Corps of Engineers Portland District, consists of 13 multipurpose dams and reservoirs and approximately 92 miles of riverbank protection projects (revetments) in the Willamette River Basin in Oregon. Each project within the system contributes to the overall water resources management in the basin by providing for flood risk management, hydropower generation, irrigation, municipal and industrial water supply, navigation, recreation, fish and wildlife habitat, and improved water quality.

NOAA Fisheries issued a Biological Opinion in 2008 concluding that spring chinook and winter steelhead would be jeopardized by continued operation and maintenance of the WS. NOAA's Reasonable and Prudent Alternative (RPA) includes a major goal to provide effective fish passage at select WS dams to allow Upper Willamette River chinook and steelhead to regain access to historic upstream spawning grounds and to increase wild fish production. Several of the WS dams identified in the RPA for fish passage are high-head, with a hydraulic head over 30 meters. Adult passage around these dams is feasible by way of trap and truck transport. However, improving downstream juvenile fish passage at high-head dams is challenging. This talk provides an overview of the approach and implementation status for improving fish passage at WS dams.

Movement and Survival of Acoustic-Tagged Juvenile Chinook Salmon Released Upriver of Shasta Dam, 2017

John Plumb, US Geological Survey, jplumb@usgs.gov
Amy Hansen
Noah Adams
Scott Evans
John Hannon

Federal, state, private, and tribal interests have initiated the reintroduction of the historic and critically endangered population of winter-run Chinook salmon to tributaries upriver of Shasta Dam, northern CA. Towards this effort, we released 262 hatchery juvenile late-fall Chinook salmon implanted with acoustic transmitters into the McCloud River upriver of Shasta Dam as surrogates to determine how juvenile Chinook salmon would distribute and survive, and perhaps, emigrate to locations below Shasta Dam. We measured travel times to the dam, and the fractions of fish that moved between locations within Shasta Reservoir and to the dam. We also fit a Cormack-Jolly-Seber model to determine average detection rates and survival probabilities of the tagged fish over the 3 month study. Of the fish released, 261 (99%) were detected upriver of Shasta Dam and 182 fish (70%) were detected at least once at the dam. A total of 41 tagged fish (16%) were detected at least once downstream of Shasta and Keswick dams, and 3 fish (1%) emigrated as far as the San Francisco Bay. The detection of tagged fish anywhere below Shasta Dam was an unexpected result, but our study was fortuitously done during exceptionally high river flows and dam discharges, which could have contributed to the downstream migration success of the fish. Our estimates of fish travel times, detection, and survival represent the first estimates about juvenile salmon emigration from locations above Shasta Dam in more than 70 years. This will help to inform resource management decisions about how to best collected winter-run Chinook salmon at the dam or head of reservoir once they are reintroduced to watersheds upriver of Shasta Dam.

When Chinook Go Astray: Analyzing Straying Trends in Elk River Hatchery Chinook Salmon

Amanda Pollock, Oregon State University, amanda.pollock@oregonstate.edu
Maryam Kamran
Andrew Dittman
Marc Johnson
David Noakes

Many hatcheries in the Pacific Northwest rear and release salmon as a means to increase harvest opportunities in commercial and recreational fishing. Adult hatchery salmon that escape the fisheries and return to spawn in freshwater, but fail to return to the hatchery, are considered strays. Most studies define straying at a river basin level, and therefore fish are categorized as strays only when they return to a different river system. However, straying within a river system can be problematic if hatchery salmon do not return to their hatchery of origin, and subsequently spawn in the wild with natural-origin salmon. In this study we examine straying, defined as failure to return to the hatchery, of hatchery fall Chinook salmon in the Elk River, Oregon. We obtained over 30 years of coded-wire tag data from the Regional Mark Information System (RMIS) database, maintained by the Regional Mark Processing Center of the Pacific States Marine Fisheries Commission. All analyses were conducted using records of salmon that were recovered on the spawning grounds or at the hatchery, as the final destination of these fish is known. Our findings suggest that sex and age of the fish influence the likelihood that a hatchery Chinook will not return to the hatchery. Females are more likely to stray than males, and older Chinook are more likely to stray than younger Chinook. However, additional tagging and telemetry studies are needed to further evaluate these findings, particularly to determine whether small male Chinook are present on the spawning grounds but are not recovered during carcass surveys.

Adaptation of N-Mixture Model Analysis Using Genetic Tagging To Estimate Fry Survival in Lookout Point Reservoir

Adam Pope, U.S. Geological Survey, apope@usgs.gov
Russell Perry
Tobias Kock

Estimation of the movement and survival of juvenile salmonids has been greatly aided by the use of mark-recapture field studies and statistical models. These mark-recapture survival models depend critically on a number of assumptions, including that the survival of marked fish is representative of the unmarked population. When the population of interest includes small fish, such as salmon fry, there are very few types of marks available which can be reasonably assumed not to impact survival. Parentage-based tagging (PBT), a type of genetic marking, offers a potentially promising means to estimate survival and movement of otherwise difficult to mark fish such as salmon fry.

In this presentation, we adapt an N-mixture model to estimate survival of Chinook salmon fry rearing in the Lookout Point Reservoir on the Willamette River. N-mixture models are used to estimate abundance and survival of populations where data consists of repeated observer counts at multiple sites. Under this approach,

repeat visits to a site (primary occasions) each give rise to counts at a site which are then replicated either in quick succession or by multiple observers (secondary occasions). One assumption of this model is that each site is closed to emigration between secondary occasions. Applying this approach to fish survival in an open reservoir is challenging from a sample design standpoint, since the requisite secondary occasion replicate samples must be taken over successive days, which likely violates the assumption of closure at a specific sample site. By redefining what we mean by a 'site' as fish with a common parentage as determined by PBT marks, the closure assumption holds, and it may be possible to fit an N-mixture model to repeated fry counts. We show results of fitting this model to simulated counts under a suite of assumptions to explore the extent and limitations of parameter estimation under this approach.

The Role of Magnetic Maps in Marine Migration

Nathan Putman, LGL Ecological Research Associates, nathan.putman@gmail.com

From a human's perspective, the navigational task of ocean migrants is daunting: the open sea is vast, featureless, and in constant motion. Yet, numerous species' transit to and fro across ocean basins with seeming ease. Pacific salmon hatch in freshwater streams, but juveniles swim to sea, travelling to distant foraging areas for a few months to years before returning to their natal river to spawn. Loggerhead sea turtle hatchlings disperse from sandy beaches in North America to follow a circular migration route across the Atlantic prior to returning to nest near their natal site 2 to 3 decades later. European eel hatch in the Sargasso Sea, transit the North Atlantic, recruit to coastal and freshwater habitats from Scandinavia to North Africa where they remain for more than a decade before the onset of their spawning migration back across the Atlantic. These migrations have evolved such that ontogenetic changes in physiology are paired with movements to regions providing suitable environmental conditions for that life-stage. For such a strategy to function efficiently, the animal needs to know where it is along its developmental migration relative to its next step. Recent experiments indicate positional information inherent in the Earth's magnetic field provides that "map" information to turtles, salmon, and eels. Juveniles of these species subjected to "magnetic displacements" display orientation that differs depending where along their migratory route the recreated magnetic field exists. For instance, salmon exposed to a magnetic field characteristic of the northern edge of their range orient southward, those exposed to a field near the southern edge of their range orient northward. Simulating the orientation observed in salmon, sea turtles, and eels within realistic ocean circulation models indicates the responses are highly-adaptive, increasing the likelihood of reaching or remaining in favorable environmental conditions. Further analyses provide evidence for the important role of magnetic maps in shaping spatiotemporal variation in these species movement patterns. These findings also show how an increased understanding of the sensory basis of animal navigation enhances our ability to manage and conserve species in the face of global climate change and widespread habitat alterations.

Meeting Challenges of Climate Change

Gordon Reeves, U.S. Forest Service, greeves@fs.fed.us
Lee Benda

Aquatic ecosystems in the Pacific Northwest will be challenged biologically and physically by potential changes in water temperatures – higher summer - and seasonal flows –lower summer and higher winter - resulting from a changing climate. The magnitude of these effects, and resulting impacts, will not occur or be expressed uniformly within or among watersheds; rather they will vary widely. Potentially mitigating or off-setting these effects requires identification of where in the streamscape the various effects and ecological processes occur and maintaining or re-establishing these processes and the connectivity between the stream and off-channel and upslope areas in these locations. We describe a spatially explicit method for identifying these locations using Digital Elevation Models (DEMs) and lidar derived model watersheds with examples from Oregon, Washington, and southeast Alaska.

Resiliency: The Application to Aquatic Ecosystems

Gordon Reeves, U.S. Forest Service, gordon.reeves@oregonstate.edu

An ecosystem is a dynamic entity that is subject to periodic disturbances and is in the process of recovering from some past disturbance. This perspective presumes the existence of multiple states, with conditions at a time depending on the time since disturbance and the legacies of that disturbance. Resilience is the capacity of an ecosystem to respond to a perturbation or disturbance by retaining the capacity to express the full range of states that it experiences. The application of this definition of resilience to aquatic ecosystems is problematic, however, because the prevailing view of these systems is that they relatively stable through time, expressing a relatively a limited range of conditions. Resilience in the context of this definition suggests that aquatic ecosystems return to a pre-disturbance condition relatively after disturbance. This perspective has resulted in unrealistic expectations for the management of aquatic ecosystems and created a continuing sense of frustration for managers and regulators. This talk explores consequences of this static view of aquatic ecosystems and present options for incorporating a more dynamic perspective into the management of aquatic ecosystems.

In consideration of the Pikeminnows

Stewart Reid, Western Fishes, WesternFishes@ashlandcreek.net

There are four Pikeminnows (*Ptychocheilus spp*.), all native to western North America. They represent the largest minnows in the western hemisphere and range in size from ca. 1.5 ft for the Umpqua Pikeminnow to ca. 6 ft for the Colorado Pikeminnow, now endangered. Due to their large size and abundance, Pikeminnows formed an important dietary component for Native Americans and early European settlers. Traditional and European names applied to Pikeminnows were often positive and denoted strength befitting a large predator. However, in the late 1800's and early 1900's social attitudes shifted and the derogatory term "squawfish" began to be broadly applied to these fishes. Notably, this was at the same time that Native American culture was being actively suppressed and the eugenics movement gained strength in America, a philosophy of judging relative worth of human populations and actively selecting for or against particular characteristics. Whether the eugenics movement played a role in the naming of the fishes is uncertain. However, the comparison bears consideration in light of continuing deprecation of native non-sport fishes, preferred management of non-native predatory fishes, attempts to control native Pikeminnow populations, and frequent lack of attention to either population status or threats to native fish populations. The apparent decline of the endemic Umpqua Pikeminnow population in its native streams is a disturbing reminder of the outcome when we neglect our native fish populations.

How to Enjoy Being a Fish Biologist

Stewart Reid, Western Fishes, WesternFishes@ashlandcreek.net

Being a fish biologist requires varied skills and knowledge, often depending on your area of activity - nevertheless, learn how to swim. However, building a successful career in fish biology, or anything else, also requires your attention and consideration, at all stages of your career. This, along with your family and friends will define your life. Different people will have different priorities. Here are some of mine: Work on projects you enjoy - you'll do it better and have more fun. Do not tolerate long-term frustration - short term frustration happens, but there are always other options out there. Regardless of your position, think of yourself as a colleague and not as a subordinate. Success, both for you and for the fishes you are responsible for, is often built through your relationships with the people and fish you interact with (in the office and in the field). That is hard work for many of us who are inclined towards introversion, but it is important. Stay wet - enough said.

Detroit and Big Cliff Long-Term Temperature Control and Downstream Fish Passage

Jon Rerecich, U.S. Army Corps of Engineers, jonathan.g.rerecich@usace.army.mil
Jeff Ament
Kristy Fortuny
Steve Schlenker
Norm Buccola
Rich Piaskowski

The Willamette System (WS) consists of 13 multipurpose dams and reservoirs, and approximately 92 miles of riverbank protection projects (revetments) in the Willamette River Basin in Oregon. As a part of the WS, the U.S. Army Corps of Engineers (USACE) completed construction of Detroit Dam (141 M tall) and Big Cliff Reregulating Dam and Reservoir in 1953, operated with multiple purposes that include flood risk management, navigation, consumptive water use, and power production. Both dams were constructed without means to provide fish passage. A NOAA Fisheries 2008 Biological Opinion Reasonable and Prudent Alternative (RPA) included measures for providing effective up and downstream fish passage for threatened spring Chinook and winter steelhead around Detroit and Big Cliff dams, and improving downstream water temperatures.

The Minto Fish Facility was rebuilt in 2012 to provide trap and haul facilities for passage of adult spring Chinook salmon and winter steelhead above Detroit Dam. Improving downstream juvenile fish passage at high-head dams (having a hydraulic head over 30 meters) is challenging. Structural solutions are being designed to collect juvenile spring Chinook salmon and winter steelhead, and to achieve downstream temperatures closely resembling pre-dam temperatures throughout the year. Temperature modeling has identified multiple structural alternatives concepts that have the capability to meet downstream temperature targets under most conditions. The USACE is proceeding with the design of the selective withdrawal structure with a floating screen structure for downstream fish passage. The presentation will focus on the design concepts and process for developing the preferred alternative.

The National Flood Insurance Program and Protection of Endangered Species

Daniel Rohlf, Lewis & Clark Law School, rohlf@lclark.edu

The Federal Emergency Management Agency implements the National Flood Insurance Program (NFIP), an initiative that makes federally-subsidized flood insurance available to property owners who wish to build or currently own property within floodplains. This usually obscure program has increasing come into the national spotlight, particularly after the recent hurricanes in Texas, Florida, and Puerto Rico demonstrated the widespread effects of increasingly devastating storms.

Habitat disturbance associated with development – and rebuilding efforts – in floodplains also take a serious toll on fish and wildlife dependent on functional riparian areas. By making flood insurance more affordable, the NFIP effectively subsidizes and thus facilitates development in floodplains. Consequently, FEMA establishes minimum protections for floodplain resources that local land use authorities must put in place in order for their communicates to be eligible for federally-subsidized flood insurance.

Over the past dozen years, conservation organizations have worked to reduce the impacts of flood insurance bankrolled by federal taxpayers in facilitating floodplain development that harms species listed as threatened and endangered under the federal Endangered Species Act (ESA). In 2010, a lawsuit with plaintiffs led by Portland Audubon forced FEMA to initiate consultation with the National Marine Fisheries Service (NMFS) pursuant to section 7 of the Endangered Species Act. In 2016, after substantial politically-driven delays, NMFS issued a NMFS finally released a biological opinion (BiOp). The BiOp found that as currently run, FEMA's flood insurance program jeopardizes the continued existence of 16 listed Evolutionarily Significant Units of salmon and steelhead in Oregon, as well as jeopardizes Southern Resident Killer Whales in Puget Sound. The BiOp also concluded FEMA's actions adversely modify the designated critical habitat of listed salmonids in Oregon.

The BiOp identifies reforms FEMA should implement that will not only better protect federally listed salmonids, but will also reduce flood risks to people and property. These measures include developing up-to-date maps of areas prone to flood damage that account for weather extremes caused by climate change. FEMA also must develop guidelines requiring local governments to limit development in flood-prone areas, as well as develop measures to mitigate development's impacts to floodplains.

The NFIP reforms called for by NMFS in its Oregon NFIP BiOp set an important national precedent for taking steps to reduce the flood insurance programs impacts on habitat for threatened and endangered species – saving taxpayer dollars in the process. Fearing limits on development, local governments, development interests, and politicians have expressed concern about these reforms' impacts on development. Two groups have also filed suit against NMFS and FEMA in district court in D.C. in an effort to overturn NMFS' Oregon BiOp.

Modeling Spawning Habitat Potential for Chum and Pink Salmon in Relation to Landscape Characteristics in Coastal Southeast Alaska

Bernard Romey, ROM3Y, h2o.bern@gmail.com

In response to the increasing need for ecosystem services throughout the Southeast Alaska region, decision makers are tasked with balancing the need for natural resources with salmon conservation. However, accurate historical and current information on salmonid population abundance, freshwater distribution, and habitat quality are sparse with limited resolution for large portions of this remote and rugged landscape. Here, I created Intrinsic Potential (IP) models for chum and pink salmon to predict the potential for portions of coastal rivers to provide high-quality spawning habitat. I developed IP models for both species from field redd surveys and synthetic habitat variables derived from 1-m resolution digital elevation models. The surveys were performed at 49 study reaches in five coastal drainage basins on the north end of Chichagof Island, Southeast Alaska. I used a spatially balanced random sampling design that included field surveys for redds during two field seasons with contrasting precipitation patterns and disparate adult salmon escapements. The IP models predict probable spawning habitat for both species based on persistent landform characteristics and hydrologic processes that control the formation and distribution of spawning habitat across the landscape. Selection of persistent reach variables for both species IP models was informed by principal component analysis (PCA), resource selection ratios, random forest modeling, and regression models of field and synthetic variable comparisons. In general, Chum Salmon redds were observed in larger unconstrained low-gradient floodplain reaches where accumulation of deposited gravels and adequate flow produce habitat heterogeneity suitable for spawning. Pink salmon utilized smaller moderate-gradient channels where substrate size and flows were better suited to their smaller body size. Remotely sensed persistent fish habitat data is valuable information for helping understand fish population distributions across the landscape. These synthetic metrics enabled the identification and evaluation of persistent landscape features as probable predictors of IP. This research highlights the utility of using IP models with high resolution remote sensing to expand known distributions and quality of spawning habitat for these two species in Southeast Alaska coastal streams.

Review of Tools for Identifying, Planning and Implementing Habitat Restoration for Pacific Salmon and Steelhead

Philip Roni, Cramer Fish Sciences/University of Washington, phil.roni@fishsciences.net
Paul Anders
Tim Beechie
David Kaplowe

A key challenge in watershed restoration is identifying the appropriate assessments, data, and analyses needed to identify disrupted natural processes, lost and degraded habitats, limiting factors, and ultimately identify and design successful restoration projects. This has proven particularly challenging for large restoration programs focused on recovery of threatened and endangered salmon and trout where numerous tools, models, and other assessments have been developed to assist with habitat restoration at the watershed, reach, and project scale. Unfortunately, it is often unclear which step in the restoration process various assessment tools will actually address. To assist with identifying the appropriate assessment tool (e.g., model, data collection, analysis, and survey), we reviewed major categories of watershed restoration assessment tools to determine their goals, inputs, outputs, and their utility in helping plan, prioritize, and implement restoration actions. The major categories of assessment tools reviewed included: 1) life-cycle and fish-habitat models, 2) watershed assessment methods and techniques, 3) reach assessments, 4) prioritization tools, and 5) common monitoring methods to identify, prioritize, and plan river and watershed restoration projects. We specifically indicated whether they directly or indirectly assisted with the key steps in the restoration process that are required to develop successful restoration plans and projects including: assessing watershed conditions, identifying limiting habitats and life stages, identifying problems and restoration actions, selecting restoration techniques, prioritizing restoration actions, or designing actual restoration projects. It is important to recognize that no single assessment tool will address all the steps in the restoration process. Selecting appropriate assessment tools requires a clear understanding of the goals of the restoration program and which step in the restoration process will be addressed by a particular tool. We close with recommendations for how restoration practitioners and managers can use our review to help select the appropriate assessment tools needed for their watershed.

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

David Roon*****, Oregon State University, david.roon@oregonstate.edu
Jason Dunham

Thinning and selective logging are being applied to second-growth forests to accelerate the recovery of late successional forest characteristics (structure and composition). These restoration practices have largely focused on uplands, but now there is interest in applying them in riparian zones. The consequences of these treatments are potentially controversial and not well studied. Part of this controversy stems over concern about cumulative effects of thinning, which involves an understanding of the spatial and temporal dimensions of the issue in whole-stream networks. To address these cumulative effects we are studying experimental riparian thinning treatments in adjacent stream networks and forests managed by the Green Diamond Resource Company and the National Park Service (Redwood National Park) in northern California. Thinning was implemented in multiple locations, allowing us to evaluate effects of these local treatments in the context of larger stream networks. To track local treatments, we followed a before-after-control-impact approach to quantify spatial and temporal patterns of riparian shade, light, and stream temperatures as possible responses to riparian thinning. To evaluate how the potential effects of these local treatments resonate at broader extents, we have quantified shade, light, and stream temperatures across entire networks. Spatial statistical models were applied to these data to determine the spatial extent to which localized thinning propagated through stream networks. Preliminary results from tracking local treatments indicate an immediate response in stream temperature associated with the reductions in shade and increases in light associated with riparian thinning. At the network extent this resulted in variable downstream propagation of the effects of upstream thinning. Future study will track how these responses adjust over time. By adopting a multi-scale approach that includes both spatial and temporal components we are better able to understand the cumulative effects of riparian thinning on stream ecosystems.

Factors and Processes Determining Water Temperature in the Willamette River, Oregon

Stewart Rounds, U.S. Geological Survey, sarounds@usgs.gov
Norman Buccola
Laurel Stratton-Garvin

High water temperatures can threaten the health and survival of temperature-sensitive fish in the Pacific Northwest. In the Willamette River in northwestern Oregon, regulatory temperature thresholds to protect spawning, rearing, and migration of threatened and endangered salmonids are routinely exceeded in spring, summer, and autumn. It is necessary, therefore, to understand the factors that determine the river's heat budget as well as the diversity of thermal conditions that occur in the river's main channel, tributary, and off-channel habitats.

As part of a study of the effects of flow management and dam operations on thermal conditions in the Willamette River, the U.S. Geological Survey used CE-QUAL-W2 flow and temperature models in the river and its major tributaries to investigate the effects of flow, weather, and dam operations on reach-scale temperatures. The CE-QUAL-W2 model was modified to track specific sources of heat, thus providing a means to determine how far downstream the temperatures of water released from an upstream dam are "remembered" by a traveling water parcel. Results from the low-flow and warm spring and summer of 2015 showed that the "heat memory" was about 2-3 days, meaning that the temperature of water released from an upstream dam was largely "forgotten" and replaced by heat from tributaries and, especially, weather-related heat fluxes within that time frame. As a result, water temperatures in the Willamette River, particularly those downstream of Corvallis, Albany, and Salem, were largely unaffected by upstream release temperatures from the dams during spring and summer of 2015, and instead were controlled mainly by streamflow (residence time, thermal mass) and weather. Closer to the upstream dams on the tributaries, dam operations and the temperatures released from those dams control river temperature.

Building on these results, regression models to predict water temperature in the more downstream reaches of the Willamette River were successfully constructed, with a mean absolute error of less than 1.0 degree Celsius. Based only on daily air temperature and streamflow data, such regression models are useful for analyzing multiyear datasets and evaluating the variability in the thermal response of the river to different strategies of flow management.

The CE-QUAL-W2 models also were used to simulate water temperatures resulting from a range of streamflow and weather conditions in recent cold/wet (2011) and warm/dry (2015, 2016) years. Measurements of conditions in off-channel habitats (2015, 2016) were compared to main-channel conditions to determine which of the off-channel habitats might serve as cold-water refuge areas for fish. These model results and measurements along the entire river network illustrate the baseline thermal conditions that make up the "thermal mosaic" of habitats in the Willamette River system, an understanding of which is critical to flow management and endangered species restoration.

Understanding Large-Scale Dynamics of Diverse Shelf Ecosystems - The Importance of Physical Context and Response to Change

James Ruzicka, Oregon State University, jim.ruzicka@oregonstate.edu
Kenneth Brink
Dian Gifford
Frank Bahr

A major feature distinguishing the dynamics of coastal ecosystems and their response to climate change is the physical context. Physical setting defines rates of nutrient import, plankton exchange between the shelf and ocean, and limits detritus recycling. To compare the roles of food web structure and physical context in controlling ecosystem dynamics, we applied a standardized end-to-end model platform to diverse shelf ecosystems: Oregon upwelling, Coastal Gulf of Alaska downwelling, Georges Bank, and the North Sea semi-enclosed basin. Comparative analyses of different food webs within each physical setting tested the null hypothesis that when nutrient input and physical factors are standardized, there are no substantial differences in the productivity of similarly defined guilds within diverse food webs. Physical context played the greater role in defining ecosystem dynamics. Physical exchange between shelf and ocean affected not only nutrient recycling but also trophic transfer efficiencies and the relative importance of pelagic vs. benthic components of the food web. Differences in plankton transport rates led to apparent decoupling of lower trophic and upper trophic level production rates - reducing upper trophic production relative to plankton production (upwelling) or enhancing upper trophic level and benthos production (downwelling). We further applied the model to more closely study how the Oregon coast upwelling ecosystem behaves under increased upwelling intensity and prolonged event duration (implications of some climate scenarios). These simulations suggest a decoupling of upwelling indices and fish production under intensified upwelling. They also suggest a shift in the size composition of the phytoplankton community and reduced productivity across all trophic levels as upwelling events become prolonged.

Anadromous Salmon Display Maladaptive Orientation to Southern Hemisphere Magnetic Fields

Michelle Scanlan, Oregon State University, scanlanmi@gmail.com
NathanPutman
Amanda Pollock
Joseph O'Neil
David Noakes

Repeated efforts to introduce anadromous salmon to the southern hemisphere and establish ocean migrating populations have seldom achieved success. In contrast, non-ocean migrating populations of multiple salmonid species have successfully colonized the southern hemisphere. This suggests that the invasive potential of anadromous salmon in the southern hemisphere may be limited by their marine phase and by inappropriate

ocean navigation. Recent studies suggest that juvenile Chinook salmon (*Oncorhynchus tshawytscha*), steelhead trout (*O. mykiss*), and Atlantic salmon (*Salmo salar*) inherit orientation responses to the geomagnetic field, termed "magnetic map," that potentially guide their migration to marine foraging grounds. To examine how magnetic maps might function in the context of a trans-equatorial introduction, we conducted a series of simulated magnetic displacements by exposing juvenile Chinook salmon, steelhead trout, and Atlantic salmon from Oregon, USA to magnetic fields representative of locations in both the northern and southern hemispheres. Exposure to southern hemisphere test fields elicited a random orientation response in juvenile Atlantic salmon. For Chinook and steelhead, magnetic fields representative of poleward locations resulted in southward orientation and equatorial fields elicited northward orientation, regardless of hemisphere. In the northern hemisphere these responses would facilitate appropriate movement to oceanic feeding grounds, whereas this orientation would be maladaptive in the southern hemisphere and would subsequently lead to unfavorable habitat. Our experiments offer a potential explanation for the many unsuccessful attempts to introduce ocean migrating salmon populations to the southern hemisphere. Additionally, this information provides further insight into how salmon perceive magnetic information and the ecological and evolutionary implications of this sensory ability.

To Move or Not to Move: Downstream Rearing Chinook Salmon in the Upper John Day River

Michael Scheu, Oregon State University, michael.scheu@oregonstate.edu
Ian Tattam
Guillermo Giannico

Juvenile Chinook salmon typically follow an early life history in which they remain in the colder reaches in which they were spawned until their second spring in freshwater. However, in some tributaries of the Columbia River Basin a variety of patterns have been observed in the timing of the movement of juveniles between natal reaches and the estuary. In the Upper John Day River, juvenile individuals have been detected moving downstream during their first spring after emerging from the gravel. Though spring conditions may be favorable for these early downstream migrants, summer warm water temperatures and low discharge create inhospitable conditions that may force the young Chinook salmon to seek thermal refuge in tributaries. In this study, we estimate the abundance of fish with this early migratory life history pattern, identify where they find summer refuge, and compare the body mass and growth rates between downstream rearing (DSR) and natal reach rearing (NRR) individuals. We captured and PIT tagged migrating juvenile Chinook salmon in the mainstem Upper John Day River during the springs of 2016 and 2017 using rotary screw traps and a fish screen bypass trap. We tracked their movements into tributaries using PIT antenna arrays, and multiple pass snorkel surveys. In the summer of 2017, we performed a capture-recapture study at randomly selected sites occupied by DSR and NRR fish to assess individual growth rates. Our results indicate that the DSR fish have high abundances in the mainstem of the river during spring and, in the summer, some of these fish move into lower reaches of smaller tributaries or migrate as far as 45 km upstream in larger tributaries. The DSR fish attain significantly larger sizes than the NRR fish in the river mainstem, but they nearly cease to grow while holding in the tributaries. Whereas, the NRR fish experience faster growth rates through the summer, largely eliminating the size difference between the two life histories. The rapid early growth of the DSR fish has the potential to

increase their survival to the estuary, however their diminished growth during the summer months reduces this size advantage and may instead impair their survival.

Temperature Change May Affect Migration Differently Across Chinook Salmon Phenotypes

Carl Schreck, Oregon State University, carl.schreck@oregonstate.edu
Arimune Munakata
TakashiYada
Karen Cogliati
David Noakes

Previously we reported that at swim-up Chinook Salmon sort into water column and bottom oriented behaviors and that the former resemble wild fall and the latter spring migrant smolts in shape. We have also reported that minute (fraction of a degree) temperature decrease induces downstream movement, likely mediated by elevations in the smolting hormone cortisol. Here, we present new data that indicates that the endocrine system involved with this temperature-induced downstream movement is upregulated in the fall in the water column phenotype and the next spring in the bottom phenotype. This is based on measurements of corticotropic hormone releasing hormone in the brains (preoptic area) of the fish, operating likely through the induction of cortisol synthesis. This contention is supported by new data that shows that a miniscule decrease in temperature in the fall results in downstream movement in fish representing the water column phenotype and not in the bottom phenotype. We speculate how climate change-induced alterations in temperature could thus affect migratory patterns in wild salmonids.

Relative Catchability of Wild Summer Steelhead Caught and Released by Sport Anglers in the Deschutes River, Oregon

Jason Seals, Oregon Department of Fish and Wildlife, t.jason.seals@state.or.us

The impacts to wild steelhead populations from catch and release sport angling in mixed stock recreational fisheries are dependent on stock abundance and the relative catchability of both wild and hatchery fish. We estimated and compared the catchability of both wild and hatchery summer steelhead in the Deschutes River from 1996 to 2016. On-site access-access based creel surveys (Pollock et al. 1994) were conducted annually. Stock composition was determined by the Sherars Falls Adult Steelhead Trap. The relative odds of wild steelhead being captured in the fishery was significantly greater than the relative odds of wild steelhead being captured in the trap. Catchability of these stock types effect harvest rates, catch and release mortality rates, and the degree to which wild populations are negatively affected by genetic introgression with hatchery fish. These findings demonstrate the need of fishery managers to consider the implications and importance of wild fish to sport anglers and recognize that selection of hatchery fish that are more susceptible to angling may occur in fisheries.

Collective Behavior of Zebrafish in the Wild

Delia S. Shelton, Oregon State University, delia.shelton@oregonstate.edu
Sierra G. Shelton
Danita K. Daniel
Anuradha Bhat
Emília P. Martins

Wild zebrafish vary in their display of collective behavior. We found zebrafish in flowing water formed large, cohesive groups that fused and fissioned frequently. In flowing water, individual fish changed leadership and position within the shoal rapidly. Groups in still water were less cohesive and smaller with group membership remaining more constant (less fission and fusion) than groups in flowing water. Leadership within groups was more stable. As found in a previous field study, groups in flowing water were large and tightly-knit (up to 2000 fish), whereas group sizes were smaller (11 fish/ group) with more space between individual fish in still water. The variation in collective behavior among zebrafish populations highlights the natural variation among group behavior in wild zebrafish.

AFS DEI Lessons and Reflections: Year 1

Gabe Sheoships, Friends of Tryon Creek; Portland State University, gabesheoships@gmail.com

The Oregon Chapter of the American Fisheries Society is a national leader in building equity in the fisheries profession: identifying power, privilege and creating inclusive pathways for both students and professionals while educating our internal community culture. This presentation will build on lessons learned in the initial year of the Diversity, Equity, and Inclusion External Committee (formerly known as Human Diversity External Committee 2016-17) and will present on recommendations for future actions and policy.

A Decade of Steelhead Entrainment: Fish Diversion Patterns at Irrigation Dams of the Umatilla River Basin, Oregon

Will Simpson, U.S. Fish and Wildlife Service, william_simpson@fws.gov

The long term monitoring of salmonid entrainment is uncommon across basinwide networks of irrigation diversions, obscuring factors that influence spatial and temporal variability in fish entrainment and how this entrainment and associated fish screening technology may affect salmonid populations. PIT tag antenna arrays were deployed at canal headgates and screens to estimate the entrainment and the river return of volitionally migrating smolt and adult steelhead at three irrigation canals in the Umatilla River basin, OR. About 5,000 hatchery steelhead smolts were tagged and released annually upstream of the irrigation diversions over eleven years, and 863 PIT-tagged adult steelhead moved upstream of Three Mile Falls Dam (TMFD) over 8 years as they entered areas of the basin with canals. Annual entrainment of hatchery steelhead smolts was variable among years and irrigation canals and often related to the interaction of low river flows and canal operations. Some of the largest annual entrainment numbers occurred at the smallest diversion monitored. Patterns of PIT tag detections suggest that these diversion-specific relationships are in part influenced by the morphology of diversion dams and streams near canal headgates. Overall a sizable number of smolts entered at least one irrigation canal (24%) during downstream migration. Between 2 and 8% of adult steelhead that moved upstream of TMFD were entrained. The entrainment of adult steelhead was associated with downstream movement (often kelts) and days with relatively low Umatilla River flows. Few dead or stranded PIT-tagged steelhead were detected within dewatered irrigation canals after entrainment. Almost all entrained steelhead smolts (98.5%) appeared to return to the Umatilla River using screened bypasses. Despite experiencing bypass delays, at least half of entrained adults ultimately returned to the Umatilla River by navigating screen and bypass infrastructure primarily designed to bypass juvenile fish. Adult steelhead approaching the canal headgate were unable to use this route to return to the Umatilla River suggesting that unscreened canals may act as habitat sinks. Screens were effective at preventing steelhead losses to irrigation canals even in years of high entrainment. These results show the value of tracking annual variability in fish entrainment at large geographic scales.

Commercial Salmon Fisheries in Off-channel Areas of the Lower Columbia River; 10-Year Trends in Harvest and Stock Composition

Anthony Siniscal, Oregon Department of Fish and Wildlife, anthony.c.siniscal@state.or.us
Cameron Duff
Douglas Case

The Select Area Fishery Enhancement (SAFE) project is a hatchery production and commercial harvest program designed to maximize harvest rates of hatchery fish while minimizing the effects of harvest and hatchery activities on imperiled salmon populations in the Columbia River.

The SAFE program was initiated and has continued with the purpose of mitigating for the loss of salmon harvest due to habitat degradation and passage impairment in the Columbia River Basin. The program releases hatchery salmon (Chinook Salmon *Oncorhynchus tshawytscha* and Coho Salmon *Oncorhynchus kisutch*) and manages fisheries in four terminal or off-channel areas in the lower Columbia River estuary. The SAFE program is cooperatively managed by Oregon Department of Fish and Wildlife, Washington Department of Fish and Wildlife, and Clatsop County Fisheries.

Performance of the SAFE program can be depicted by (1) overall survival, rate of return to fisheries, and homing rates of hatchery releases and (2) landings, value, and stock composition of the commercial catch in the Select Areas. This presentation will focus on the metrics of the landings from commercial fisheries in the Select Areas over a 10 year period (2007 – 2016). During this period, average landings have totaled over 69,000 salmon (Chinook and Coho) with an average ex-vessel value of over $1.7 million annually with 85 to 90% of the Chinook (spring and fall run, respectively) originating from program hatcheries. Hatchery fish produced by this program return consistently to program fisheries and comprise a majority of the harvest, and commercial landings from the Select Areas add considerable value to the local economy.

Variability of Thermal and Water-Quality Conditions in Off-Channel Features Along the Willamette River

Cassandra Smith, U.S. Geological Survey, cassandrasmith@usgs.gov
Joseph Mangano
Norman Buccola
David Piatt

The U.S. Geological Survey monitored water temperature and water quality in off-channel features (such as sloughs, alcoves, and side channels) of the Willamette River in northwestern Oregon during the low-discharge and warm conditions in the summers of 2015 and 2016. These data were collected to better characterize thermal diversity in off-channel features and identify suitable cold water habitat along the Willamette River for anadromous fishes, including ESA-listed Chinook salmon. Off-channel features displayed a variety of water quality and thermal conditions that are linked to their source water, aquatic vegetation, and geomorphic history.

Six multiparameter water-quality instruments and nearly 20 additional temperature probes were deployed to record temporal variations in water temperature and dissolved oxygen in a variety of off-channel features. In addition, discrete point measurements of water temperature and dissolved oxygen were collected in the main stem and off-channel features multiple times throughout both summers to document the horizontal and vertical spatial variability in these parameters.

Initial data analyses revealed a variety of water-quality conditions in off-channel features. Some off-channel features exhibited consistent, cool temperatures compared to the main channel. Other features, while cooler than the main channel, followed a similar diurnal or seasonal fluctuation in temperature. Conversely, several small and shallow off-channel features were over three degrees Celsius warmer than the main channel during the summer. Dissolved oxygen concentrations varied greatly, with some off-channel features being consistently anoxic (yet cold) for most of the summer and others having large diurnal variations in dissolved oxygen because of photosynthesis and respiration by aquatic vegetation.

Preliminary analyses also suggest that the geomorphic histories of the off-channel features and river discharge influenced observed water-quality conditions. Specifically, an off-channel feature's upstream connectivity to the main channel can cause the dissolved oxygen concentration in a feature to change suddenly when reconnection occurs, such as when the main channel discharge increases. Additionally, the geomorphology of an off-channel feature, past and present, can influence the amount of hyporheic exchange between the main channel and the feature. For instance, abandoned historic channels with thick plugs of coarse bed material at their upstream end often were cooler than other types of off-channel features due to abundant cool hyporheic input. 3

These low-flow summer measurements demonstrate the wide variation of thermal and water-quality conditions that exists within and between off-channel features of the Willamette River system, providing a large diversity of aquatic habitat.

Individual Based Modelling Approach to Thermal Refuge Use by Migrating Adult Salmon and Steelhead

Marcia Snyder, U.S. Environmental Protection Agency, snyder.marcia@epa.gov
Joseph Ebersole
NathanSchumaker
Randy Comeleo
Jason Dunham
Matthew Keefer
Scott Heppell
Dru Keenan
John Palmer

Diadromous fish populations in the Pacific Northwest face challenges along their migratory routes from declining habitat quality, harvest, and barriers to longitudinal connectivity. Changes in river temperature regimes are producing an additional challenge for upstream migrating adult salmon and steelhead, species that are sensitive to absolute and cumulative thermal exposure. Adult salmon have been shown to utilize cold water patches along migration routes when mainstem river temperatures exceed thermal optimums. We are developing and employing an individual based model (IBM) to explore the advantages and disadvantages of spatially-distributed cold water refugia for adult migrating salmon. Our model, developed in the HexSim platform, is built around a mechanistic behavioral decision tree that drives individual interactions with their spatially explicit simulated environment. Population-scale responses to dynamic thermal regimes, coupled with other stressors such as disease and harvest, become emergent properties of the spatial IBM. Other model outputs include arrival times, species-specific survival rates, body energetic content, and reproductive fitness levels. Here, we discuss the challenges associated with parameterizing an individual based model of salmon and steelhead in a section of the Columbia River.

Klamath Dam Removal Process - Current Status

Glen Spain, Pacific Coast Federation of Fishermen's Associations, fish1ifr@aol.com

The Klamath Basin, once the third most productive salmon river system in the US Lower 48, has been bisected by four major hydropower dams built sequentially since the beginning of Klamath dam building in earnest in 1916. But the second 50-year FERC license for these four dams expired in 2007, and the four mainstem dams are now limping along on annual automatic renewals while FERC and the Company consider what to do with them in the long-term.

The existing FERC license review now gives the public the once-in-a-lifetime chance to help restore the once mighty salmonid runs of the Klamath Basin by having these dams removed and full fish passage restored to more than 420 steam miles of once fully-occupied salmonid habitat.

These dams were built with no fish passage (which would be illegal under current law) and have proven to be extremely destructive to the river and its salmon ecosystem, in return providing very little hydroelectric power.

But after more than 10 years of hard-fought negotiations, in 2010 the Company that owns these four dams (PacifiCorp) and numerous stakeholder groups and governments agreed on a pathway for four-dam removal, embodied in a document called the ""Klamath Hydropower Settlement Agreement (KHSA)."" This KHSA called for the creation of a separate ""dam removal entity"" which is now known as the ""Klamath River Renewal Corporation (KRRC)."" The KRRC's only purpose is to take title to the Klamath Hydropower Project and remove its dams, targeted to begin in 2020.

Glen Spain has been an advocate for Klamath Dam Removal since 1984, was one of the chief negotiators of the original KHSA, and now serves as an Alternate Director representing the Pacific Coast Federation of Fishermen's Associations (PCFFA), the west coast's largest organization of commercial fishing families, on the KRRC Board. He will present the current status of Klamath Dam removal, and the KRRC process, with some of its ins and outs over time, and some lessons learned.

At present the KRRC is on target to begin four-dam removal in the Klamath in 2020. Once accomplished this will be the largest dam removal project in Human history to date, and a long step toward full ecological restoration of one of the nation's most important salmon rivers.

Playing With Our Food: Catch-And-Release Angling for White Sturgeon

Peter Stevens, Oregon Department of Fish And Wildlife, peter.m.stevens@state.or.us

The objective of this talk is to synthesize and describe the existing peer-reviewed and grey literature on catch-and-release direct mortality and indirect impacts to White sturgeon populations. North American White sturgeon populations support popular fisheries throughout much of their range. While retention fisheries are regionally more popular, substantial catch-and-release fisheries exist in many locations and some jurisdictions have even transitioned to strict catch-and-release (e.g. – Fraser River, British Columbia, Canada). Catch-and-release fisheries present a potentially useful management option for retaining angler involvement in marginal or rebuilding populations. However, very limited information is available on the possible direct and indirect impacts of catch-and-release fishing on individual or populations of White Sturgeon. Future research should focus on quantifying not only direct mortality from angling events but also indirect effects on fitness, fecundity and behavior.

Effects of Stocking and Translocation on White Sturgeon Movement Through the Federal Columbia River Power System (FCRPS)

Peter Stevens, Oregon Department of Fish And Wildlife, peter.m.stevens@state.or.us

A long-term dataset of tagged White Sturgeon (*Acipenser transmontanus*) was used to examine sturgeon movements within the Federal Columbia River Power System (FCRPS). This study used multi-state mark-recapture modeling with group and individual co-variates to examine differences in movement patterns between wild, hatchery-release and translocated (i.e. – “Trawl and haul”) fish populations. Overall the large majority of tagged sturgeon across all groups are recaptured in the same pool as they were tagged/released in.

However, a small number of fish move either up or downstream. Downstream movement predominates across all groups. While the vast majority of fish were found to have moved only a single pool in either direction, some fish did move through multiple pools even leaving the Columbia River entirely and moving into the marine environment. Wild, hatchery and translocated fish had differences in their movement patterns and their probabilities of movement. These results appear to indicate net downstream movement of all groups of White sturgeon within the FCRPS. However, potentially important differences exist among fish subjected to different types of early-life management actions.

Fish and Habitat Monitoring with Unmanned Aircraft: Session Introduction and Overview of ODFW's Program

Erik Suring, Oregon Department of Fish and Wildlife, erik.suring@oregonstate.edu

Unmanned aircraft systems (UAS), also referred to as UAVs or drones, are becoming more common as tools in collecting video, photos, and geospatial data. If it can be seen from the air it can counted and measured it with a UAS with results that may be safer, more efficient, and better quality than traditional methods. Improvements in regulations and continual technological advancement have made it easier to deploy UAS in the field. ODFW has adopted a decentralized coordinated model as a method of allowing interested projects to implement this new field technique while complying with all regulations and policies.

Using Unmanned Aircraft for Habitat Restoration Implementation Monitoring

Erik Suring, Oregon Department of Fish and Wildlife, erik.suring@oregonstate.edu
Tiffany Newman

Unmanned aircraft systems (UAS) have the potential to be used as a field monitoring method that is safer, more efficient, and more capable than some current methods. We explored how aerial photogrammetry could be used for implementation monitoring of a large wood addition in a small coastal Oregon stream. Habitat restoration grants often require implementation monitoring and reporting to ensure projects were completed as proposed. In Mill Creek (Siletz) large wood was added in 2016 to improve stream habitat. Following restoration work crews surveyed the basin on foot counting and measuring placed wood. Some restoration flights were also flown with a small UAS and similar data were collected from aerial photos and structure from motion models. Results from the two methods are compared. Monitoring by UAS was effective in areas were restoration could be viewed from the air, providing much more data beyond counts and measures, but canopy cover at some sites precluded accurate implementation monitoring.

Effects of Terrestrial Herbicides and Pesticides on Aquatic Organisms: Implications for Policy and Management

Ian Tattam, Oregon American Fisheries Society, Ian.A.Tattam@state.or.us
Ben Clemens

Identification and amelioration of limiting factors to fisheries stocks are a basic and crucial aspect to fisheries management. For example, fisheries professionals are aware of the “four Hs” (hydropower, habitat, harvest, and hatcheries), and awareness of these H’s drives fisheries research programs and management practices in Oregon and the Pacific Northwest. However, many people do not realize the pervasiveness and magnitude of other potentially crucial limiting factors to aquatic ecosystems. For example, the effects of terrestrial herbicide and pesticide contaminants (herein, ‘pesticides’) on aquatic organisms and their habitats (i.e., aquatic ecosystems) do not appear to be acknowledged, discussed, researched, and managed for in a level comparable to the aforementioned four Hs. In order to educate and raise awareness among fisheries professionals and state legislators about the ‘silent’ effects of pesticides on aquatic organisms, we are developing an Oregon Chapter of the American Fisheries Society “White Paper.” Our collation of the pertinent scientific, peer-reviewed literature indicates a substantial number of papers examining the effects of pesticides on aquatic ecosystems. However, many of these papers occur in journals that are not typically available to fisheries biologists. And perhaps more importantly, the availability of reports or public outreach materials that synthesize this information in a holistic and meaningful way for the general public and state legislators is lacking. During the past four decades, most published studies have found that pesticides significantly impact aquatic ecosystems. Most of the effects of pesticides on aquatic biota are sub-lethal and may affect only specific life-stages. Other effects may be acute, and still other effects are unknown, given the chemical interactions in water and the presence of other contaminants that may result in contaminant ‘cocktails’. Consideration of all of these effects and trophic interactions suggests complicated and unknown effects to aquatic ecosystems that require further research. Assimilation of sub-lethal effects to individual organisms through life-cycle models will be challenging. Scientific and political challenges exist towards furthering understanding and guidance of policy on the effects of pesticides on aquatic ecosystems. We will present preliminary guidance and recommendations from this White Paper, and solicit “crowd-sourced” feedback and assistance on finalization.

Use of Deep Drawdowns for Downstream Juvenile Chinook Salmon Passage At Fall Creek Reservoir, Willamette Basin, Oregon

Greg Taylor, U.S. Army Corps of Engineers, gregory.a.taylor@usace.army.mil
Doug Garletts
Chad Helms
Todd Pierce
Terri Berling
Ben Cram

The U. S. Army Corps of Engineers (USACE) completed construction of Fall Creek Dam in the fall of 1965. The Dam included upstream and downstream fish passage facilities. An evaluation of the fish passage facilities conducted by the Fish Commission of Oregon (1966-70) determined the emigrant passage facilities were ineffective, but noted large numbers of juvenile salmonids migrated from the reservoir using the regulating outlet (Smith and Korn 1970). From 1968-77 the reservoir elevation was lowered to streambed to facilitate fish passage and survival. This resulted in annual returns of spring Chinook from 1,000 - 4,500 fish. Changes in reservoir evacuation schedule beginning in 1977 are implicated with the smolt mortality and adult return problems observed at Fall Creek since 1980 (Downey 1992). Downey (1992) showed a 30% improvement in survival for juvenile outmigrants under low flow and low head conditions. In 2010, the reservoir was lowered to 690 ft. to improve passage survival for outmigrating fish. In 2011-17, the USACE lowered Fall Creek Reservoir to elevation 680 ft. which resulted in a complete drawdown to streambed. This presentation summarizes data collected on adult returns and juvenile downstream passage associated with reservoir operation and drawdown.

Resilience Thinking About Estuarine Habitat Support for Fisheries Species

Ronald Thom, Pacific Northwest National Laboratory (emeritus), thom.ronald@gmail.com
Kate Buenau
Amy Borde
John Vavrinec

Estuarine habitats play important roles in the life history and ecology of fisheries resources including juvenile salmon, herring, and Dungeness crab. In particular, eelgrass (*Zostera marina*) meadows, common in many estuaries, can provide superior access and capacity in terms of refuge, rearing and feeding habitat for juvenile salmon. While the widespread global distribution of eelgrass and its ability to recover from large-scale disturbances suggests a relatively high level of adaptability and resilience, collapses of eelgrass populations have occurred in several systems in the region that remain poorly explained. We have been using field measurements of density and growth rate, physiological experiments, numerical modeling coupled and monitoring of natural experiments (e.g., warm events) to formulate broad hypotheses as follows: (1) inter-annual variation in growth, density and biomass is affected by variable sea level, water temperature and light conditions; (2) these interactions are complex and dependent upon the system; (3) highly anomalous conditions (e.g., ENSO; droughts) that persist for more than one year may drive localized and system-wide collapses of eelgrass to a point were recovery is severely protracted; (4) local disturbances (e.g., eutrophication; turbidity) can interact with climate variation to exacerbate unfavorable conditions; and, (5) success of efforts to restore eelgrass may be hampered by a severely altered system state. We conclude that eelgrass is resilient to moderate to strong climatic variations lasting a few years, but is susceptible to collapse and extirpation when extreme, unprecedented climatic conditions persist over a similar time period. These findings should be considered when analyzing variation in eelgrass-associated fish and shellfish and when developing strategies to restore salmon and crab populations.

Humans Impact Some Life Histories More Than Others: Potential Consequences for Resilience Explored Through Salmon Runtime Genetics

Tasha Thompson*****, University of California, Davis, tthompson@ucdavis.edu
Michael Miller

Life history diversity is an important component of the portfolio effect in salmonids, and can increase the resilience of a population experiencing variable environmental conditions. However, human activity disproportionately impacts some life histories more than others, and can, in extreme cases, lead to the

complete elimination of a life history even while the total number of individuals in a population remains stable. The consequences of disproportionate impacts for the long term resilience of a population are often unclear because, in most cases, the basis of a trait (genetic vs. environmental) is unknown. Here we explore the case of adult migration time in steelhead and Chinook salmon, an important life history trait where diversity in the trait facilitates diversity in temporal and spatial habitat utilization, but early migration is disproportionately impacted by human activity compared to late migration. Our research reveals a strong genetic component to migration time in both Chinook and steelhead, and analyses of Rogue and Klamath Chinook indicate the loss of the early migration life history can rapidly lead to the loss of the potential for it to reemerge, impacting the portfolio of the population. We discuss the factors that create this scenario to understand when disproportionate impacts in other cases can negatively affect a population's portfolio.

A Supplemental Conservation Framework May be Necessary to Protect Adaptive Variation Within Closely Related Populations

Tasha Thompson*, University of California, Davis, tthompson@ucdavis.edu
Michael Miller

Preserving adaptive variation is a key goal of conservation policy, and conservation unit delineation aims to protect adaptive differences between distant populations. However, no standard framework currently exists to address threats to adaptive variation within closely related populations (i.e. a single conservation unit). Here, we examine the case of adult migration time in coastal Chinook salmon, a differentially adaptive, bimodal trait, to understand if and when a framework for protecting adaptive variation within a single conservation unit may be necessary. Our research reveals strong genetic control over migration time, and indicates that the genetic variants needed for early migration evolved only once. Furthermore, individuals who are heterozygous at the run time locus exhibit intermediate migration times, and surveys of two locations that previously hosted early migrants but now only host late migrants reveal the early migration variant has not been maintained in the late migrating populations. Together, this evidence strongly suggests that the genetic variation necessary for early migration is vulnerable to irreversible loss, and the development of a supplemental conservation framework to address adaptive variation within conservation units may be necessary to preserve it.

Using a Small Unmanned Aerial System to Survey Fall Chinook Salmon Redds And Recover Carcasses in the Snake River

Ken Tiffan, U.S. Geological Survey, ktiffan@usgs.gov
Brad Bickford
Tobyn Rhodes

After receiving all Department of Interior and FAA certifications, we used a small unmanned aerial system (sUAS) to collect information on fall Chinook salmon redds and carcasses in the Snake River in 2017. We conducted biweekly surveys of 15 known spawning sites to derive season-wide total count of redds at each site. A subset of sites was surveyed more frequently to determine the time it took for algae and periphyton to regrow and obscure redds. We found that even after 4 weeks, redds could still be reliably identified compared

to when they were first observed. This will be important to determining the frequency of surveys when effort is limited. The sUAS was invaluable in locating carcasses which were then retrieved to collect biological samples. We found a total of 67 carcasses in 91 flights and anticipate increasing our search and retrieval efficiency in the future as we learn where and when to search. Although the sUAS is an effective tool and a safer alternative to manned helicopter surveys, we were limited by how many sites we could search in a day given the 75 miles of river we were working in. A big advantage of using a sUAS for redd surveys is there is a video record that can be reviewed and compared to previous surveys which increases that accuracy of redd counts.

Evaluating an Experimental Commercial Pound Net Trap for Stock-Selective Harvest in the Lower Columbia River

Adrian Tuohy*****, Wild Fish Conservancy; University of Washington, adrian@wildfishconservancy.org
Nick Gayeski

Bycatch mortality from gillnets and other conventional harvest techniques impedes the recovery of Endangered Species Act (ESA)-listed salmonids and commercial fishing opportunities when ESA-take limits are exceeded. To benefit wild salmon, threatened ecosystems, and coastal fishing communities, Wild Fish Conservancy and local commercial fishermen conducted a post-release survival study in the Lower Columbia River Sub-basin to evaluate the potential of an alternative commercial gear—specifically, an experimental pound net trap—as a stock-selective, sustainable harvest technique. Expanding upon the 2016 pilot study, a modified trap was constructed and operated under a variety of tidal stages, light levels, and weather conditions between August 26th and September 29th, 2017. Utilizing a mark-recapture methodology with Passive Integrated Transponder (PIT) tags, post-release survival from the trap was estimated by comparing tag detections at upstream dams to that of a control source of fish; total catch, catch-per-unit-effort, and covariates of recapture probabilities were analyzed. Preliminary results demonstrate that pound net traps can effectively target commercially viable quantities of hatchery reared Fall Chinook (*Oncorhynchus tshawytscha*) and Coho Salmon (*Oncorhynchus kisutch*) while reducing immediate and post-release bycatch mortality of ESA-listed species relative to conventional commercial gears. Throughout the 33-day test fishing period, the experimental trap captured and released 7,129 salmonids. Relative post-release survival ranged from 94% for steelhead trout (*Oncorhynchus mykiss*) to 99% for Chinook salmon. Further investigation will incorporate a sub-sample of genetic data to improve the precision of post-release survival estimates.

Effects of Dietary Lipid Concentration on Growth, Survival and Smoltification of Hatchery-Reared Steelhead

Ronald Twibell, U.S. Fish and Wildlife Service, ronald_twibell@fws.gov
Kyle Hanson
Racheal Headley
Kieslana Wing
Richard Glenn
Benjamen Kennedy

Salmon diets produced for commercial aquaculture contain as much as 40% lipid, whereas diets used in Pacific Northwest hatcheries that produce salmon and steelhead for conservation and mitigation purposes contain about 16-27% lipid. Although research has been conducted to identify optimal dietary lipid concentrations for commercial salmon aquaculture, studies aimed at identifying appropriate lipid concentrations in diets fed to steelhead reared for conservation and mitigation purposes have not been reported. Dietary lipid concentration can have a direct effect on tissue lipid level which can in turn affect the physiology and behavior of the fish, including rates of male sexual maturation and outmigration. Thus, the aim of this ongoing study is to examine the effects of dietary lipid concentration on hatchery growth, survival and smolting as well as adult returns in hatchery-origin steelhead. Results of the first two years of rearing hatchery steelhead on diets containing low or standard lipid concentrations at Abernathy Fish Technology Center will be presented.

Recent Research and Management of Japanese Chum Salmon Propagation in a Changing Climate

Hiroshi Ueda, Hokkaido University, Hokkaido Aquaculture Promotion Corporation, hueda@fsc.hokudai.ac.jp

In Japan, Chum Salmon *Oncorhynchus keta* is the most abundant Pacific salmon species and has been used as an important protein source since the prehistoric period, especially in Hokkaido, where the Ainu people (an indigenous people) might use these fish for autumn and winter food. Japanese Chum Salmon propagation began in 1888, when the first governmental hatchery was built in the Chitose River, Hokkaido, introducing an artificial salmon propagation system from the Bucksport hatchery in Maine, USA. Owing to both precisely high homing ability of adult Chum Salmon to their natal streams and enormous efforts to improve techniques of fry feeding to grow about 1 g in body weight (suitable size) and juvenile release timing when the coastal sea surface temperature is approximately at 5-13˚C (suitable timing), the numbers of released juveniles and returning adults had increased steadily from 0.5 to 2 billion and from 10 to 90 million, respectively, from the late 1970s to 1996. However, likely due to a regime shift in the North Pacific Ocean ecosystem and recent unstable climate changes, a sharp decline in adult returns with an approximately 8-year interval was observed from 1992 to 2008, and rapid decreases in recent years, despite an almost constant number of juveniles released.

It is now widely accepted that specific factors in the natal stream are imprinted on the nervous system of juvenile Chum Salmon during downstream migration and that adults use these factors to recognize their natal streams during their upstream homing migration. Recent physiological researches from behavioral to molecular biological approaches have clarified mechanisms of imprinting and homing migration in Chum Salmon. Physiological biotelemetry studies show that salmon can navigate in open water using different sensory systems. Endocrinological studies demonstrate that the Brain-Pituitary-Thyroid and Brain-Pituitary-Gonad hormones play important roles in imprinting and homing migration, respectively. Neurophysiological studies on olfactory function suggest that a stable dissolved free amino acids composition in the natal streams is crucial for olfactory imprinting and homing of Chum Salmon. These valuable new findings are useful for developing new Chum Salmon propagation systems to enhance the survival rates of juveniles in coastal areas and stabilize the returning rate of homing adults.

Winter Movement and Survival of Juvenile Coho Salmon in Freshwater Creek, California

Nick Van Vleet*, Humboldt State University, nicholas.vanvleet@humboldt.edu
Mark Henderson

Life history diversity of juvenile Coho Salmon (*Oncorhynchus kisutch*) has not been documented until relatively recently, and can have important implications for population production. Recent studies have identified multiple patterns of downstream movement into estuaries, including spring fry migrants, fall and winter parr migrants, and spring smolt migrants. The most typical pattern are spring smolt migrants, and Coho Salmon juveniles that migrate into estuaries as fry or parr, typically referred to as nomads, can make significant contributions to adult returns. Previous research in Freshwater Creek and other northern California streams, has estimated winter movement and survival rates with mark-recapture models that utilize passivate integrated transponder (PIT) tag technology. Both movement and survival have been typically estimated in two separate Cormack-Jolly-Seber (CJS) models. Typically, these models ignore temporal variations in survival (i.e., detection date is irrelevant) in order to estimate movement and survival rates at particular locations within the study area over a period of time. In contrast to CJS models, multi-state models use mark-recapture data to estimate survival and movement within the same model framework. The multi-state model can also be used to separately estimate survival rates in space and time by having time-varying occasions paired with discrete spatial states that animals can transition between. This project uses a multi-state model to provide estimates of early emigration rates for fall/winter migrant juvenile Coho Salmon, as well as survival rates for spring smolt migrants. Preliminary simulation trials have been conducted to validate model structure, explore potential parameter biases, and test the effects of violations of model assumptions. Based on the results from these simulations, I developed models to examine the effect of various individual and environmental covariates (e.g., streamflow, gradient, fork length at fall tagging) on survival and migration probabilities.

The Use of sUAS Based LiDAR to Capture Channel Cross Sections and Detailed Terrestrial Surfaces in a Riverine Environment

Andres Vargas, Technical Expert, avargas@quantumspatial.com
Colin Cooper
Russ Faux

The integration of progressively more sophisticated sensor payloads into small unmanned airborne systems (sUAS) has greatly expanded the utility of these systems for riverine mapping and habitat assessment. QSI recently deployed the RIEGL BDF-1 (or BathyCopter) system over three river reaches in Oregon with active habitat assessments. The BDF-1 sensor is comprised of a green wavelength laser range finder (λ= 532 nm) that can penetrate clear water and map channel cross sections at the reach scale. The BDF-1 sensor was field interchangeable with the Riegl VUX-1 sensor which provided high density laser scanning of terrestrial surfaces and riparian condition. In this presentation, we will review the results of the data collected on Oregon Rivers and explore the utility of these emerging unmanned technologies for natural resource and engineering applications.

Evaluating Angler Harvest in an Intensely Stocked Trout Fishery in Coos Bay, Oregon

Gary Vonderohe, Oregon Department of Fish and Wildlife, Gary.R.Vonderohe@state.or.us

Empire Lakes is located within the city of Coos Bay, Oregon and consist of two small reservoirs which combine for 45 surface acres. The upper lake has an approximate maximum depth of 26 feet while the lower lake has a maximum depth of 12 feet. Empire Lakes contains self-sustaining populations of several warmwater fish species along with stocked rainbow trout. The Oregon Department of Fish & Wildlife (ODFW) stocks approximately 38,000 legal size (3 fish/lb) and 1,300 trophy size (0.5 fish/lb) hatchery rainbow trout each year. These stocked trout receive lots of angling pressure but no one has estimated the harvest of these trout in Empire Lakes. In 2016, ODFW staff implemented a tag reward program on Empire Lakes to estimate harvest of legal size and trophy size trout. This program is similar to other tag reward programs implemented elsewhere in Oregon for stocked trout in lakes and reservoirs. Changes were made to the Empire Lakes stocking program in 2017 and a second year of tag reward was implemented. This presentation will provide the results of the two years of tag rewards and future management changes to the Empire Lakes stocking program.

Utilizing Flow and Geomorphic Processes to Enhance Rearing Habitats for Spring Chinook Salmon in the Willamette River Basin

Rose Wallick, US Geological Survey, rosewall@usgs.gov
James White
Gabriel Gordon
Joseph Mangano
Mackenzie Keith
Krista Jones
Brandon Overstreet

Along the large gravel-bed rivers of the Willamette River basin, flow and bank erodibility exert primary controls on the availability of rearing habitats for spring Chinook salmon. Despite major reductions in peak flows, sediment supply and channel complexity resulting from flood control dams and bank stabilization, today's flow regime influences rearing habitat availability in two main ways: habitat creation which occurs locally in geomorphically dynamic areas and inundation of existing habitats, which occurs along the entire river corridor. On river segments unconstrained by bank stabilization structures and where flows can readily support coupled processes of bank erosion, bar building and succession of riparian vegetation, a complex physical template is formed that supports a diverse array of habitats at a wide range of discharges. Within these limited sections of the Willamette River valley, flows actively create and inundate features like gravel bars, alcoves, side channels and floodplain swales that provide high-quality rearing habitats at a wide range of discharges. Dynamic sections like the Upper Willamette and North Santiam River below Stayton stand in contrast to more extensive stable river sections where the present-day flow regime mainly serves to inundate existing channel features, the majority of which are relict features created by the historical flow and sediment regime prior to dam and revetment construction. These relict features include widespread vegetated gravel bars, floodplain swales and occasional side channels that are inundated at moderate to high flows. Stable reaches typically have far fewer actively shifting gravel bars and other morphologic features that support high-quality low-flow rearing habitats.

Multiple USGS geomorphic and environmental flow studies from across the Willamette River basin provide a basis for evaluating the influence of flow on physical habitat conditions and considering how the efficacy of flow as a singular tool for habitat management varies with local hydrogeomorphic conditions and bank erodibility. Recent high resolution bathymetric surveys and hydraulic modeling studies from the mainstem Willamette River reveal stark differences in depths and velocities for the Upper Willamette compared with the less diverse conditions in the Middle Willamette River. Relations between flow and habitat availability also highlight flow conditions and spatial locations where rearing habitat is limited, but could potentially be improved with strategic habitat enhancements. This presentation will outline the current state-of-the science regarding the role of flow management in determining habitat creation and rearing habitat availability in the Willamette Valley. Key knowledge gaps also will be highlighted, that if addressed, could better inform the development of realistic flow targets to support rearing habitat availability that are aligned with present-day hydrogeomorphic processes.

Oregon's Native Freshwater Mussels – What Are They, Who Manages Them, and Why Should We Care

Michele Weaver, Oregon Department of Fish And Wildlife, michele.h.weaver@state.or.us

Oregon is home to three genera of freshwater mussels: Anodonta, Gonidea, and Margaritifera. Freshwater mussels are long-lived, need a fish host to complete their life cycle, and have the ability to filter substantial amounts of water. ODFW has management authority for mussels, which currently entails requiring scientific take permits to study them and prohibiting their recreational harvest through fishing regulations. ODFW has received several inquiries over the past year about their importance and conservation status. While we know basic information about their distribution and general life history, and ODFW's Oregon Conservation Strategy considers two of the three genera "species of greatest conservation need", many details about their biology and status are still uncertain. With their unique life cycles and important role in a healthy ecosystem, they warrant more attention. More information about freshwater mussel abundance, habitat needs, and specific life history traits would help ODFW better identify status, risks, and best management actions to ensure their conservation. Given that few studies currently target freshwater mussels and most agencies continue to struggle with funding and staffing, some collaborative and coordinated efforts could start filling in data gaps to help ensure we are adequately managing these remarkable native species.

Stream Samples to Species Lists: Multiple Species Detection Using Multiplex PCR and High-Throughput Sequencing

Kevin Weitemier, Oregon State University, kevin.weitemier@oregonstate.edu
Brooke Penaluna
Laura Hauck
Richard Cronn

The use of environmental DNA (eDNA) for single-species detection has shown enormous promise of becoming a rapid, accurate, and standardized assessment method for diverse aquatic taxa. However, techniques for multiple species detection are in their infancy, especially when species are closely related. To address this challenge, we evaluated the potential for identifying aquatic and riparian species by combining metabarcoding with microfluidic multiplex PCR and high-throughput sequencing. This strategy allows for the simultaneous detection of up to 48 gene targets from ~100 ng of eDNA. In our implementation, gene targets include a mixture of conserved metabarcoding genes (e.g., ribosomal DNA) and taxon-specific barcoding genes (e.g., NADH dehydrogenase). Following sequencing, taxon identification and measures of abundance are made via comparison of sample sequences against a database of known reference sequences. The method of database construction, whether narrowly targeted or of broad scope, and the method of sample sequence classification can influence measures of abundance. We construct a custom broad scope database and use a k-mer matching method, implemented in CLARK, to assign sample sequences to taxon. This multilevel strategy surveys genetic variation across a broad taxonomic spectrum (fish, amphibians, macro-invertebrates, oomycete pathogens), and provides finer discrimination for closely-related species, as well as a mechanism to corroborate detection across redundant targets.

Rearing and Movement of Juvenile Chinook Salmon in the Willamette River

Luke Whitman, Oregon Department of Fish and Wildlife, luke.whitman@oregonstate.edu
Kirk Schroeder
Brian Cannon
Tom Friesen

Spring Chinook salmon from the Willamette basin follow different life history pathways as they migrate to the Columbia River estuary. We quantified the number of juveniles following different pathways by sampling and tagging juveniles in different rearing in the mainstem Willamette River. Juvenile fish were caught with beach seines and implanted with passive integrated transponder (PIT) tags. PIT antennae at Willamette Falls provided data on migration timing of different groups of fish. The two primary life history types are those juveniles that migrate to the estuary as subyearlings and those that migrate as yearlings. Both types spent some time rearing in the mainstem Willamette River. Growth and migration timing varied by year, likely from river conditions such as temperature and flow. These difference may affect survival to adult by the different life history types.

Restoration Strategies to Mitigate Future Changes in Climate: How Long Will They Take?

Steve Wondzell, U.S. Forest Service, swondzell@fs.fed.us

The Middle Fork John Day River (MFJD) has been the focus of extensive restoration and monitoring. Comparisons between current conditions and descriptions from 1881 GLO land-surveys suggest that channels have been straightened and riparian vegetation has been converted from a patchy mixture of forests, shrubs, and wet meadows into expansive dry meadows. Today, the MFJD is poorly shaded. The river supports spring Chinook Salmon, but in some summers, maximum stream temperatures already exceed lethal thresholds raising concerns that future increases in air temperature will further threaten these cold-water fishes. Potential riparian restoration strategies were examined using the mechanistic stream temperature model, Heat Source, to compare alternative future scenarios based on downscaled projections from climate change models and different riparian forest conditions. Current conditions were compared to future conditions in which air temperatures were 4° C hotter than today under 4 riparian vegetation scenarios: (1) a post-wildfire with 7% effective shade, (2) current vegetation with 19% effective shade, (3) a young-open forest with 34% effective shade, and (4) a mature riparian forest with 79% effective shade. Results showed that the future 7-day, daily average maximum stream temperature (7DADM) ranged from ~4° C hotter to ~8° C colder than current conditions. Shade from riparian vegetation dramatically influenced future maximum stream temperatures. Loss of existing shade increased 7DADM by only 1° or 2° C. In contrast, the 79% effective shade from a 30-m tall riparian forest with 50% canopy cover actually decreased the 7DADM by 7° C despite the much warmer air temperatures.

The influence of shade on stream temperature has long been recognized. Consequently, thousands of seedlings of native woody riparian species were planted in 2006 throughout several meadow-dominated reaches of the MFJD. These plantings had limited success, even in areas fenced to exclude cattle. By 2009 most cottonwood had died; those species that survived had not grown substantially. Consequently, eight-foot tall, fenced exclosures were established to measure the effects of elk and deer browsing. The results showed that browsing was preventing the growth of most hardwoods. Only ponderosa pine and thinleaf alder showed consistent growth without protection from browsing.

These two studies pose a critical question: “Can shade be grown fast enough to mitigate effects of climate change, given the rate at which such changes are projected to occur?” The answer is a qualified maybe. Ponderosa pine grow slowly in northeastern Oregon; trees growing in riparian zones require, on average, 120 years to reach 30-m height. Cottonwood may grow much faster, but the browse study showed high mortality and growth was severely limited by browsing. Clearly, substantial hurdles remain when attempting to mitigate impacts of future climate changes by growing trees to provide shade.

Quantifying the Stabilizing Effects of Population Diversity with the Portfolio Effect

Lauren Yamane, University of California, Davis, layamane@ucdavis.edu
Louis Botsford
D. Patrick Kilduff

Biodiversity loss threatens aquatic ecosystems by reducing community stability. The portfolio effect is the statistical phenomenon that describes how total community variability is less (i.e., greater stability) when community components are statistically more independent (i.e., more diverse). Portfolio theory is popularly applied to the population diversity of multiple spawning stocks in salmon fisheries. However, these portfolio effect calculations have limited management utility because they have neglected to quantify how much increasing population diversity can reduce total fishery variability. Here we describe a new metric quantifying the maximum reduction in aggregate variability possible through increased diversity. We apply this metric to the Sacramento River Fall-run Chinook (SRFC) salmon population complex, which was closed to fishing in 2008-2009 and for which diversity has diminished. We identify the spatial and temporal sources of reduced diversity evident in SRFC’s portfolio effect. We found that one population in the mid-1980s was primarily responsible for the reduced diversity, and that the fishery could have remained open if maximal population diversity had been maintained.

Learning To Fly, But I Ain't Got Wings: Injury And Survival of Trout After Air-Stocking. Is Coming Down Really The Hardest Thing?

Jeff Yanke, Oregon Department of Fish and Wildlife, Jeff.Yanke@state.or.us
Kyle Bratcher
Richard Stocking
Sally Gee

Aerial stocking is commonly used to create recreational fisheries in waterbodies that are inaccessible by other means. In Oregon over 350 high-elevation lakes are stocked via helicopter in the Cascade and Wallowa Mountains. While it is well-known that aerial stocking produces viable fishing opportunities, post-release survival rates have not been previously quantified. Our objective was to evaluate injury and associated survival of rainbow trout following a simulated aerial stocking event. Hatchery rainbow trout were reared to three representative sizes stocked in Wallowa Mountain lakes in 2017. Replicate groups of fish were dropped from two fixed platforms at 11.0 and 20.8 meters into a portable reservoir. Control groups were also transported to the site but not released. Mortalities were enumerated and surviving fish were monitored for 72 hours after the simulated release. Fish were then euthanized and post-mortem necropsies were performed. While 5-10% of fish were temporarily incapacitated post-release, we documented high rates of survival after 72 hours in all groups (> 97.0%). Survival did not differ between fish size or drop height. Minor internal and external damage, of which fish were likely to recover from, was observed in all groups but at low rates. Minor fin hemorrhaging was more prevalent in the two largest size groups, but did not differ from control groups. Our results substantiate previous assumptions of high survival from aerial stocking, also indicating that resulting injuries were not substantial enough to contribute to latent mortality. However, temporarily incapacitated fish may experience higher rates of predation if released into a natural environment. While our experiment indicated that fishery managers should expect high survival of fish dropped up to 21 meters, some releases may occur from much greater heights and may warrant further evaluations.

Spatiotemporal Variability of Aquatic Habitat and Fish Distribution Over a 16-Year Record in the Elk River Basin in the Oregon Coast Range

Kimberly Yazzie*****, University of Washington, kyazzie@uw.edu
Daniel Schindler
Christian Torgersen
Gordon Reeves
Kelly Christiansen
Kelly Burnett

This spatiotemporal analysis aims to understand long-term physical and biological patterns in a coastal riverscape. Quantifying changes in stream morphology and habitat structure in a regionally important Pacific salmon stream with long-term ecological data will provide critical insight into forested aquatic ecosystems, which have typically been studied at relatively small spatial and temporal scales. Sixteen years of existing data

will be used to assess patterns of habitat redistribution and fish composition in response to ecological phenomena from hydrologic and climactic change in the Elk River basin in coastal Oregon. This unprecedented data set includes complete censuses of aquatic habitat (e.g. pools, riffles, substrate, large wood) over approximately 47 km annually. Preliminary work that includes dynamic segmentation in ArcGIS, and linear analysis will be presented. The ultimate aim of this work will be to improve understanding of historical context and the long-term effects of disturbance on resilience of Pacific salmon by comparing the changes in habitat size, stability, and spatial reorganization after disturbances throughout the stream network.

The Phylogeography of Westslope Cutthroat Trout

Michael Young, U.S. Forest Service, mkyoung@fs.fed.us
Kevin McKelvey
Tara Jennings
Katie Carter
Richard Cronn
Ernest Keeley
Janet Loxterman
Kristine Pilgrim
Michael Schwartz

Identifying units of conservation of aquatic species is fundamental to informed natural resources science and management. We used a combination of mitochondrial and nuclear molecular methods to identify potential units of conservation of westslope cutthroat trout, a taxon native to montane river basins of the northwestern U.S. and southwestern Canada. Mitogenomic sequencing identified two major lineages composed of nine monophyletic clades, and a well-supported subclade within one of these, largely delineated by river basins. Analyses of microsatellites and single nucleotide polymorphisms corroborated most of these groupings, sometimes with less resolution but demonstrating more complex connections among clades. The mitochondrial and nuclear analyses revealed that Pleistocene glacial cycles profoundly influenced the distribution and divergence of westslope cutthroat trout, that this taxon crossed the Continental Divide in two separate events, and that genetically pure but nonindigenous fish were widely distributed. Herein, we recognize nine geographically discrete, cytonuclear lineages largely circumscribed by major river basins as potential units of conservation: 1) John Day; 2) Coeur d'Alene; 3) St. Joe; 4) North Fork Clearwater; 5) Salmon; 6) Clearwater headwaters; 7) Clearwater-eastern Cascades; 8) neoboreal, consisting of most of the Columbia upstream from central Washington, the Fraser in British Columbia, and the South Saskatchewan in Alberta; and 9) Missouri.

Native Science: The First Salmon Ceremony

Jason Younker, University of Oregon, jyounker@uoregon.edu

The First Salmon Ceremony varies from tribe to tribe in the Pacific Northwest. Once debased as a cultural phenomenon, scientists are now realizing the ingenuity of this fish and wildlife best practice. As we become more inclusive in our consultation processes with sovereign domestic nations, what other traditional practices should we reconsider?

Upstream Passage of Bull Trout at Large Dams in the Upper Willamette Basin – Successes, Challenges, and Knowledge Gained

Nik Zymonas, Oregon Department of Fish and Wildlife – Corvallis Research Lab, nik.zymonas@oregonstate.edu
Michael Hogansen
Vince Tranquilli

Habitat fragmentation associated with large dams presents a potentially important threat to bull trout populations in the upper Willamette River basin. Efforts to provide upstream passage for adult bull trout below these dams began in the 2000s, although collection methods, habitat and operational constraints, and population characteristics have varied among dams and across years. The Cougar Dam upstream fish passage facility has been operated by the USACE annually from about mid-March to mid-October, beginning in 2010. The facility collected 64 adult bull trout varying from 415–680 mm FL during 2010–2016, including 76% of PIT-tagged bull trout we detected in the tailrace. We detected 74% of bull trout transported upstream of Cougar Dam in spawning reaches, and the annual percentage of the total population consisting of post-transport fish was about 9%. At Hills Creek Dam, we documented 21 bull trout in the tailrace during 2010–2016. No passage facility exists, and we captured and transported eight bull trout (36%) upstream, mainly by angling. Despite this low number, the post-transport contribution of adult females has been an estimated mean of 12% of the annual redd count for the small population upstream. We have experimented with traps to increase capture efficiency and will operate a floating weir in 2018. At Trail Bridge Dam, 136 bull trout have been passed upstream since 2003, with most fish captured by angling. Construction of up- and downstream passage facilities at Trail Bridge Dam is planned.
Upstream passage of bull trout at dams has increased production of juveniles and the amount of available foraging and overwintering habitat, reduced risk from adverse factors upstream of the dams, and potentially contributed to increased life history diversity, genetic variation, and probability of long-term persistence. However, extremely high discharge can constrain monitoring efforts, and the total number of bull trout passing through the dams and any associated mortality were probably considerably higher than the number of fish we detected in the tailrace, particularly at the high-head Cougar and Hills Creek dams. Some fish survived two downstream passage events, but we also found evidence of severe turbine strike injuries from downstream or attempted upstream passage. Furthermore, genetic analyses and other monitoring provided evidence that some bull trout passed above dams were from other spawning populations and passed back downstream. Therefore, improvements to downstream passage safety could lead to improved status of bull trout in these populations.

Posters

Installation of a Lamprey Passage System and evaluation of adult Pacific Lamprey upstream passage at Warm Springs NFH, Oregon

Judith Barkstedt, U.S. Fish and Wildlife Service, judith_barkstedt@fws.gov
Andy Johnsen
Joseph Skalicky
Cyndi Baker
Mary Bayer

Population declines of Pacific Lamprey Entosphenus tridentatus in the Columbia River Basin are partially attributed to impediments to upstream spawning migration of adults. To promote adult Pacific Lamprey passage, fishway modifications have been installed at both high-head and low-head dams across the basin. In 2014, the U.S. Fish and Wildlife Service completed an assessment of the low-head dam and fish ladder at Warm Springs National Fish Hatchery, Oregon and identified passage deficiencies for adult Pacific Lamprey. In fall 2017, per the recommendations of the assessment, we installed a Lamprey Passage Structure (LPS) in the fish ladder, which will become fully operational in spring 2018. Prior to installation, we evaluated adult Pacific Lamprey passage efficiency and route selection. These data provide a baseline against which to compare the effectiveness of the LPS. In 2016 and 2017 we trapped, PIT- and/or radio-tagged, and released adult Pacific Lamprey approximately 100 m downstream of the dam. We monitored fish passage using PIT- and radio-telemetry antennas located upstream, downstream, and within the fish ladder. In 2016, we captured, PIT-tagged, and released one adult Pacific Lamprey; in 2017, we captured nine adult Pacific Lamprey, six of which were PIT- and radio-tagged and released. Radio telemetry results showed three fish moved upstream of the dam using the fish ladder and exiting at a turning pool instead of moving through the entire ladder. One additional fish was detected upstream of the dam, however, it was not detected on any telemetry antennas in the fish ladder and therefore its route was not determined. Two fish have not moved upstream and are currently downstream of the dam near the release location. We will continue evaluate adult Pacific Lamprey passage to estimate the number of fish moving upstream of the dam, the percentage of radio-tagged fish using the LPS versus the ladder, and the timing of their movements. Our evaluation will determine the effectiveness of the LPS and help identify necessary modifications to facilitate fish passage and in turn increase the population contribution of Pacific Lamprey in the Warm Springs River to the Columbia River Basin.

A Genome-wide Association Study (GWAS) for resistance to the parasite *Ceratonova shasta* in Rainbow Trout

Damien Barrett*****, Oregon State University, barredam@oregonstate.edu
Jerri Bartholomew

Ceratonova shasta is a virulent myxozoan parasite of salmon and trout. It is endemic to the Pacific Northwest where it is regarded as a major cause of mortality in juvenile salmonids. Resistance to *C. shasta* is strongly

heritable and is known to be a dominant, polygenic trait; however, the location and identity of the loci responsible for resistance is unknown. It is also unclear if different salmonid species are resistant through the same mechanism. In order to address these research gaps, resistant redband rainbow trout (*Oncorhynchus mykiss*) were crossed with susceptible rainbow trout to create an F1 population. These fish are currently being reared at the Aquatic Animal Health Laboratory in Corvallis, OR. Upon reaching sexually maturity, males from the F1 generation will be backcrossed with the females from the susceptible parental lineage to create a backcross (BC) population where the resistance trait is segregating and can be mapped. At 3 months of age, BC generation fish (n = 1000) will be challenged with *C. shasta* to phenotype their level of resistance or susceptibility. These individuals will be genotyped using RAD Capture (Rapture), a sequence-based genotyping approach, and a genome-wide association study (GWAS) will then be conducted to identify genetic markers that correlate significantly with disease resistance. This work will contribute to our understanding of disease resistance to a parasite responsible for major losses of socially and economically important fish species, and enable more informed management strategies.

Advancements in Technology Increase Accuracy and Efficiency of *O. mykiss* and Fall Chinook Redd Mapping on the Deschutes River

Micah Bennett, Portland General Electric, Micah.Bennett@pgn.com
Brad Wymore
Megan Hill

Recent advancements in technology have improved the accuracy and efficiency of redd surveys on the Deschutes River. Portland General Electric Company and the Confederated Tribes of the Warm Springs Reservation of Oregon conducted redd surveys for rainbow trout/steelhead (*Oncorhynchus mykiss*) on the Deschutes River from 2007 to 2014 and re-initiated redd surveys on rainbow trout/steelhead and fall Chinook (*O. tshawytscha*) in 2017. These surveys are part of the Lower Deschutes River Gravel Study which aims to understand how the dams affect recruitment of gravel in the three-mile segment immediately below the Pelton Reregulating Dam. The first phase of the Gravel Study, from 2007 to 2014 showed a decrease in available spawning habitat for rainbow trout/steelhead, and hypothesized this may be due, in part, to increased fall Chinook spawning. As a result, current redd surveys (Phase 2) are designed to assess if fall Chinook spawning is contributing to substrate mixing, making the correct size spawning substrate inaccessible to rainbow trout/steelhead. Recent advancements in technology have yielded rugged, accurate and waterproof Global Navigation Satellite System (GNSS) equipment for field application at a more reasonable cost than was available during Phase 1. Data collected on redds surveyed during Phase 1 were measurements of length and width for area, GPS point location of redds using a sub-meter GPS unit, hand sketching redds on maps to represent the footprint, and later digitizing the hand sketches in the office. This method had several limitations. Digitizing of redds from sketches was labor intensive. Hand sketched redds varied in accuracy. It was difficult to account for redds from previous surveys leading to potential over or under estimating of area or superimposition. Finally, the area derived from length and width didn't represent redds with an irregular shape, or aggregate redds. In Phase 2, we are using a GNSS receiver allowing accuracy in the field of ≤10 cm. The 2017-2018 spawning period for rainbow trout/steelhead and fall Chinook is our first year using this methodology and we have seen advantages over the previous method. It eliminates the time consuming task of digitizing redds from sketches. This level of accuracy provides confidence in spatial analysis and mapping results. This equipment also allows us to view each redd mapped in the field and its corresponding attributes so we can determine if redds have expanded, are new, or have already been mapped. This new equipment/methodology has allowed us to streamline workflow for field data collection, data management, and allows us to more accurately assess how fall Chinook spawning is affecting substrate availability.

Assessing Lotic Water Quality Using Satellite Imagery: Oregon as a Case Study

Gwendolynn Bury, Oregon State University, Gwendolynn.Bury@oregonstate.edu
Ivan Arismendi

The goal of this study is to identify develop best predictive models of water quality using satellite imagery. To test these models, we will study multiple water bodies located across Oregon, in diverse physiographic conditions (e.g., coastal zones, high elevation plateau, and complex mountain terrain). We will use satellite images and in situ data, including from a subset of lakes were we will deploy water quality sensors. Accurate models for water quality are important to forecast changes from increased human use, economic development, and climate fluctuations, and are especially valuable in areas where resource-based conflicts may arise.

Influence of Climate Variability on Cutthroat Trout and Coastal Giant Salamander in Headwater Streams

Alvaro Cortes*****, Oregon State University, cortesa@oregonstate.edu
Dana Warren
Matt Kaylor
Allison Swartz

In response to climate change, the Pacific Northwest (PNW) ecoregion is expected to experience increased frequency and duration of droughts. Such events can be particularly devastating to stream biota, which can experience declines in abundance, biomass and condition during prolonged periods of extreme low flow. While a number of studies have demonstrated the initial negative impacts of a drought on stream biota, our understanding of how these populations recover following a drought is more limited. Understanding these recovery dynamics will provide important insight into how anticipated changes in climate will affect aquatic biota in headwater streams across the PNW. We evaluated abundance, condition factor and biomass for cutthroat trout (*Oncorhynchus clarkii*) and coastal giant salamander (*Dicamptodon tenebrosus*) in five headwater streams annually from 2013-2017, a period that encompassed a severe summer drought in 2015. Cutthroat trout densities, and total trout biomass declined in the drought year across all five streams, but in four of the five streams abundances had recovered to pretreatment levels within two years. In the smallest stream, the abundance and biomass of both trout and salamanders remained significantly lower two years after the drought year. However, salamander condition did increase significantly in the period after the drought compared to previous years, which we attribute to a density-dependent response to reduced abundance of vertebrate predators in these reaches. These results suggest that fish and salamander populations in mid-order streams may be relatively resilient to the impacts of drought conditions, however fish populations in small isolated headwater ecosystems with limited access to source populations may be quite vulnerable to an increase in the frequency and severity of droughts.

The Influence of Broodstock Management and Ocean Condition on Whatcom Creek, WA Chum Return Dates and Escapement

Tim Danner*****, Bellingham Technical College, danner0689@beltc.ctc.edu
Patrick Roche
Emily Lozeau
Jacob Hess
Alex Morris

Fish hatchery operating procedures has the potential to greatly impact fish stocks through artificial selection of desirable traits. The Whatcom Creek Hatchery in Bellingham, WA has reared Chum Salmon since the 1970s. Previous hatchery practices included selecting early returning fish to move the spawning date earlier in the season. The purpose of this research was to determine if progressively earlier spawning dates have led to earlier and more varied returns each year. An additional purpose of this research was to determine if there is a relationship between ocean conditions and salmon returns to Whatcom Creek. The first phase of this project was to determine the timing of the salmon run in Whatcom Creek, and compare the data year to year. The next phase of this project was to compare the run timing data to ocean and creek conditions of each individual year. By determining if there is a relationship between salmon returns and ocean conditions we can better assess the size of salmon returns in the future. Also by evaluating whether artificial selection in broodstock management has caused shifts in chum return dates we can better understand the historical impacts on our broodstock and evaluate how to manage our hatchery in the coming years.

The Effect of Juvenile Life History on the Marine Survival Rate of Coho Salmon

Grace Ghrist*****, Humboldt State University, gkg47@humboldt.edu
Darren Ward

Juvenile Coho Salmon (*Oncorhynchus kisutch*) in coastal California streams exhibit various life history strategies during their freshwater development. One strategy of interest to managers and conservationists is the early emigrant. This juvenile type migrates from natal habitat into lower parts of the watershed or estuary during the winter, where it rears before migration to the ocean in spring. By contrast, the more prevalent life-history type resides in natal reaches over the winter and emigrates the following spring. Salmon monitoring programs generally estimate juvenile production and demographic rates using only spring emigrants. In a Northern California stream, we PIT tagged juvenile Coho Salmon in the fall and detected their movements throughout the stream and estuary over their first winter, and then as they returned to spawn as adults. With the use of a multistate mark recapture model, we tested for distinct marine survival rates between these emigration periods. Our model allowed us to incorporate multiple life history strategies onto a single platform which can be used to report unbiased survival estimates of juvenile Coho Salmon.

Fisheries Technology Program, Mount Hood Community College

Joseph Gregoire*, Mount Hood Community College, joegregoire95@gmail.com
Anthony Pedro
Marla Chaney
Todd Hanna

The Fisheries Technology Program at Mount Hood Community College has been in place since the early 1970's, helping hundreds of graduates gain employment in the fisheries profession. The purpose of the two-year Fisheries Technology AAS degree curriculum is to prepare students for successful careers with private, federal or state agencies as a fish culturist and/or a fishery technician. Over and above such required work as fish biology, fish husbandry and fisheries techniques, a significant portion of the program provides hands-on experience through field and propagation projects, including operations in the campus fish hatchery. It is the only program of its kind in Oregon. In 2016 the Mount Hood Community College Fisheries Club was formed. Shortly thereafter, in cooperation with the Oregon Chapter of AFS, the Fisheries Club petitioned to become the first Community College Student subunit in the country. The Mount Hood Community College Student subunit has been organized to promote the understanding of fisheries and fisheries related issues and to encourage participation within the American Fisheries Society, fostering a community of students and fisheries professionals. Specific objectives of the subunit include assisting the Oregon Chapter of the American Fisheries Society with the annual chapter meeting as well as encouraging participation, and facilitating increased opportunities for professional development and networking.

Effects of Sediment and Filtration on Chum Salmon Embryo Development

Camoran Hollan*, Bellingham Technical College, camoranhollan41@gmail.com
Jacob Bartel
Cody Tracy
Breanne Phillips
Andrew Kazeck

We tested how filtration systems affected the development of chum (*Oncorhynchus keta*) incubated at the Whatcom Creek Hatchery in Bellingham, WA. Sedimentation and water quality are very important to the development of chum eggs and without proper water quality the developing eggs may not develop properly. The Whatcom Creek Hatchery is fed by Whatcom Creek, which runs through the city of Bellingham in a very urban area. The hatchery is located at the mouth of Whatcom Creek so the water quality of the creek is likely constantly poor quality. Whatcom Creek has historically suffered from high sediment loads and developing salmonid eggs are particularly sensitive to this. To test whether fine sediment was affecting chum embryo development a filtration system was set up in two separate incubation units, one was set up in shallow troughs, and the other was set up in vertical incubation trays. An aquatic poly filter was used to filter inflowing Whatcom Creek water before it reached the incubating eggs. These filters were placed at the head of each shallow trough and in the first tray of each vertical tray stack. Eggs were then placed in each incubation unit. During the course of the experiment we found that the filtration of the water improved water quality and increased embryo survival. This experiment has shown that proper water quality can increase the survival of salmon eggs and poor water quality can be manipulated with different filtration systems to improve the production of a hatchery.

Examining Growth, Timing, and Run Characteristics of Iteroparous Wild Adult Steelhead in the Lewis and Clark River

Kara Jaenecke, Oregon Department of Fish And Wildlife, kara.e.jaenecke@state.or.us

The life history of steelhead trout (*Oncorhynchus mykiss*) is unique among most salmonid species in their ability to demonstrate iteroparity, with a portion of some populations returning to their spawning grounds more than once to reproduce. By examining characteristics of known iteroparous adults over consecutive run years we created a useful dataset from which we can evaluate changes in run size, annual growth between spawning years, and migration time between returns. The Oregon Adult Salmonid Inventory and Sampling Project has operated a fish trap on the Lewis and Clark River in Northwest Oregon since December 2013, allowing us to capture wild adult steelhead during the winter spawning run. We visited the trap daily from December 1st until the approximate end of spawning migration in late May from 2013-2017. When adult steelhead were captured we affixed two uniquely numbered Floy tags into the base of the dorsal fin, collected scales, and recorded length, body condition, and sex before releasing them upstream. The Floy tags allowed us to identify repeat spawners and create a dataset to track these individuals across multiple run years. We considered all recaptured steelhead to be iteroparous individuals. In the past 4 run years (2013-14, 2014-15, 2015-16, 2016-17), we captured and tagged a total of 1273 wild adult steelhead and identified 46 as repeat spawners. In 2015, 21 of these fish returned, 19 returned in 2016, and only 6 in 2017. As a percentage of total annual captures, these made up roughly 3%, 6%, and 7% of the population, respectively. Return time ranged from 330 days to 739 days, with 12 fish returning within 5 days of their original entry day, one year later. By investigating return characteristics of iteroparous steelhead we can better understand the local life history, demographic, and reproductive strategies of this species.

Impact of Artificial Lighting on Early Chum Development

Xanth Kirschenman*****, Bellingham Technical College, xanthkk@gmail.com
Alexis Condit
Sidney Hazen
Jake Straub
Ryan Brake

Photoperiod is not widely controlled in hatchery settings and eggs are often reared under artificial lighting instead of natural photoperiod regimes. This experiment looked at the effects of artificial lighting on early chum development at the Whatcom Creek Hatchery in Bellingham, WA. By controlling the light that comes into the hatchery and using only red light, which developing embryos are less sensitive to, the experiment tested the impacts of artificial lighting on chum embryo development. The experiment was conducted in both shallow troughs and v-trays to determine if there is any interaction between light exposure and incubation type. One row of v-tray stacks and one of the shallow troughs were exposed to artificial lighting. One row of v-tray stacks and one of the shallow troughs received only red lighting. The results concluded the more artificial lighting the higher mortality rates in early chum development. Red light exposure had minimal effects on mortality. These results demonstrated the importance of controlling artificial light exposure in a hatchery setting.

Otolith Shape and Microchemistry Revealing Life History Traits of Introduced Chinook Salmon In Patagonia

Alex Koeberle*****, Oregon State University, koeberla@oregonstate.edu
Alex Koeberle
Ivan Arismendi
Cecilia Di Prinzio

Biological invasions can drastically alter aquatic ecosystems and the societies that depend on them. Human activities propagate non-native species both intentionally and accidentally, which in some cases eliminate native species, while in other cases they may coexist or the invasive may never succeed. This begs the question, why are some species successful invaders while others are not? In southern Chile and Argentina (Patagonia) introduced salmon and trout support commercial and recreational industries and attract anglers from around the world. Introduced Chinook Salmon (*Oncorhynchus tshawytscha*) in particular are genetically diverse due to multiple propagations and hybridization, and have high variation in population structure, size, and behavioral traits. Yet, few studies have documented specific life history traits contributing to the success of Chinook Salmon in Patagonia. Here, we will use the otolith morphology of Chinook Salmon to contrast among introduced populations in South America, and hatchery origin fish and wild populations in Oregon. Because these two regions have similar environmental conditions, physiography, and latitudes, we can compare across different origin Chinook Salmon. In addition, otolith microchemistry will identify life history strategies (e.g., ocean versus stream type) among multiple introduced populations along a latitudinal gradient in Patagonia. Determining specific life history characteristics of Chinook Salmon in novel systems like Patagonia will help to better understand conservation strategies for wild and hatchery fish in their native range in the Pacific Northwest. Sampling efforts will involve a network of local collaborators of scientists, volunteers, and anglers in Chile and Argentina as well as collaboration with Oregon Department of Fish and Wildlife for otolith samples in Oregon. This research has implications for future scenarios as Patagonia may face climate change and competition among native and non-native species, and will develop management tools for salmonid populations in South America and elsewhere.

Examining the Genomic Connectivity Among Dungeness Crab (*Cancer magister*) Recruits Along the Coast Of Oregon

Elizabeth Lee*****, Oregon State University, elizabeth.lee@oregonstate.edu
Kathleen O'Malley

Maintaining sustainable fisheries in a changing environment requires an understanding of the demographic structure and connectivity of the fisheries species. Dungeness crab (*Cancer magister*) is the most valuable single-species commercial fishery in Oregon. Adult Dungeness crab migration is limited; therefore, population connectivity is driven by larval dispersal. The dispersal patterns of Dungeness crab larvae are complex due to their long pelagic larval duration. During this time, the larvae are moved offshore and are dispersed along the coast by oceanographic current systems. After the larvae develop into megalopae, they are transported back to the coast and settle within the nearshore environment. Previous studies have found evidence for genetic differentiation of adult Dungeness crab across oceanographic regimes. To extend this research, we are using a genotyping-by-sequencing approach to: 1) examine the intra-annual genomic diversity among megalopae recruits and 2) test for evidence of genetic differentiation between early- and late-season recruits based on variation at both neutral and adaptive genetic markers. Results will help us understand how ocean conditions influence larval dispersal and the connectivity among adult Dungeness crab.

Climate Change and Salmonid Hybridization Risk

Michael Manning, Oregon State University, manninmi@oregonstate.edu
Gwendolynn Bury

There are many reproductive barriers to salmonid hybridization, and few studies have considered which environmental factors may be influential. Differences in temporal and spatial use of spawning habitat are a reproductive barrier, along with habitat characteristics such as water temperature, flow, and streambed composition. Higher incidence of hybridization in salmonids is found when at least one of the involved species is outside its natural range. Anthropogenic impacts on disturbance regimes, climate change, and land use may influence the risk of hybridization. The goal of this study is to identify which factors are most important to hybridization risk in salmonids. I will focus on populations in the Pacific Northwest. My initial model looks at changes in species distribution in response to climate change, and incorporates covariates such as stream characteristics.

Predicting the Establishment Of Pacific Salmon in Chilean Patagonia: Is Propagule Pressure Enough?

Andres Olivos*****, Oregon State University, andres.olivos@oregonstate.edu
Ivan Arismendi
Brooke Penaluna

Propagule pressure has been widely described as one of the best predictors for invasive species success, however different perceptions arise when considering salmonid invasions in Chilean Patagonia. Currently, Chile maintains the largest industry of farmed salmon in the world. The industry is in constant expansion with hundreds of established net-pens along southern coastal areas. Several reports of mass escapements and habitual leaks are continually increasing propagule pressure leading to an accumulated risk of establishment over time. Here, we present a spatial quantification of propagule pressure from aquaculture for Oncorhynchus spp. in Chilean Patagonia and couple it with reports of self-sustaining populations. Based on reports and estimates of fish escapements from salmon farming facilities (n = 1,259), we estimated propagule pressure indexes (PPI) for 27 counties for the past 25 years. We used Kernel densities to identify hotspots across different watersheds. We estimated that about 20 million individuals have been released into Chilean Patagonia during the last 25 years. Coho Salmon has had the highest number released (~50%), followed by Rainbow Trout (~45%), and Chinook Salmon represents only a minor proportion (<5%). There is no evidence of self-sustaining populations of Coho Salmon, but a recent study reports juvenile fish presence in areas where salmon farming is absent. In contrast, Rainbow Trout and Chinook Salmon have widely established populations in this region. Our results suggest that propagule pressure itself is not always a good predictor of salmon establishment in receiving ecosystems. Moving forward, we will use environmental DNA and intrinsic potential models of salmon to predict areas of risk for salmon invasion in Chilean Patagonia.

Synchronicity of Environmental Regimes Affecting Aquatic Vertebrates in Mediterranean Rivers: An Experimental Approach

Francisco Pickens*****, Oregon State University, andy.pickens@oregonstate.edu
Ivan Arismendi

The anticipated impacts of climate change have been researched in various geographies, taxa, and ecological phenomena. Significant efforts have focused on the impact of increasing temperature conditions on species abundance and distribution. However, changes in temporal synchrony of environmental regimes may be more influential on residing biota. Headwater streams of western Oregon are regulated by a Mediterranean-type regional climate, in which most precipitation falls between October and March, with the remaining months being relatively dry. In this region, climate change is expected to extend the duration of summer low-flow, causing it to begin earlier in the year. This may coincide with maximum summer temperature, thereby simultaneously increasing two primary environmental stressors on cold adapted aquatic animals: temperature and flow. To investigate the effects of simultaneous increased temperature and low-flow on cold adapted aquatic animals, we conducted an experiment at the John L. Fryer Aquatic Animal Health Lab, Corvallis, OR summer 2017. We installed fifteen experimental tanks, each with two Coastal Giant Salamander (Dicamptodon tenebrosus) and five Coastal Cutthroat Trout (Oncorhynchus clarkii), split evenly among three treatments of flow conditions. We measured behavior through video observation over the experiment duration, and final blood-glucose levels to determine if animals were physiologically stressed after a period of 8 weeks. Understanding whether cold adapted animals are affected by these conditions is essential for their conservation in a changing climate.

Assessing Variability in Length Measurements of Chum Salmon Carcasses over Time

Brent Priz, Oregon Department of Fish and Wildlife, brent.j.priz@state.or.us
Matt Weeber
Jon Nott
Ryan Emig

For many decades fisheries professionals have collected length measurements on fish species for a variety of reasons. These data have provided many insights into fish ecology, such as annual growth rates and detecting changes in population size classes over time. Due to varying measurement techniques utilized by fisheries management agencies it is often problematical comparing historical length measurement data. Recent work conducted by Oregon Department of Fish & Wildlife staff is leading to the development of an equation to convert length data for Chum Salmon between three measurement standards: 1) Fork Length, 2)Total Length, and 3) MEPS (Mid Eye to Posterior Scale) Length. Each of these measurement standards rely on differing morphological features to represent the size of the fish. Due to varying rates of decomposition, it is probable that collecting length measurements on salmonid carcasses could produce varying values over time. During the Fall spawning season of 2017 weekly spawning ground surveys were conducted on Chum Salmon standard surveys on multiple reaches of Mill Creek, within the Yaquina River Basin located outside the town of Toledo, OR. Chum Salmon carcasses were marked with individually numbered Floy tags, and multiple surveyors recorded standard lengths, sex and carcass condition over the course of multiple survey dates. The purpose of this study is to determine if the condition of a carcass plays a role in biasing length measurements or sex identification over time, and to assess the variability between length measurements collected by multiple surveyors.

Oregon State University ORAFS Student Subunit

Brooke Schlipf, Oregon State University, schlipfb@oregonstate.edu
Alvaro Cortes
Rachel Lertora
Becky Friday

The purpose of the Oregon State University ORAFS Student Subunit is to foster interactions between students, faculty, natural resource professionals, and the community. The subunit focuses on providing students with informational speakers, educational activities, professional development opportunities, and interactions pertaining to the fields of fisheries, wildlife, and other natural resources sciences. We will be presenting photos and information about the subunit's past events along with plans and ideas for the future.

Freshwater Habitat Committee

Cory Sipher, Bureau of Land Management, csipher@blm.gov

The Freshwater Habitat Committee of the Oregon Chapter American Fisheries Society represents a large and diverse group of land managers, academic researchers, environmental protection specialist and fisheries managers. Whether working on issues directly affecting freshwater habitat or by managing the resources on which they rely, the expertise and experience of this group can play a vital role in helping guide the chapter when it comes to responding to statewide or regional issues.

Effects of Beaver on Water Quality in Urban Streams in the Tualatin River Basin, Oregon

Casie Smith, U.S. Geological Survey, cassandrasmith@usgs.gov
Erin Poor

Krista Jones
Stewart Rounds

Populations of North American beaver (*Castor canadensis*) have increased in recent years due to decreased trapping, habitat restoration, and recognition of their importance as a keystone species in stream systems. It is commonly known that beaver activity can change stream morphology, trap sediment and attached pollutants, alter the composition and amount of riparian vegetation, slow down and push water onto the floodplain, and change surrounding habitats for fish, amphibians, and birds. Little work has been completed, however, to quantify the effects of beaver on water quality in urban streams. This study found that beaver do not have a single clear effect on the water quality of urban streams. The effects often are transient and complex and can be positive or negative, but typically cause an increase in the diversity of water-quality conditions and potential associated habitats.

Over a two-year period, U.S. Geological Survey staff collected continuous water-quality data and characterized variations in temperature and dissolved-oxygen (DO) concentrations in and around beaver ponds in several urban streams of the Tualatin River basin in northwestern Oregon. The effects of beaver on water quality were highly variable, but when interpreted with the aid of site-specific characteristics and process-based knowledge, the data illustrate several important concepts. Water-quality effects depend on (1) stream slope and substrate, (2) presence and type of riparian vegetation, (3) composition of suspended sediment, and (4) the degree to which beaver activity inundates the stream's floodplain.

Where beaver ponds inundate the floodplain, water temperatures in shallow ponded areas tend to warm in summer above levels that might occur if the creek remained in its channel. Despite general warming in exposed areas, the diversity of thermal conditions can greatly increase, with cooler water in deeper pools and in areas with riparian cover. Warmed pond water reverts back to more normal temperatures after re-occupying its channel some distance downstream. Ponded areas tend to have a wide DO range, from near-anoxic in areas where ponds trap sediment and the associated organic matter exerts high oxygen demands, to supersaturated in areas of high photosynthetic activity from macrophytes and algae. Turbidity measurements aided in the evaluation of sediment transport and trapping. In some reaches, beaver activity increases stream stage and induces stream infiltration into the surrounding floodplain soil and shallow groundwater, which increases water flow through the subsurface and thereby affects temperature and the concentration of dissolved substances downstream. This study has helped to fill a water-quality knowledge gap and provide useful information for water-resource managers, regulators, and restoration practitioners.

Primary Production and Consumer Responses to a Riparian Canopy Gap

Allison Swartz*****, Oregon State University, allison.swartz@oregonstate.edu
Dana Warren

Fish production in forested headwater streams is strongly influenced by food availability. While allochthonous litter is a primary basal food source, algal biofilms (periphyton) have been shown to be a disproportionately important food resource. Recent studies suggest that light limitation may be a key impediment to benthic primary production in headwater ecosystems – even those with low nutrient availability. In forested headwaters, light is controlled largely by trees in the riparian zone. Therefore, changes in the canopy, whether due to natural or anthropogenic processes, can strongly influence primary production and biota in streams. Streams with old-growth riparian forests often have canopy gaps adjacent to the stream, which have been hypothesized to create productivity hotspots that can contribute to fish abundance. In summer 2016, we conducted an experimental shading study in which we excluded light from patches of the stream and found that primary production, invertebrates and fish populations declined in reaches where light was excluded. In summer 2017, we initiated a complementary study in which we increased light patches along a stream by felling trees in the riparian zone to create a small (10 meter radius) canopy gap. Preliminary results suggest that stream primary production and benthic algal standing stocks increased rapidly in response to increases in light, despite low nutrient levels. Our results suggest the potential for a positive bottom-up response to localized increases in light.

CRISPR/Cas9 Mutation to Knockdown Estrogen Receptors in the Hepatocytes of Rainbow Trout

Christine Trahan*****, University of Idaho, christinha339@gmail.com
Timothy Cavileer
James Nagler

CRISPR/Cas9 is a new and innovative method useful for targeted gene mutation which is being rapidly applied across organisms, including fishes, to understand basic physiology. The intent of this approach is to elucidate the role of the four estrogen receptor (ER) isoforms in rainbow trout by targeting their associated genes ER1, ER2, ER1, and ER2. A further objective is to assess their role associated with the production of the egg yolk precursor protein, vitellogenin. Vitellogenin synthesis (i.e. vitellogenesis) is known to be temperature sensitive. With climate change causing an increase in global average temperatures, fish populations could be harmed by impacts during this process. In addition, the mode of action of environmental contaminants (e.g., polychlorinated biphenyls) will be altered by increasing ambient water temperatures further complicating their susceptibility. The purpose of this study is to present an in vitro model system to assess the function of ERs in rainbow trout hepatocytes using CRISPR/Cas9-mediated mutation. Four CRISPR constructs were constructed to target each ER gene in single knockouts. Primary hepatocytes from immature male rainbow trout will be treated with 17-estradiol (E2) to induce vitellogenesis. The differential mRNA expression of the four ERs and the vitellogenin gene will be assessed using real time RT-PCR. In addition to the four CRISPR treatments, four controls are included: Cells only treated with E2, not treated with E2, treated with the transfectant agent alone, and an empty CRISPR/Cas9 plasmid control. A further advantage of this system is that proteins (e.g., vitellogenin) can also be quantified from the culture medium. Our goal is to develop a model system that could be applied to target other genes and is amenable to variable temperature treatments. These studies could lead to an important tool for exploration of the potential impacts of global climate change on fish physiology.

Fusing Remote Sensing and Acoustically Measured Depth to Map High Resolution Bathymetry and Habitats on the Willamette River

James White, U.S. Geological Survey, jameswhite@usgs.gov

Brandon Overstreet
Jacob Macdonald
Rose Wallick
Greg Lind
Patrick Haluska
Gabe Gordon

The mainstem Willamette River supports a diverse mosaic of habitats used by a wide range of fishes and other aquatic species. The distribution and character of these habitat reflect underlying channel morphology and vary substantially in time, space, and use. A side channel, for example, may transform from a dry, unconnected feature in the fall to a high flow refuge in the winter, to partially connected, cold-water alcove in the early-summer. Each of these phases may provide an important habitat to different species at different life stages. A comprehensive understanding of how habitat availability changes with discharge on the Willamette River is lacking, owing in large part to the dearth of detailed bathymetry data from with to map and model aquatic habitats.

Large non-wadeable rivers, such as the mainstem Willamette River, provide unique challenges for mapping bathymetry due to the large range of depths and high diversity of channel forms. Numerous approaches exist for air- and boat- based collection, and often a combination of techniques is required to characterize the full range of depths found in large rivers. The USGS, US Army Corps of Engineers and Quantum Spatial are partnering to generate a preliminary continuous bathymetric dataset for the mainstem Willamette River by combining bathymetric lidar, single- and multi-beam sonar, acoustic doppler current profiler, and aerial imagery spectral analysis. We will highlight the utility and limitations of each approach along the diverse reaches of the Willamette River, and challenges of combining datasets collected at different times with different instruments, each with their own uncertainty, range of application and resolution. We will also illustrate the utility of combining this continuous bathymetric dataset with detailed two-dimensional hydraulic models to assess changes in rearing habitat for juvenile spring Chinook salmon with varying discharge for a ~5km-km reach on the mainstem Willamette River near Harrisburg. This effort will inform Willamette River flow management, but lessons learned can also inform future efforts to develop high resolution bathymetry datasets on other large rivers in the Pacific Northwest.

Coexistence of Top Aquatic Predators in Headwater Streams: Intraguild Predation and Implications of Shrinking Habitat Ranges

Lauren Zatkos*****, Oregon State University, lauren.zatkos@oregonstate.edu
Ivan Arismendi

Cutthroat Trout (Oncorhynchus clarkii) and the Coastal Giant Salamander (Dicamptodon tenebrosus) are the dominant aquatic predators in headwater streams of the Pacific Northwest. In most of these streams, the habitat and prey preferences of trout and salamander overlap, making intraguild predation a common occurrence. However, in the upper part of the headwaters, salamander presence extends further upstream than trout. In addition, studies indicate that as headwater streams warm as climate change persists, optimal habitat for trout will shrink, leaving salamanders to be the sole dominant predator in these habitats. The goal of this study is to monitor the variation in aquatic and terrestrial food sources available to these predators in sites where both fish and salamanders coexist as well as sites where only salamanders are present. In addition, mark-recapture surveys to estimate fish and salamander abundances will be conducted via backpack electrofishing. From a subset of individuals, gastric lavage will be employed to identify variations in summer diet composition between upstream and downstream sites. The study will take place at the HJ Andrews Experimental Forest, a long-term ecological research site where several decades of stream temperature recordings and fish monitoring data will provide the spatiotemporal context of our study. We will conduct an additional experiment using artificial streams to track the fine-scale movement and habitat use of salamander and trout when in close proximity. This experiment will shine light on the poorly understood concept of how intraguild predation, if present, may play a role in habitat use of aquatic predators in headwater streams. Collectively, this research will help to answer the questions forming about how headwater streams and their biota are organized and how this ecosystem will be affected as climate change progresses and sensitive predators experience habitat shifts.