01-01 **Engaging Stakeholders in the Practice of Fishery Management: There is an Island of Consistency Amidst the Sea of Change**

Charles E. "Chip" Corsi*, Idaho Department of Fish and Game, charles.corsi@idfg.idaho.gov

A generation ago, fisheries professionals had a relatively limited tool box with which to work when it came to communicating with the public. There was no internet, there were no cell phones, typewriter ribbons and Kodak film were common purchases, and data bases were still contained in filing cabinets and hand-written notebooks. Newspapers were the primary outlets for disseminating information, we used rotary dial phones, and a letter might take a week to reach a recipient. We thought we had it pretty good, after all at the birth of the North American conservation model the telegraph was high speed communication, yet the founding fathers of fish and wildlife conservation were able to succeed in building state and federal agencies, and the university programs, that have developed into the basic infrastructure for the profession today. Over the past 30 years, however, our ability to communicate with the public has increased exponentially, as a function of exponentially increasing technological capabilities. Along with those changes, however, is an increasing expectation by the public for nearly instantaneous results in almost everything – an expectation not easily met when we deal with systems that often respond slowly to management efforts. On top of that, in the "information age", the market for impatience is often easily met by armchair biologists and managers with easy access to electronic media which allow for rapid and widespread dissemination of "information", often with little accountability. Fisheries professionals must learn to adapt by taking advantage of the new tools available for communicating with the public and managing expectations. At the same time, we need to constantly remind ourselves that communication is a two way process in which receiving is at least as important as sending, and of the importance of building and maintaining relationships as we tackle difficult and often long term management and conservation challenges.

01-02 **AFS Communication in a Twitter World**

Travis Neebling*, Wyoming Game and Fish Department, travis.neebling@wyo.gov

Fisheries, and particularly AFS, communication has changed over time from primarily annual meetings and scientific journals beginning in the 1870s to the current use of social media. This presentation will examine the current use, and potential future, of various modes of electronic communication including online newsletters, websites, and social media technologies. Real-world examples will be used to illustrate how the current generation wants to receive information and how this can be tailored so as not to exclude other generations. Many groups within AFS (i.e., Parent Society, Divisions, Chapters, and Sections) are currently using some form of social media to keep their members informed. Data will be presented on the current use and acceptance of these technologies, along with suggestions for improving their use.

01-03 **Make Your Science Stick! Messaging Tips for Motivating People to Conservation Action**

Jonathan Gelbard*, Conservation Value, Inc., jon@conservationvalue.com

Conservation science offers land managers and policymakers a remarkable body of knowledge to guide decisions for protecting and restoring ecosystem services. Yet it seems that at virtually every ecological conference, scientists despair that decision-makers are ignoring our expert recommendations. The rise of social media is a game-changing opportunity to emerge from this rut, as tools such as Twitter shine an ever-watchful light on agency and corporate practices. Are there proven messaging approaches that scientists and management specialists can use to improve our effectiveness at leveraging new media to motivate decision-makers to take the actions we advise? Here I tell the story of my journey from undergraduate Communication major to Natural Resources major, to Ph.D. in Ecology, and back to my communication roots, where I now serve as "a bridge" between the worlds of science and decision-makers. I share my favorite communication tips from the science (and art) of influence, drawing from such experts as communication psychology luminary Robert Cialdini, marketing guru, Seth Godin and messaging mavens, Chip and Dan Heath. I present a simple, strategic and science-based communication framework that you can follow to advance your unique and important ideas in a world increasingly influenced by social media. This framework follows five steps: (1) Understand the identity, values and desires of your target audience(s), (2) Leverage this understanding to shape top scientific recommendations into targeted "sticky" messaging, (3) Apply this messaging to develop customized strategies for influencing your audience via scientifically-demonstrated logical and emotional drivers of change, (4) Measure your effectiveness in achieving objectives, and (5) Use measurement results to refine and improve your communication strategies and tactics. In illustrating this framework, I offer examples of how top organizations are (sometimes quite amusingly) leveraging the power of Twitter to spread viral ideas that advance their conservation goals.

01-04 **Cast to the Happy Ones: Science as Narrative Art**

Christina Swanson*, Natural Resources Defense Council, cswanson@nrdc.org

For centuries, even as our communication methods have dramatically changed and diversified, storytelling has been the dominant—and most effective—structure for conveying information. As fisheries scientists, natural resource managers and restoration practitioners, we all recognize that effective communication of the content and relevance of our work is an essential strategy for successfully translating our science into action. But many scientists feel discomfort with the storytelling approach, fearing pressure to "bend the science to tell a better story." Are science and storytelling compatible? In this talk, I explore science as a narrative art and argue that reclaiming our storytelling skills will help us adapt to the changing communications landscape and the rise of new media like Twitter, without diminishing the integrity of our work. I will

discuss some specific scientific and communication tools, including use of indicators to synthesize and simplify complex quantitative and mechanistic information, narrative techniques to build a compelling storyline, and information management strategies to ensure that the rich body of data that underlies our work neither overwhelms nor is lost from the story. In today's challenging environment of competing priorities, information overload and short attention spans, how we talk about our work to do science and use it for resource management will likely become an increasingly important determinant of our success.

01-05 **Plenary Perspectives: From Fortran to Facebook**

Michael Stone*, Wyoming Game and Fish Department, mike.stone@wyo.gov

Rapid changes in technology and communications present challenges and opportunities far beyond what humans have ever experienced. The internet is only approximately 5500 days old. Online advertising and marketing expenditures exceeded that of print media in 2010. Over one third of adults in the U.S. now use smart phones, and that may exceed half by the end of next year. Rising popularity of mobile devices and social media over traditional computer internet access has led to predictions that traditional websites may be gone in five years. Social media is driving a reinvention or a change in organizations. Society struggles globally with the rapid pace and unintended consequences of these advances. Fisheries professionals and conservation agencies are no different. We reap benefits and face challenges from routine data collection and analysis to how we approach scientific research and interact with the public. Generations that grew up with modern technology are more eager to embrace social media and associated changes than those who grew up with pen and notebook, or even with Fortran. The theme of this meeting, with emphasis on approaches to engage stakeholders, better communicate within the profession, develop more effective messaging approaches, and tell our story with integrity to a non-scientific audience, demonstrates that the fisheries profession is up to these challenges.

02-01 **Movement and life history characteristics of bluehead suckers (Catostomus discobolus) in the Snake River drainage, Wyoming**

Brian Hines*, Wyoming Game and Fish Department, brian.hines@wyo.gov

Rob Gipson, Wyoming Game and Fish Department

The bluehead sucker (Catostomus discobolus), which is native to the Green, Colorado, Bear, Weber, and Snake Rivers, is a species of concern in several western states. Population declines of this species are typically associated with habitat alteration and hybridization with introduced species. Most research conducted on the species has occurred in the Green and Colorado Rivers, but none in the Snake River drainage. The purpose of this study is to gain a better understanding of movement, life history characteristics, and the status of bluehead suckers in the upper Snake River drainage, WY. The specific objectives are to determine (1) distribution, (2) seasonal

movement patterns, (3) age structure and growth rates, and (4) prevalence and intensity of "black spot" disease. Raft and backpack electrofishing surveys were conducted and bluehead suckers were found in five Snake River tributaries where they were previously undiscovered. Radio transmitters were surgically implanted into sixty bluehead suckers and movements were recorded biweekly year-round. Movements ranged from just a few miles to more than eighty miles, with most movement occurring in early summer and early winter. Two hundred and twenty pectoral fins were embedded in epoxy and sectioned for age and growth analysis. Ages, so far, range from 5 to 24 years. Two hundred and fifty eight photos were taken and analyzed for "black spot" disease prevalence. Fish captured in the upper sections of the Snake River have significantly ($p<0.001$) higher "black spot" prevalence rates than fish downstream in the canyon sections.

02-02 **Despite gloomy forecast, not all sucks for the Catostomidae**

David Cole*, Utah State University, dave.cole@aggiemail.usu.edu

Brian Cardall, Wildland Resources Department and the Ecology Center, Utah State University

Karen Mock, Wildland Resources Department and the Ecology Center, Utah State University

Todd Crowl, Watershed Sciences Department and the Ecology Center, Utah State University

Five recent species of lakesuckers, mid-water planktivores, are recognized in four hydrologic basins: June sucker (Chasmistes liorus) – Bonneville basin; cui-ui sucker (Chasmistes cujus) – Truckee River drainage; shortnose sucker (Chasmistes brevirostris) and Lost River sucker (Deltistes luxatus) – Klamath River watershed; and the reportedly extinct Snake River sucker (Chasmistes muriei) – upper Snake River basin. All extant Chasmistes species and D. luxatus are federally listed as endangered.

The Snake River sucker is known from a single specimen collected from the Snake River below Jackson Lake Dam in 1927 by the late naturalist, Olaus Murie. It was believed to inhabit lakes in Jackson Hole, WY prior to its alleged extinction in the mid 20th century. Currently, suckers in Jackson Lake, its tributaries and outflow, and nearby lakes are assumed to be benthivorous Utah sucker (Catostomus ardens). Recently, however, many individuals sampled from Jackson Lake / Snake River have been described which morphologically resemble lakesuckers rather than Utah sucker, raising questions about the possible persistence of the Snake River sucker.

Here we describe and evaluate genetic variation via microsatellite and mitochondrial DNA analyses and variation in diet via stable isotopes analysis in the morphologically diverse suckers in Jackson Lake / Snake River. Suckers were subjectively identified to morph (Chasmistes, Catostomus, or intermediate) using mouth characters associated with planktivorous verses benthivorous feeding strategies. We found no genetic evidence for deep divergence between Chasmistes and Catostomus morphs or for hybridization of ancient lineages (despite many suckers displaying intermediate morphology). Bayesian model-based genetic clustering analysis detected a single sucker population in Jackson Lake. Stable isotopes analysis revealed that the Catostomus morph was significantly enriched in 13C relative to the Chasmistes morph as would be predicted given their presumed diets, whereas δ 15N did not differ significantly between the

two morphological extremes. The persistence of Snake River sucker provides a valuable opportunity to study lakesucker ecology and evolution given that other lakes which lakesuckers inhabit are much older and much more eutrophic than oligotrophic Jackson Lake and that there are younger lakes upstream in the Snake River drainage, including at least one with anecdotal reports of a Chasmistes population.

02-03 **Spatial and temporal variation in spawning within an augmented endangered lake sucker population: implications for conservation**

Kevin Landom*, Utah State University, kev.land@aggiemail.usu.edu

Todd A. Crowl, Utah State University

Intraspecific phenotypic variation in life history characteristics, such as the timing and location of spawning migrations, is an attribute that has been found in many fish populations. In some augmented, imperiled fish populations, the development of such life history variation has lead to genetic and/or morphological structuring within the population; structuring that has had important implications for conservation. The federally endangered June sucker (Chasmistes liorus mictus) is endemic to Utah Lake, Utah, and historically performed annual spring migrations from Utah Lake into surrounding tributaries to spawn. However, due to anthropogenic disturbances, the greatly reduced and poorly understood adult spawning population had been believed to be restricted to the largest and historically most important tributary, the Provo River. Nevertheless, due to recent improvement in augmentation efforts, the abundance of the spawning population has increased substantially, and previously unknown pre-spawn and spawning behaviors have been revealed. Using a combination of netting techniques and instream passive integrated transponder antennae from 2008 through 2010, we documented pre-spawn migratory behavior that showed extensive inspection of different tributaries prior to spawning site-selection. Our evaluation of larval sucker drift illustrated that spawning occurred in six tributaries, and that the temporal variation in lake-wide spawning spanned as much as one month. Historically, temporal variation in spawning has been suggested to contribute to observed morphological variation within the sucker population. The possible implications of spatial variation in larval production are discussed, and include the effects of variations in growth, survival, morphological development, and unknowns associated with natal homing instinct and genetics. Ultimately, the results of our study have lead to more questions and interesting hypotheses than conclusions; hypotheses that are welcomed as we begin to fill in important information gaps. Our principal hypothesis is that the spatial and temporal variation in spawning may ultimately lead to genetic and/or morphological structuring within the population. Such a development could have crucial implications for future strategies regarding conservation and management of this unique native lake sucker population.

02-04 **Drift And Retention Of Flannelmouth Sucker Catostomus Latipinnis, Bluehead Sucker Catostomus Discobolus, And White Sucker Catostomus Commersonii In The Big Sandy River, Wyoming**

Koreen Zelasko*, Larval Fish Laboratory, Colorado State University, Koreen.Zelasko@Colostate.Edu

Kevin Bestgen, Larval Fish Laboratory, Department of Fish, Wildlife, & Conservation Biology, Colorado State University

Kevin Hayes, Larval Fish Laboratory, Department of Fish, Wildlife, & Conservation Biology, Colorado State University

Potential loss of native flannelmouth and bluehead sucker larvae in Big Sandy River, Wyoming, over a proposed barrier to upstream movement of non-native species from Big Sandy Reservoir was investigated. Goals of this study were to estimate abundance of native catostomid larvae that drift into Big Sandy Reservoir, determine catostomid retention upstream, and characterize catostomid spawning periods.

Larval drift net sampling at three stations captured 1112 catostomid larvae (10.2/hour) in 2009 and 509 (3.3/hour) in 2010. Flannelmouth sucker was the most abundant larvae captured in 2009 (60% of suckers), while non-native white sucker was most abundant in 2010 (53% of suckers). Bluehead sucker made up 15 and 8% of catostomids in 2009 and 2010, respectively. Most flannelmouth suckers were captured at the downstream station (89% and 64% in 2009 and 2010, respectively). Only 41 bluehead sucker larvae were captured in 2010 and half were from the upstream station. Nearly 1,350,000 flannelmouth suckers and 52,000 bluehead suckers may have drifted into Big Sandy Reservoir in 2009, compared to 147,000 flannelmouth suckers and 10,000 bluehead suckers in 2010. Spring flows were higher than average and may have increased drift rates. Preponderance of flannelmouth sucker downstream and bluehead sucker upstream suggested longitudinal separation of species, with flannelmouth sucker potentially affected most by a barrier.

Native catostomid peak spawning periods were similar between years: 30 April–18 May 2009 and 3–20 May 2010 for flannelmouth sucker; 15 May–3 June 2009 and 16 May–8 June 2010 for bluehead sucker. White sucker periods were longer (13 May–9 June 2009 and 9 May–4 June 2010) and more uniformly productive, perhaps leaving the species less susceptible to recruitment failure. Mean daily water temperatures during peaks were ≤9.2°C in 2009 and 8.6–11.0°C in 2010.

In seine sampling, white sucker was captured in higher proportions and densities than each of the native catostomids at most locations. Samples within Big Sandy Reservoir revealed high densities of white sucker and no native suckers. Therefore, potential impacts of a barrier to native sucker movement may be outweighed by benefits stemming from prevention of white sucker upstream movement.

02-05 **Non-Native Fish Removal To Benefit The Three Species In Wyoming 2009-2011**

Paul Atwood*, Wyoming Game and Fish Department, Paul.Atwood@wyo.gov

William Cleary, Wyoming Game and Fish Department

Robert Keith, Wyoming Game and Fish Department

Non-native fish removal was conducted in 2009, 2010, and 2011 to benefit native bluehead suckers Catostomus discobolus, flannelmouth suckers Catostomus latipinnis, and roundtail chub Gila robusta in three priority drainages: the Big Sandy River, Little Sandy Creek, and Muddy Creek within the upper Green River and Little Snake River watersheds in southern Wyoming. The focus of this project was to remove as many non-native fish as possible in priority drainages prior to chemical restoration. Single pass electrofishing was used to remove non-native fishes and sample native fish populations. A total of 33,019 white suckers Catostomus commersoni, 1,104 longnose suckers Catostomus catostomus, 464 bluehead-white sucker hybrids, 2,787 flannelmouth-white sucker hybrids, 1,753 burbot Lota lota and 3,298 creek chub Semotilus atromaculatus were removed over the course of three years. A decline in the relative abundance of non-native fish was observed following years of mechanical removal efforts. While this work has not completely eliminated the threats posed by non-native fish, it does seem to have alleviated the pressures (hybridization, competition and predation) placed on native fish populations by introduced fish. For example, population structures suggest that recruitment is occurring in native fish populations in the Big Sandy River and Little Sandy and Muddy Creeks. Recruitment of native sucker populations in the Big Sandy River has not been observed in several years. Future management of native non-game fish throughout the stated priority drainages should focus on selective mechanical removal efforts of non-native fish and chemical treatments to eliminate the non-native fish threat from the Big Sandy River and Little Sandy and Muddy Creek drainages.

02-06 **Discrimination of wild and hatchery June suckers Chasmistes liorus in Utah Lake, Utah using natural geochemical markers in otoliths and fin rays**

Brian Wolff*, Colorado State University, wolffba@gmail.com

Brett Johnson, Colorado State University

Hatchery-reared and marked June sucker ("JS"), an endangered species, have been stocked into Utah Lake, Utah for many years. When unmarked fish began to appear in the lake at a higher rate than expected from tag loss, the June Sucker Recovery and Implementation Program wanted to know if natural reproduction was occurring. We examined natural geochemical markers (87Sr/86Sr and Sr/Ca) in otoliths and pelvic fin rays to determine the likely source of unknown origin JS. We obtained geochemical signatures ("signatures") from JS from all potential rearing locations before the fish were stocked into Utah Lake and compared them to core (region corresponding to natal period) signatures of all unknown origin JS. Using signatures of both otoliths and pelvic fin rays we determined that roughly half (13 of 31) of unknown origin JS probably came from one rearing location, the Fisheries Experimental Station (FES; Logan, Utah). The remaining JS likely originated in Utah Lake or a tributary of Utah Lake. There were some cases of overlap of edge (region corresponding to time of capture) signatures of JS from Utah Lake and a few other rearing locations, so some of the fish not assigned to FES could have come from another rearing location (e.g., not wild origin). However, a minimum of 6 of 31

unknown origin JS had signatures that strongly indicated they were wild origin from Utah Lake. Lastly, we found high correlation (nearly 1:1) between pelvic fin and otolith 87Sr/86Sr. Thus, pelvic fin rays appear to be adequate structures for microchemical analysis to determine origins of unknown origin JS in the future and they can be obtained by nonlethal sampling.

02-07 **Gene flow and habitat connectivity in the Gila River: which native fish species are most susceptible to negative effects of habitat fragmentation?**

Tyler Pilger*, University of New Mexico, tjpilger@unm.edu

Thomas Turner, University of New Mexico

The upper Gila River Basin in southwestern New Mexico is one of the last unimpounded drainage basins in North America, and is a stronghold for a unique and largely endemic fish fauna. However, coincident with introduction of nonnative predators, such as smallmouth bass Micropterus dolomieu and yellow bullhead, Ameiurus natalis, distributions of native fishes have declined. Reaches with high predator densities could inhibit natural source-sink dynamics of native fishes by disrupting migration and reducing gene flow, thereby isolating local populations and decreasing overall genetic diversity. We used microsatellite DNA markers to examine population structure of five native species with varying life history strategies and different distributions in the system. Species with opportunistic life history strategies include spikedace, Meda fulgida, and loach minnow, Tiaroga cobitis, (federally listed species that have patchy distributions in the Gila River of New Mexico), and longfin dace, Agosia chrysogaster (widespread throughout the basin). Species with periodic life history strategies are desert sucker, Catostomus clarkii and Sonora sucker, Catostomus insignis (widespread throughout the basin). We collected fin clips from species at seven localities representing a 96 km longitudinal section of the Gila River of New Mexico. A canyon-bound reach with high densities of predators was interspersed within this array of sampling sites. Genetic diversity of opportunistic species increased longitudinally upstream to downstream and tests of genetic divergence indicated significant population substructure within the basin. Longfin dace showed the least amount of longitudinal genetic divergence, but more patchily-distributed opportunists exhibited significantly higher divergence values. Analyses of periodic species indicated higher genetic diversity at upstream sites than those downstream but no appreciable population substructure. Our comparative genetic study shows that migration and persistence of patchily-distributed opportunistic species will be most strongly affected by anthropogenic and natural factors that limit habitat connectivity in the Gila River.

02-08 **Genetically and morphologically distinct sculpin in the Spokane River basin, Idaho; a new species?**

Michael LeMoine*, Univeristy of Montana, michael1.lemoine@umconnect.umt.edu

Lisa Eby, Wildlife Biology Program, University of Montana

Michael Young, Rocky Mountain Research Station, Forestry Sciences Lab

Kevin McKelvy, Rocky Mountain Research Station, Forestry Sciences Lab

Freshwater sculpin of the genus Cottus are small, benthic fishes, common to many lakes and streams of Western North American. Sculpin tend to occupy a mid-trophic position where they may play an important role in ecosystem processes and can act as integrators in aquatic communities. Monitoring sculpin assemblages, however, is complicated by the morphological similarity of many sculpin species. Consequently, a lack of taxonomic clarity currently exists for sculpin of Western Montana and Northern Idaho. Recent genetic evidence presented by United States Forest Service, from the Pacfish Infish Biological Opinion (PIBO) sampling of nearly 400 streams in this area, indicates there are likely several undescribed sculpin species present. Analysis of two portions of the mtDNA genome and nuclear microsatellites identify that only one of the three species currently reported from the upper Columbia and Missouri River basins in Montana was actually present; the other two potential species represent undescribed taxa. A fourth potential species, primarily found in the Spokane River basin in Idaho, is also undescribed. To examine taxonomic relationships among these sculpin, we documented meristic and morphometeric characteristics of sculpin in the upper Columbia River. We identified novel meristic traits that distinguish the presently undescribed Spokane River sculpin from other sculpin in the region. The usage of genetic information to instruct meristic comparisons may lead to a new species of sculpin in the Spokane River basin, Idaho and may resolve current issues with sculpin taxonomy in the upper Columbia River and Missouri River basins.

02-09 **Quantifying cumulative entrainment effects for Chinook salmon in a heavily irrigated watershed**

Annika Walters*, Wyoming Cooperative Fish and Wildlife Research Unit, annika.walters@uwyo.edu

Damon Holzer and James Faulkner , National Marine Fisheries Service, Northwest Fisheries Science Center

Patrick Murphy and Chuck Warren , Idaho Department of Fish and Game, Anadromous Fish Screen Program

Michelle McClure, National Marine Fisheries Service, Northwest Fisheries Science Center

Pacific salmon experience multiple, small-scale disturbances throughout their freshwater habitat, but the cumulative effect of these disturbances is often not known or easily quantifiable. One such disturbance is water diversion which can entrain fish and alter streamflow regimes. We explore the effects of entrainment for threatened Lemhi River Chinook salmon Oncorhynchus tshawytscha smolts that encounter 41 to 71 water diversions during their outmigration. We used PIT tag data to model the entrainment rate of Chinook salmon smolts as a function of the proportion of water a diversion removes. Under median streamflow conditions with unscreened diversions, the estimated cumulative effect of the diversions was a loss of 71% of outmigrating

smolts due to entrainment. This is a large potential source of mortality, but screening is an effective mitigation strategy and reduces estimated mortality to 1% when all diversions are screened. If resources are limited, targeting diversions that divert a large amount of water and diversions in locations with high fish encounter rates is most effective. Our modeling approach could be used to quantify the entrainment effects of water diversions and set screening priorities in other watersheds.

02-10 **Nutrient transport by fishes: potential impacts of migratory native fishes on stream ecosystem function**

Kit Wheeler*, Utah State University, kitwheeler@gmail.com

Scott Miller, BLM National Aquatic Monitoring Center and Watershed Sciences Department, Utah State University

Todd Crowl, Watershed Sciences Department and the Ecology Center, Utah State University

In western North America, there is an abundance of potamodromous native fishes that move among and within fluvial networks, thereby linking different aquatic environments. Migrant-derived material subsidies (e.g., excreted nutrients, deposited eggs) can have strong effects on ecosystem function in recipient habitats, particularly in retentive systems that otherwise lack abundant nutrients during periods of fish migration. Despite the potential impact of freshwater migrants on ecosystem function, related studies are rare, especially for non-game species. Thus, there is a need to better understand the ecosystem role played by migratory native fishes and how that role varies in response to unique biological and physicochemical conditions associated with individual systems.

Excreted nutrients, primarily nitrogen (N) as NH4 and phosphorus (P) as PO4, may be important given the speed with which they can be assimilated by stream biota. However, the relative importance of migrant excretion varies as a result of interspecific differences in excretion rates and ratios and intersystem differences in background nutrient levels and hydrogeomorphic conditions that influence system retention. Data from Utah Lake and Strawberry Reservoir indicates differences in nutrient excretion rates and ratios between two native species [June sucker and Bonneville cutthroat trout (BCT)] that make annual adfluvial migrations. Moreover, substantial variation in physicochemical conditions exists between tributaries in these two systems, further suggesting differences in the potential impact of migrant excretion. Additional data from Trout Creek, a Strawberry Reservoir tributary, allowed us to put BCT excretion into the larger context of watershed nutrient dynamics. In 2011, 1629 BCT spawned in Trout Creek, resulting in peak daily biomass of 84.56 g/m2. Excretion-related nutrient loadings averaged 22.5 g N and 2.9 g P per day during the BCT spawn, and these inputs comprised 16 and 2% of average watershed N and P export, respectively, during the migration. These results suggest excretion of dissolved inorganic nutrients by migratory fishes can be an important biogeochemical component in small streams, especially when spawner biomass is high and background tributary nutrient concentrations are low. Furthermore, they illustrate the need to consider the potential influence of animals like migratory fishes on freshwater ecosystem function.

02-11 **Distribution, habitat associations, and genetic diversity of northern leatherside in Wyoming**

Luke Schultz*, Wyoming Game and Fish, luke.schultz@wyo.gov

Jason Blakney, Idaho State University

Ernest Keeley, Idaho State University

Janet Loxterman, Idaho State University

Human activities have extensively altered native fish assemblages and their habitats in the Western United States. Conservation and restoration for the long-term persistence of these fishes requires knowledge of distributional patterns and life history requirements. Northern leatherside Lepidomeda copei is a cyprinid native to the Snake and Bear River basins of Wyoming, Idaho, Nevada and Utah that has declined in distribution relative to historic records. In addition, understanding of the basic biology of the species is relatively poor. To address these information gaps and assess the status of northern leatherside in Wyoming, the objectives of this study were to document its current distribution, evaluate habitat and biotic associations, assess patterns of genetic diversity, and examine seasonal habitat use. Sampling throughout the Bear and Upper Snake river basins delineated the distribution of northern leatherside and identified areas of conservation interest for the species. Tissue samples were collected to examine patterns of genetic diversity in Wyoming. We assessed seasonal habitat use and habitat features related to the distribution and abundance of northern leatherside in the Bear River basin. Northern leatherside were found across the Bear River basin and were present in two streams in the Upper Snake River basin in Wyoming; populations in Wyoming represent the core range of the species. In the Bear River basin, northern leatherside was found across a wide range of habitats, but was most strongly associated with increased channel depth and depth variability. It also tended to be associated with other native fishes. Adult northern leatherside were collected from two intermittent streams during the spring runoff period, indicating that these habitats might be used for spawning. Multiple unique haplotypes were detected, indicating that genetic diversity of northern leatherside was relatively high in Wyoming populations. Genetic patterns were congruent with distributional information. This understanding of the distribution and ecology of northern leatherside will greatly improve the likelihood of successful management and conservation efforts within Wyoming and across its range.

03-01 **Discovery of Single Nucleotide Polymorphisms (SNPs) in Cutthroat Trout Subspecies Using Next-Generation Sequencing Technology**

Derek Houston*, Brigham Young University, derek.houston@byu.edu

Dennis Shiozawa, Department of Biology, Brigham Young University

Peter Maughan, Department of Plant and Wildlife Sciences, Brigham Young University

Paul Evans, Department of Microbiology and Molecular Biology, Brigham Young University

Single nucleotide polymorphisms (SNPs) are powerful genetic markers that are increasingly being used in phylogenetic and population genetic studies. Advances in high-throughput sequencing technologies have made SNP identification faster and cheaper than traditional methods that utilize Sanger sequencing. This makes SNP discovery in non-model organisms more attainable. Salmonid fishes are non-model organisms for which SNP discovery has garnered much attention in recent years, but a growing need for additional SNP discovery exists for certain groups of salmonids. Cutthroat trout is a native western North American salmonid species that is comprised of ten extant subspecies, each with a unique geographic distribution. Cutthroat trout are a popular sport fish, were historically stocked within and between major western drainages with little concern for, or recognition of, genetic variability among subspecies. Hybridization between cutthroat trout subspecies has occurred as a result of these stocking practices. Additionally, rainbow trout, another popular sport fish, has been stocked extensively throughout western North America. Rainbow trout readily hybridize with cutthroat trout in areas where the two species co-occur. Because of the resulting intra- and interspecific hybridization between native cutthroat trout and introduced cutthroat and rainbow trout strains, management agencies have increased their efforts to assess the genetic composition of cutthroat trout populations within their native ranges. While some researchers have succeeded in identifying SNPs that differentiate between cutthroat trout and rainbow trout, as well as among some cutthroat trout subspecies, there is a need to identify SNPs that can differentiate all subspecies of cutthroat trout. Here we used next-generation sequencing technology to expand on previous research efforts and identify additional SNPs that characterize more of the cutthroat trout subspecies than have diagnostic SNP markers to date. We used genomic reduction, barcoding, and 454 pyro-sequencing to identify 7564 putative SNPs that could be used to characterize nine unique lineages of cutthroat trout and rainbow trout. We chose a subset of those SNPs for validation, and have currently verified approximately 80 SNPs as valid markers.

03-02 **Genetic variation in and among populations of non-native brook trout in Idaho: the ghost of introductions past**

Helen Neville*, Trout Unlimited, hneville@tu.org

Louis Bernatchez, University of Laval

How do founding populations of introduced species establish and invade when they should have reduced genetic variability, high extinction risk, and little adaptive potential? Recent studies of this “genetic paradox” have demonstrated that, in fact, invasive populations often have advantageous genetic characteristics (high diversity, novel variation) arising from multiple introductions and in-situ hybridization among disparate native lineages. Somewhat uniquely, fish have been introduced intentionally throughout the world, with local introductions often executed repeatedly and using mixtures of different strains from the native range – a context which may greatly influence invasive potential. Here, we evaluate patterns of genetic diversity in non-native brook trout, which were introduced across the western US for over a century but

have also invaded broadly and pose a primary threat to native trout species. We analyzed 155 Single Nucleotide Polymorphisms (SNPs) identified in coding gene regions among 34 samples of brook trout populations across several large river systems in Idaho as well as samples from the only four hatchery strains documented to have been introduced in Idaho. We uncovered high within-population genetic diversity, significant genetic structuring across and even within watersheds, and evidence of admixture in field populations. Integration of genetic structure with assignments back to introduced hatchery strains, which have a broad geographic origin ranging from Quebec to Wisconsin, provides a genetic and historical context for this species' ubiquitous invasive success.

03-03 **Evaluating Links Between Genetic Theory And Conservation Management Of Isolated Cutthroat Populations**

Kellie Carim*, University of Montana, kellie.carim@gmail.com

Craig Barfoot, Confederated Salish-Kootenai Tribes

Lisa Eby, University of Montana

Matt Boyer, Montana Fish Wildlife and Parks

The primary threat to westslope cutthroat trout (Oncorhynchus clarkii lewisi) is hybridization with introduced rainbow trout (Oncorhynchus mykiss). Isolation management is currently the most successful method of protecting cutthroat from negative interactions with invasive species. Yet, isolation management also comes with tradeoffs including reduced population viability and loss of genetic diversity. Theoretical models for maintaining genetic diversity in isolated trout populations recommend a minimum 8km of stream habitat based on fish densities and effective population size. When considering isolation and its tradeoffs, testing these models and quantifying risks is necessary to inform conservation decision-making. We compared genetic diversity in cutthroat trout across 14 polymorphic microsatellite loci in two connected streams and 12 streams of varying length and time since isolation in the Flathead River Basin of western Montana. As expected, isolated populations in smaller streams have lower genetic diversity. However the amount of genetic diversity lost within isolated populations varied greatly, independent of time since isolation. To gain a better understanding of how maintenance of genetic diversity may change through time, we also analyzed seven geologically isolated populations of varying length from the Flathead River Basin across the same 14 loci. All seven geologically isolated populations show reduced heterozygosity compared to connected populations, regardless of amount of occupied stream length. Furthermore, these geologically isolated streams have significantly lower average heterozygosity compared to streams more recently isolated by anthropogenic activities. Together, these results demonstrate inevitable loss of genetic diversity in populations persisting in isolated systems, highlighting the need to explore options to prevent inbreeding depression under isolation management. Finally, this study has direct implications for management of native trout across watersheds of the Rocky Mountains, as well as to genetic theory that can be applied broadly across taxa.

03-04 **Combining Field Data and Simulation Models to Explain Trends and Potential Mechanisms behind the Spread of Trout Hybridization**

Patrick Della Croce*, Fluvial Landscape Lab, Montana State University, Dept of Land Resources and Environmental Sciences, patrick.dellacroce@gmx.ch

Geoffrey C. Poole, Fluvial Landscape Lab, Montana State University, Dept of Land Resources and Environmental Sciences

Andre B. C. Thees, Leibniz University Hannover (Germany), Dept of Computer Science in Civil Engineering

Hybridization between native cutthroat trout (Oncorhynchus clarki, CTT) and introduced rainbow trout (O. mykiss, RBT) is a major threat to the conservation of CTT populations across their entire native range. To date, large datasets describing the spread of RBT genes across several systems have been collected. While of crucial importance, these datasets are rarely used to shed light on the mechanisms that cause the observed abundances and distributions of RBT genes. As for any other case of hybridization, RBT genes are likely to spread across a network as a function of the interactions between landscape connectivity patterns and genetically driven differences among CTT, RBT, and hybrids with respect, for example, to their fitness and propensity to crossbreed. We present here a novel approach that is aimed at understanding these mechanisms. To reach our goal we are currently combining field data from various streams hosting CTT experiencing hybridization with RBT (e.g., Rose Creek, Yellowstone NP) with a novel computer simulation model that simulates the life cycle and tracks the genetic composition of individual fish within a population over time. Using inverse modeling via a genetic algorithm, we are identifying model parameter sets (e.g. combinations of fitness and propensity to crossbreed for pure and hybridized fish) that are consistent with the temporal patterns of abundance and distribution of rainbow trout genes observed on the systems of interest.

03-05 **The status of Yellowstone cutthroat trout in the Henrys Fork, Teton, and Sinks drainages**

Jim DeRito*, Henry's Fork Foundation, jderito@henrysfork.org

Jim Gregory, Gregory Aquatics

Lee Mabey, Caribou-Targhee National Forest

Yellowstone cutthroat trout (YCT) are the only native trout in the Henrys Fork of the Snake River, Teton, and Sinks drainages in Idaho and Wyoming. However, YCT distribution, abundance, and genetic integrity across about 4,300 km of stream length have been greatly diminished by non-native trout introductions and habitat alteration. YCT status was compiled using fisheries survey data collected by numerous organizations from 1997 to 2011. Among these drainages, YCT are present in 24% to 80% of stream length with trout, but exclusively

occupy only 5% to 14%. Brook trout are ubiquitous throughout the headwaters of all three drainages and rainbow trout are found throughout most main stem rivers and streams. YCT-only populations are typically present in small headwater streams above fish barriers and most of those genetically tested are not introgressed with rainbow trout. A few additional YCT-only headwater populations have been discovered in recent years, but the majority of unsurveyed stream length, mostly in the Sinks drainage, has a low probability of YCT presence. The YCT migratory life history is largely absent from most stream length throughout the drainages, but fluvial YCT are still present in the Teton River and adfluvial YCT are present in Henry's Lake. Interestingly, YCT from outside of the Henrys Fork drainage were translocated into historically fishless streams and lakes in Yellowstone National Park in the early 1900's and now represent the largest YCT-only populations in that drainage. Several organizations are working cooperatively to protect, conserve, and restore YCT in these drainages. YCT restoration projects focused on the renovation of headwater brook trout streams have been successful, but additional straightforward opportunities are limited.

03-06 **Watershed boundaries and geographic isolation: patterns of diversification in cutthroat trout from western North America**

Janet Loxterman*, Idaho State University, loxtjane@isu.edu

Ernest Keeley, Idaho State University

For wide-ranging species, intraspecific variation can occur as a result of reproductive isolation from local adaptive differences or from physical barriers to movement. Cutthroat trout (Oncorhynchus clarkii), a widely distributed fish species from North America, has been divided into numerous putative subspecies largely based on its isolation in different watersheds. In this study, we examined mtDNA sequence variation of cutthroat trout to determine the major phylogenetic lineages of this polytypic species. We use these data as a means of testing whether geographic isolation by watershed boundaries can be a primary factor organizing intraspecific diversification. We collected cutthroat trout from locations spanning almost the entire geographic range of this species and included samples from all major subspecies of cutthroat trout. Based on our analyses, we reveal eight major lineages of cutthroat trout, six of which correspond to subspecific taxonomy commonly used to describe intraspecific variation in this species. The Bonneville cutthroat trout (O. c. utah) and Yellowstone cutthroat trout (O. c. bouvieri) did not form separate monophyletic lineages, but instead formed an intermixed clade. We also document the geographic distribution of a Great Basin lineage of cutthroat trout; a group typically defined as Bonneville cutthroat trout, but it appears more closely related to the Colorado River lineage of cutthroat trout. Our study indicates that watershed boundaries can be an organizing factor isolating genetic diversity in fishes; however, historical connections between watersheds can also influence the template of isolation. Widely distributed species, like cutthroat trout, offer an opportunity to assess where historic watershed connections may have existed, and help explain the current distribution of biological diversity across a landscape.

04-01 **Geomorphic and hydrologic effects of Jackson Lake Dam on the Snake River in Grand Teton National Park, WY**

Susannah Erwin*, Utah State University, s.erwin@usu.edu

John Schmidt, Grand Canyon Monitoring and Research Center, USGS Southwest Biological Science Center

Nicholas Nelson, Inter-Fluve, Inc., Cambridge, MA

Construction of Jackson Lake Dam (JLD) at the outlet of Jackson Lake has fundamentally altered the hydrology and sediment regime of the Snake River in Grand Teton National Park. JLD was originally constructed in 1908, but reservoir operating rules were significantly changed in 1957 following the construction of Palisades Dam downstream. In an effort to understand the downstream effects of JLD on the Snake River, we conducted a statistical comparison of regulated and unregulated hydrology, assessed bed mobility with tracer gravels, and developed a sediment budget based on direct measurement of bed load transport. Our analysis shows that average peak flow releases are substantially less than the unregulated average peak flows. Although common floods are still capable of entraining bed material, the total sediment load is substantially less than would be in absence of the dam. However, summer flows are now significantly greater than unregulated summer flows and bed load transport often persists through late summer. In some years, this transport accounts for a substantial portion of the total sediment load. Despite these significant changes in hydrology and sediment flux, our findings demonstrate that although operations of JLD have significantly altered the flow regime of the Snake River, the effects of the dam are moderated by tributary inputs of water and sediment. These tributary inputs substantially reduce impacts of JLD on the hydrologic and geomorphic attributes of fish habitat in the Snake River. Our findings also provide guidance for dam management strategies that minimize the effects of the altered flow regime on fish habitat, while still meeting water transfer requirements in the Snake River basin.

04-02 **The food habits and growth rates of native and non-native salmonids in Jackson Lake, Grand Teton National Park, Wyoming.**

David Harper*, USGS CERC, JFRS, dharper10@centurytel.net

Aida Farag, USGS CERC, JFRS

Mark

The food habits and growth rates of 271 lake trout Salvelinus namaycush, 105 cutthroat trout Oncorhynchus clarkii bouvieri, and 81 brown trout Salmo trutta were assessed in Jackson Lake, Grand Teton National Park, Wyoming during May-October 2004 and 2005. Young lake trout (< 350 mm, <3 years old), cutthroat and brown trout consumed primarily aquatic invertebrates during spring and fall. However during summer, cutthroat and brown trout diets were dominated

by terrestrial invertebrates, while consumption of zooplankton by lake trout remained high. Lake trout 350-600 mm consumed an increasing proportion of fish with age, with lake trout >600 mm consuming almost exclusively fish. Prey fishes were primarily sculpin Cottus sp., Utah sucker Catostomus ardens, Utah chub Gila atraria, Speckled dace Rhinichthys osculus and mountain whitefish Prosopium williamsoni, with cutthroat trout observed in only one lake trout stomach. Growth of lake trout was slow, with fish requiring 10 years to reach approximately 500 mm and 1 kg. Fish aged 10-15 years grew more rapidly. Bioenergetics modeling and historical length/weight data revealed that young lake trout have high proportional consumption rates and relative weights, which decline to minimum values in fish 350-600 mm, and then increase to maximum values in fish 600-1000 mm. When compared with food consumption, young lake trout feeding exclusively on invertebrates were relatively robust. As their diet switched to small forage fish, consumption and condition declined, but large lake trout feeding exclusively on fish were the most robust.

04-03 **Life-history diversity and spatial structure in the distribution patterns and habitat use of Snake River finespotted cutthroat trout in the upper Snake River**

Kris Homel*, Montana State University, kristen.homel@gmail.com

Robert Gresswell, U.S.G.S. NOROCK

Jeffrey Kershner, U.S.G.S. NOROCK

Over the last century, native trout in western North America have experienced dramatic declines in abundance and distribution because of habitat degradation, fragmentation, invasive species, and hybridization. Declines have been particularly pronounced for the riverine migratory forms that rely on intact corridors to access seasonal habitat. In response to these declines, conservation of native trout has focused on identifying how fish respond to the physical template to better manage for specific attributes that promote population resiliency (e.g., life-history diversity or habitat quality). Much of what we know about the relationship between fish and the physical template comes from small streams with limited complexity of the physical template, limited life-history diversity, and limited movement among seasonal habitat. In these systems, assessment of habitat use tends to focus on instream attributes, and there is an implicit assumption that the spatial arrangement of habitat or behavioral patterns do not influence habitat use. However, as river systems increase in size and complexity, it is unclear whether patterns observed in small streams or habitat models derived from attributes of small streams could inform the conservation of fish in large river networks. To better understand life-history variation and habitat use in a large river network, radio telemetry was used to identify spawning patterns, life history diversity, distribution and movement patterns, and habitat use of Snake River finespotted cutthroat trout Oncorhynchus clarkii behnkei during the year spawning occurred. Cutthroat trout from the same spawning location exhibited significant spatial structure in distribution patterns throughout the year spawning occurred. Distribution and movement patterns also differed substantially among individuals from different spawning areas or expressing different life-history strategies. As a result, patterns of habitat selection were primarily influenced by selection for a location in the stream (e.g., the confluence of the

spawning area) and not the other attributes of that location (e.g., channel geometry). This study demonstrated the importance of habitat topology and behavioral complexity in a large river network and could be informative as a template for conservation planning for native trout in other large river systems.

04-04 **Boom-and-bust lake trout-kokanee fisheries: turning runaway consumption into sustainable fisheries for both species**

Bill Pate*, Colorado State University, bill.pate@colostate.edu

Brett M. Johnson, Colorado State University

Jesse Lepak, Colorado Parks and Wildlife

Dan Brauch, Colorado Parks and Wildlife

Kokanee Oncorhynchus nerka are stocked in coldwater reservoirs throughout the western United States for sport fishing. Kokanee are popular with both managers and anglers alike. They are efficient planktivores, fast growing, and relatively innocuous to native species. Kokanee are also inexpensive to culture and very popular with anglers. Lake trout Salvelinus namaycush have also been introduced to many western reservoirs, partly because they can attain enormous size (>30 kg). These piscivores require a large prey biomass to sustain growth and kokanee can be a substantial part of their diet where they coexist. A “boom and bust” scenario often ensues where initially lake trout growth is extreme due to abundant, high energy kokanee. Then runaway consumption can destroy both fisheries as lake trout decimate the kokanee population, and lake trout growth and condition decline precipitously. Our work on Blue Mesa Reservoir, Colorado, has focused on finding a sustainable balance for the two fisheries with the primary management goal being a sustainable kokanee population. We developed an age-structured kokanee model and combined it with estimates of natural mortality and harvest, and a fixed stocking quota of 3.1*106 fry. Instantaneous natural mortality (Mi where i = age), including background predation, was estimated using an allometric model based on kokanee age. We found that M0 = 1.288, M1 = 0.741, M2 = 0.518, M3 = 0.428, M4 = 0.377, and M5 = 0.345. Estimates of kokanee harvest by age were obtained from creel surveys. We then determined the current level of lake trout predation (PM = 0.431) by matching model output to kokanee abundance (130,000 in 2010) as estimated with hydroacoustics. The level of predation in the model was incrementally reduced until a stable equilibrium was reached at PM = 0.299. Current efforts to remove lake trout <765 mm and angler harvest have reduced the population by only 16%. This level of suppression is insufficient to reach PM = 0.299. Removal of lake trout must be intensified if the kokanee and fast-growing lake trout are to persist in Blue Mesa Reservoir.

04-05 **Investigating The Influence Of Human Disturbance On Juvenile Chinook Salmon Life History Variability In The Willamette Valley**

Samuel Bourret*, University of Idaho, bour6715@vandals.uidaho.edu

Brian Kennedy, University of Idaho

Chris Caudill, University of Idaho

Lisa Borgerson, Oregon Department of Fish and Wildlife

Understanding the distribution, abundance and relative performance of life history types is critical for development of passage for juvenile Chinook salmon in the Willamette Valley Basin (WVB), and an important element of the Willamette Valley Biological Opinion. Recent analyses of screw trap data suggest that juvenile Chinook salmon life history strategies are variable within and among WVB populations, including traits that resemble both an ocean-type life history with subyearling emigration in summer or fall as well as a stream-type life history with yearling emigration the following spring. We reconstructed the juvenile rearing and migratory patterns of a sample of natural origin adult Chinook salmon that returned to the Middle Fork Willamette Basin. Scale morphometric patterns and otolith isotope ratios of Sr87 /Sr86 were used to characterize juvenile life histories and estimate juvenile size at freshwater emigration. We also used alkaline earth elements Sr, Ba, Mn, Mg, and Ca in otoliths and water, combined with otolith morphometric attributes, to discern movement and rearing of natural origin juvenile Chinook salmon in natal rearing (adult out-plant) tributaries and downstream project reservoirs. We found that a significant portion of sampled juvenile Chinook salmon reared in project reservoirs and emigrate from freshwater at large sizes, which may be provide a survival advantage to adulthood. Elemental water samples between the North Fork Middle Fork Willamette and Lookout Point reservoir were heterogeneous, and similar trends were found in otoliths from juveniles captured in each habitat. Preliminary results from analysis of otolith microstructure suggest increased growth in project reservoirs relative to natal rearing streams. Determining the juvenile rearing habitat and emigration ecology of these populations will enhance the understanding of the interaction between life history variation and anthropogenic disturbance and assist in developing appropriate management strategies.

05-01 **Things to do to a spring creek, NOT!**

Jim Gregory*, Gregory Aquatics, Gregory_Jim@yahoo.com

Techniques to enhance the fisheries production potential of spring creeks have been implemented in many locations across the state over the past several years and are becoming even more common. Often these improvement efforts have involved adding large rock and woody debris to spring creeks to focus the stream energy and create fish habitat within those segments. While this often does increase the amount of habitat available to fish, it often does not restore stream function and can interfere with natural stream recovery. I suggest that spring creek restoration be conducted over a broad reach with the focus being to adjust the stream such that the stream width, slope, discharge, and sinuosity are in equilibrium. I also caution against construction of too many off-channel ponds and suggest when pond construction may be done without unduly affecting the spring creek.

05-02 **A Tale of Two Stream Habitat Projects**

Christina Barrineau*, Wyoming Game and Fish Department, christina.barrineau@wyo.gov

Two stream habitat projects in southeastern Wyoming will be presented detailing the differences in enhancement and restoration approaches applied. The Laramie River Greenbelt Enhancement is located in Laramie, Wyoming, and was initiated in 2009. A traditional armoring approach with vegetation was used for streambank stabilization and fisheries enhancements in the Laramie River. The enhancement goals were to install stabilization and restoration treatments to help protect infrastructure, improve aesthetics, provide information and education opportunities, and increase recreation use along the urban river corridor. The second project is located on the Encampment River near Riverside, Wyoming, where the river flows through a wide valley predominantly utilized as irrigated hay meadows and grazing pastures. A Natural Channel Design approach is being utilized for stabilizing streambanks, improving bedload transport, and enhancing fisheries habitat. The Encampment River Restoration is a multi-year project and construction was initiated last fall. Both stream habitat projects have received great support and interest from the public.

05-03 **Geomorphic Lessons Learned and Improvement to Natural Channel Habitat Structures**

David Bidelspach*, Stantec, David.Bidelspach@stantec.com

Natural stable streams are defined to be in a state of dynamic equilibrium. Many disturbed river systems can't be restored to a stable state due to limitations in project goals and objectives. Changes is the flow regime, sediment supply, slope and substrate can cause local channel instabilities that can lead to systematic reach wide instability and possible channel evolutions. Habitat improvements have been historically focused on the processes and structure of an individual bank and not reach wide restoration. Many stream restoration projects can be good examples and experimentations of the effect of changes in flow regimes that affect sedimentation and erosion rates and consequently on the availability of suitable habitat within a disturbed reach. The changes in geomorphology have a significant impact on the biological components of stream systems and the fisheries and should not be separate from the planning and design for habitat improvements.

Most stream restoration and habitat improvement projects North America have unstable and conflicting boundary conditions. The use of reference reaches have been limited to idealize boundary conditions and is less practice to many transition reaches. A process focused design for stream restoration will evaluate risk of multiple design flows that are at, above and below the bankfull stage. The low-flow channel dimensions are very important geomorphic features that can positively affect the stream temperature, drift, feeding lanes as well as channel stability.

This presentation will discuss many lessons learned from evaluating the geomorphic potential and departure analysis of a disturbed river system and restored river systems that have failed. A couple examples from of habitat improvement projects in Western Canada and the Western US will be presented and compared to project goals and objectives. Finally this presentation will suggest improvements that are being made to typical habitat structures.

05-04 **The Inner Berm: An Effective Solution for Stream Restoration in an Irrigation-influenced Environment**

Jim Broderick*, Rocky Mountain Ranch Management, jim@rmrm.biz

Darrell Westmoreland, North State Environmental

Irrigation practices developed to cultivate uplands has furthered settlement in much of the west but can often create a highly variable, non-natural hydrograph through water withdrawals and irrigation returns that offers unique challenges in stream restoration. In some western streams bankfull flows are rarely, if ever reached; in others, bankfull flows are evident numerous times throughout the year or even a single month. Both of these circumstances are contrary to the natural hydrograph upon which western streams evolved: a single bankfull event predicated on snowmelt and an extended runoff event. The stream restoration design feature of the inner berm, however, can be utilized to ameliorate the impacts of irrigation practices and its inherently variable flows regime to produce effective restoration designs. This design feature, sometimes referred to as a channel within a channel, utilizes the basic dimensions of the overall channel to adequately transport higher discharges associated with snowmelt while a smaller channel within it is created to maintain concentrated flow at lower discharge (e.g., during periods of higher irrigation withdrawal). The net result is two stable "channels" capable of providing adequate fisheries habitat across varied discharges. Cost-effective implementation of this design feature is, however, dependent upon a construction contractor knowledgeable and skilled in the intricacies of creating channel dimensions suitable for a varied flow regime and the habitat requirements of the intended fish species.

05-05 **Coho Salmon Fisheries Compensation though the use of Stream Restoration**

Michael Geenen*, Stantec, mgeenen@stantec.com

With the construction of a new four land highway along the Fraser River in Surrey British Columbia, efforts have been made to locate, design, and construct onsite fisheries compensation sites that offset the impacts of the new roadway alignment. The compensation is being completed to replace fish and riparian habitat that is being altered, disturbed or lost during the construction of the road. Though the use of natural channel design, segments of tributaries have been designed to stable form and habitat ponds have been designed for the juvenile Coho Salmon population. The compensation areas are meant to enhance, restore or create habitat in areas

where existing habitat has been lost, degraded or never existed. Currently, the acceptable compensation credit has been given for development of just these ponds without adjustment to the stream pattern or profile. This presentation will go over current compensation projects that are and have been designed and constructed using natural channel design in conjunction with habitat ponds for Coho Salmon, the type of structures that are being implemented and the benefits to this approach.

05-06 **Morphologically Based River Restoration: Methods, Accomplishments, and Regulatory Hurdles**

Ryan Colyer*, Biota Research and Consulting, rcolyer@biotaresearch.com

Accurate identification of aquatic habitat potential in degraded fluvial systems is only achieved through implementation of assessment and design techniques that quantify independent variables (boundary conditions, hydrologic regime, and sediment supply). Knowledge of these parameters enables calculation of stable channel morphology and corresponding hydraulic forces which, in turn, dictate the aquatic habitat potential of the fluvial system. Implementation of this multidisciplinary restoration approach in a variety of spring creek and freestone systems has resulted in documented fisheries benefits. These projects have also explored the differences between “habitat enhancement” and “restoration” activities, specifically related to the fact that restoration to a pre-disturbance condition is often not possible due to ongoing anthropogenic activities. We found that both habitat enhancement and restoration activities, however, can be subjected to regulatory hurdles during the permitting process that often jeopardize the economic viability and ultimate success of ecological improvements.

05-07 **River Enhancements Along the North Platte River**

Nathan Jean*, Stantec Consulting, nathan.jean@stantec.com

Luke Keil, Wyoming Anglers

High quality trout habitat is complex; consisting of an array of rapid flowing riffles, deep pools, submerged or semi-submerged wood, boulders or rock piles, undercut banks with overhanging riparian vegetation, and aquatic vegetation. These habitat features provide food sources for trout, shelter, and overwintering habitat. These features also provide areas that concentrate fish density, thus improving angler success and satisfaction.

The North Platte River through the City of Casper is rated as a blue ribbon trout fishery. While the fishery is high quality based on the number of fish per mile, the fishery is known to fluctuate in density and size of trout based primarily on winter flow conditions. The habitat in North Platte River through Casper currently consists of large runs with limited availability of riffle and pool complexes. At the request of the City of Casper Wyoming, Stantec Consulting Services Inc. and

SWCA Environmental (Stantec Team) prepared the North Platte River Master Plan. The purpose of the project is to provide an assessment of the existing condition of, and to propose restoration strategies for improving fish habitat for, the North Platte River in a 13.5-mile stretch that flows through the City of Casper, the Town of Mills, and Natrona County.

The Stantec team gathered data on the North Platte River to assess the current conditions of the river. Several stream assessment tools were used to evaluate the condition of the streams, including Rosgen Stream Classification, geomorphic cross-sections, geomorphic profiles, Bank Erosion Hazard Index and Near Bank Stress, and the Channel Evolution Model.

The entire 13.5-mile project length was floated with a local fishing guide (Luke Keil, Wyoming Anglers) to gain a better understanding of the quality of the fishery within the project area. Mr. Keil noted areas of either poor or good fishing along the project reach. When compared with data obtained during the geomorphic assessment the areas of the poorest fishing correlated with the areas of the most geomorphic instability. This information was used to help identify potential project locations for restoration activities.

05-08 **Water for fish: Instream Flows in Wyoming**

Mike Robertson*, Wyoming Game and Fish, mike.robertson@wyo.gov

Since 1986, Wyoming has recognized instream flow for fisheries as a “beneficial use.” Since then, the Wyoming Game and Fish Department (WGFD) has been working with the Water Development Office and State Engineer’s Office to generate instream flow water rights in streams with high priority fisheries. This has resulted in 115 water rights applications covering over 450 miles of stream statewide. This program has contributed to the conservation actions necessary to prevent ESA listing of the four subspecies of cutthroat trout in the state. The WGFD has a statewide program dedicated to identifying streams that have important fisheries and carry out detailed studies to quantify necessary flows. We use several methods to assess habitat conditions for fish and recommend appropriate flows to keep in the stream and to maintain these existing high priority fisheries. The definition of “high priority” has changed over time and will continue to do so as the program evolves into the future. The recent focus of the program has been to identify watersheds with high density of Yellowstone cutthroat trout (Oncorhynchus clarki bouvieri), including two tributaries of the Snake River, the Hoback and Greys River watersheds. A new water management report was prepared in 2011 that re-evaluated previous statewide efforts to prioritize streams and will guide efforts into the near future. The new method of prioritization involves several metrics for comparing the relative importance of securing instream flow water rights among Wyoming's many rivers and streams. An effective prioritization process allows us to direct limited resources to the streams that can benefit most and maximize the effectiveness of the program.

05-09 **A decade of Russian Olive control in Wyoming: Accomplishments, struggles, and future challenges.**

Nick Scribner*, Wyoming Game and Fish Department, nick.scribner@wyo.gov

Amy Anderson, Wyoming Game and Fish Department

Russian olive (Elaeagnus angustifolia) is a native plant from Eurasia that was introduced to many Great Plains and southwestern states in the early 1900s. They were extensively planted to provide windbreaks at first, and then federal conservation programs promoted their use for wildlife habitat among other uses. The Natural Resources Conservation Service (NRCS) continued to subsidize Russian olive seedlings for conservation plantings until the 1990s. Currently, Russian olive is present in every western state, and occurs in most drainages across Wyoming except for portions in the far west and at higher elevations. In 2007, Wyoming joined other states (CO, CT, NM, UT) with its listing of Russian olive as a noxious weed by the Wyoming Department of Agriculture. Like many exotic plant introductions to North America, the future consequences of establishing Russian olive were unknown in the 1900s, but are apparent in many of our watersheds across Wyoming today. Russian olive can take over and dominate native vegetation similar to other weeds such as cheatgrass and knapweed. The climate and soils of Wyoming provide ideal conditions for Russian olive to establish since they are drought tolerant and can handle the high salinity of our soils. However, they tend to flourish on moist sites near streams, irrigation ditches, and low lying areas and outcompete our native cottonwoods, willows, and other shrubs. Over 12,000 acres of Russian Olive have been removed over the past 10 years from riparian areas in Wyoming with various methods and levels of success. The greatest struggle following removal has been reestablishment of native shrubs and trees. Meanwhile, disagreement between biologists, agencies, and landowners on the premise of Russian Olive removal leads to additional obstacles to restoring native riparian habitat. The author will present Wyoming Game and Fish's strategy on Russian Olive management and highlight some of the concerns and projects currently ongoing in Wyoming.

05-10 **The Benefits Of Three Dimensional Design And Data Collection For Stream Channels**

David Bidelspach*, Stantec, David.Bidelspach@stantec.com

Mike Geenen, Stantec

Greg Jennings, NCSU-BAE

Darrell Westmoreland, North State Environmental

Three-dimensional channel design is the process of using computer aided design software and building a continuous three-dimensional design surface. The process of natural channel design can be optimized while the design can have a better idea of risks and uncertainties to a design using a three-dimensional design process. Over the past ten years, North Carolina State University and Stantec Consulting Ltd. has developed an Excel based computer freeware that creates logical stream break-lines and works with most computer aided design software. The use of break-lines is the basis for being able to build a continuous three-dimensional stream channel

surface. This process is currently being improved for stream restoration optimization by Stantec consulting and North State Environmental.

There are four major reasons for producing three-dimensional stream design. The first reason is that a three dimensional design will not limit hydraulic modeling. Second, all channel design methodology, including natural channel design, rely on an iterative approach for optimization that is simplified by creating and modifying a three-dimensional surface. The third advantage of a three-dimensional stream design is simplification of construction preparation and site stakeout. Finally, an advantage of three-dimensional stream design is being able to load the design surface into global position system guided construction equipment. The technology to guide hydraulic excavators and dozers by global positioning has advanced to a dependable, accurate and affordable level. North Carolina State University, Stantec Consulting and North State Environmental have evaluated and implemented all of the major advantages of three-dimensional stream design. This presentation will also include case studies of a 3D designs from the geomorphic data collection through design and into construction

05-11 **Fisheries Habitat Compensation – Stream Restoration Design Pacific North West**

Michael Geenen*, Stantec, Michael.Geenen@stantec.com

David Bidelspach, Stantec

The South Fraser Perimeter Road (SFPR) project is a new four-lane highway that runs along the south side of the Fraser River in British Columbia. Approximately 40km long, the roadway is part of a Gateway Program to deal with the development in response to the impact of growth in the Greater Vancouver area. As part of the new roadway and alignment, the Canadian Environmental Assessment Act (CEAA) requires that there be no significant adverse impacts as a result of the project. Currently, Compensation is being completed to offset and replace fish and riparian habitat that is being altered, disrupted or lost during the construction of the road. The compensation areas are meant to enhance, restore or create habitat in areas where the existing habitat has been lost, degraded or never existed. As part of DFO's guiding principle of "No Net Loss" of fish habitat, which leads into their policy objective of a net gain of habitat whenever habitat compensation is required. Though Natural Channel Design Stream Restoration approach compensation is being performed that ties Habitat Pond features for juvenile fish habitat to the channel. This presentation will go over the process from assessment of the sites though design and construction. The presentation will also go over a site from Segment 8 that was design and constructed in September of 2011 using Natural Channel Design to show the benefits of the habitat ponds and how addressing the streams dimensions and profile can directly relate towards the functions and success of the ponds.

06-01 **Climate change effects on stream and river temperatures across the northwest U.S. from 1980–2009**

Dan Isaak*, USFS, disaak@fs.fed.us

Sherry Wollrab, USFS

Dona Horan, USFS

Gwynne Chandler, USFS

Thermal regimes in rivers and streams are fundamentally important to aquatic ecosystems and are expected to change in response to climate forcing as the Earth's temperature warms. Description and attribution of stream temperature changes are key to understanding how these ecosystems may be affected by climate change, but difficult given the rarity of long-term monitoring data. We assembled 18 temperature time-series from sites on regulated and unregulated streams in the northwest U.S. to describe historical trends from 1980–2009 and assess thermal consistency between these stream categories. Statistically significant temperature trends were detected across seven sites on unregulated streams during all seasons of the year, with a cooling trend apparent during the spring and warming trends during the summer, fall, and winter. The amount of warming more than compensated for spring cooling to cause a net temperature increase, and rates of warming were highest during the summer (raw trend = 0.17°C/decade; reconstructed trend = 0.22°C/decade). Air temperature was the dominant factor explaining long-term stream temperature trends (82–94% of trends) and inter-annual variability (48–86% of variability), except during the summer when discharge accounted for approximately half (52%) of the inter-annual variation in stream temperatures. Seasonal temperature trends at eleven sites on regulated streams were qualitatively similar to those at unregulated sites if two sites managed to reduce summer and fall temperatures were excluded from the analysis. However, these trends were never statistically significant due to greater variation among sites that resulted from local water management policies and effects of upstream reservoirs. Despite serious deficiencies in the stream temperature monitoring record, our results suggest many streams in the northwest U.S. are exhibiting a regionally coherent response to climate forcing. More extensive monitoring efforts are needed as are techniques for short-term sensitivity analysis and reconstructing historical temperature trends so that spatial and temporal patterns of warming can be better understood. Efforts are also needed to develop a comprehensive regional stream temperature database and temperature model that could facilitate more precise climate vulnerability assessments and prioritization strategies. Such strategies will be needed as continued temperature increases this century place increasing stress on important regional salmon and trout populations and make efforts to conserve these species more difficult.

06-02 **Scour power: potential climate change risks for incubating salmonids in the Middle Fork Salmon River, Idaho**

Jaime Goode*, Center for Ecohydraulics Research, University of Idaho, jaimeg@uidaho.edu

John Buffington, US Forest Service, Rocky Mountain Research Station

Daniel Isaak, US Forest Service, Rocky Mountain Research Station

Daniele Tonina, Center for Ecohydraulics Research, University of Idaho

Russell F. Thurow, US Forest Service, Rocky Mountain Research Station

Seth Wenger, Trout Unlimited

David Nagel, US Forest Service, Rocky Mountain Research Station

Charlie Luce, US Forest Service, Rocky Mountain Research Station

Salmonid embryos incubating within streambed sediments may be at risk to climate-driven shifts in the frequency, magnitude and timing of streamflow. Potential risk is expected to vary by species and life history type as a result of differences in egg burial depths, spawning periods, and locations of spawning sites within a river network. We investigated this issue for three salmonid species in the Middle Fork Salmon River, central Idaho: spring/summer Chinook salmon (Oncorhynchus tshawytscha), summer steelhead (O. mykiss), and resident and migratory bull trout (Salvelinus confluentus). To assess relative risks, we develop species-specific predictions of the probability of critical scour during respective incubation periods at known or predicted spawning reaches. Potential spawning reaches were predicted from geomorphic variables (slope, width, median grain size) at observed spawning sites. Scour probability for historic and future flow regimes were predicted by coupling digital elevation models with empirical predictions of grain size and bankfull geometry measured at 120 channel reaches throughout the basin. Historic and future flow regimes were derived from the Variable Infiltration Capacity (VIC) hydrologic model (Liang et al., 1994) at a scale of 1/16th degree cells. Future discharges represent ensemble Global Climate Models (GCMs) under an A1B emission scenario for the 2040s and 2080s. For all flow scenarios, the scour risk for late summer/fall spawning Chinook salmon is low (<30% probability of scour to egg burial depths). In contrast, scour risk predictions are higher for both fall-spawning bull trout and spring-spawning steelhead. We address how factors such as spawning location, incubation timing, adult body size, and egg burial depth may have influenced our scour risk predictions. Finally, we discuss how intra-species diversity and species plasticity to altered habitats may affect our scour risk predictions. Our framework for assessing risk is easily generalized to other basins using downscaled GCMs, digital elevation models, and site-specific field measurements of channel and habitat characteristics for model calibration.

06-03 **Effects of climate change on physical habitat of unconfined low-gradient mountain streams**

Jim McKean*, US Forest Service, jmckean@fs.fed.us

Daniele Tonina, University of Idaho

Carolyn Bohn, US Forest Service

Russ Thurow, US Forest Service

Climate has strong effects on channel physical habitat through variations in flow and water stage. We have used extensive detailed stream bathymetry maps, to investigate two components of

mountain stream habitat that might be vulnerable to a varying climate: a) increased mid-winter scour of redd sites, and b) loss of off-channel habitat during declining low flows. The bathymetry was acquired with the Experimental Advanced Airborne Research Lidar (EAARL) in tributaries of the Middle Fork Salmon River. We used a 2D hydraulic model to examine the potential for scour in low gradient and unconfined channels at discharges ranging from normal winter low lows to near bankfull conditions. At even the highest flows, less than 20% of the surface area of spawning riffles was predicted to be mobile. In this landscape, alterations in flood timing due to climate change are unlikely to decrease the success rate of salmonid egg incubation by the mechanism of increased channel bed scour. The keys to this channel bed stability are the very low stream gradients (avg. 0.3%) and the lack of channel confinement, which prevents flow depths greater than at bankfull. Field measurements of very limited gravel bed load transport at near bankfull flows support the numerical modeling results.

In our study streams, critical salmon and trout rearing habitat is in off-channel areas of shallow, low-velocity water; typically semi-abandoned channel meanders in adjacent meadows. This habitat is still hydraulically connected to the main channel, depending on flow stage. Measurements at nearby gages indicate that average late summer and autumn low flows in these streams have declined by about 5% per decade over the prior 60 years and are predicted to fall further in the next century. We calculate the historic decline has caused a loss of 15-20% of off-channel habitat and predict a further 5% decline by 2100. Modern off-channel habitat along the 20 km of study streams is not uniformly arranged, even at high flows, and the habitat becomes more fragmented as flows decline. Further investigation is needed to understand the risk to fish populations from this reduction of rearing habitat during declining base flows.

06-04 **Bioenergetic calculations as a means of estimating and predicting changes to habitat quality for stream-dwelling salmonid fishes**

Ernest Keeley*, Idaho State University, keelerne@isu.edu

Freshwater ecosystems are being increasingly modified as a result of human activities and habitat alteration is often cited as a principal factor causing the decline of fish populations. Understanding how climate change will alter habitat conditions for stream fishes is perhaps one of the most elusive challenges for biologists because of the slow and chronic increases in temperature that are predicted to occur. Bioenergetic models offer an approach to assess how changes in primary habitat characteristics, such as temperature, may drastically alter the range of suitable habitat for fishes. In this study, I use bioenergetic calculations to estimate energy availability and the amount of suitable habitat for populations of stream-dwelling salmonids as a way of illustrating how temperature can influence habitat quality. Bioenergetic calculations can estimate habitat quality over the principal growing season for salmonids to determine how seasonal changes in habitat conditions may restrict the length of time when fish are able to capture and metabolize food sources. In addition to estimating habitat quality under ambient conditions, bioenergetic calculations can also be used to simulate changes under different scenarios of habitat alteration. As cool or cold-water species, predicted increases in temperature due to changing climate conditions may have significant impacts on the habitat conditions for

salmonid fishes. Bioenergetic models that estimate net energy intake rates offer an approach to estimate the profitability of stream habitat by calculating the energetic costs and benefits of foraging locations.

06-05 **How does river surface ice influence water temperature and fish energy use?**

Eriek Hansen*, University of Wyoming, eriek_hansen@hotmail.com

Frank Rahel, Program in Ecology, Department of Zoology & Physiology, University of Wyoming

Temperature variation in lotic ecosystems occurs at annual and diel temporal scales, and projected climate change will alter winter thermal conditions in rivers. Since fish are ectothermic and have limited dispersal capabilities, their responses to changes in temperature variation are limited. Prior to ice formation, river temperatures can fluctuate from 0-6°C on a diel basis. After ice formation, temperatures remain constant near 0°C. In the Northern Hemisphere, climate change is projected to reduce the duration of surface ice-cover in aquatic ecosystems. We conducted a laboratory experiment to evaluate fish energy use among three temperature regimes simulating: ice-cover (i.e., low temperature variation 0.5 °C), ice-free conditions (i.e., diel cycling temperatures 0 - 6 °C), and the mean of the cycling temperature (3.0 °C). We compared cool water (creek chub; Semotilus atromaculatus), and cold water (brook trout; Salvelinus fontinalis) temperature guilds. Fish were fasted for 60 days during which we monitored the dry, water, and lipid mass of each species. We found no significant differences in the dry, water or lipid mass among treatments for either species. Similarly there were no differences between the species within a temperature treatment. This pattern is similar to that observed in Atlantic salmon (Salmo salar) held at cycling versus mean temperature regimes. These results indicate that differences in temperature variation created by the presence or absence of surface ice-cover do not affect the overall energy use by fish.

06-06 **Effects of climate change on thermal habitat for native and nonnative salmonids: looking across multiple scales in a mountain-valley stream network**

Shane Vatland*, USGS-Northern Rocky Mountain Science Center, USGS-MT Coop Fisheries Research Unit, Montana State University-Bozeman, svatland@gmail.com

Robert Gresswell, USGS-Northern Rocky Mountain Science Center

Climate in the western United States is expected to become warmer and more variable during the next century, and concurrent demands for watershed resources are expected to increase. Accordingly, understanding how changes to broad-scale factors (such as climate) and local-scale factors (such as land use) affect local aquatic ecosystems has become a fundamental concern for fisheries ecologists and managers. In addition, a majority of salmonid populations in the western

United States currently persist in fragmented stream networks, and these coldwater fish may be particularly vulnerable to changes in thermal habitat. In this study, we assess the availability of suitable summer stream temperatures for native (Arctic grayling and mountain whitefish) and nonnative salmonids (brown trout, brook trout and rainbow trout) in a mountain-valley stream network. Past climate and stream monitoring data were collected to assess trends in summer air temperature, stream discharge, and stream temperature. To evaluate the present extent of suitable thermal habitat, stream temperatures were surveyed with a combination of remote sensing (thermal infrared-TIR), continuous longitudinal temperature profiling, and fixed-station water temperature loggers. TIR imaging and continuous longitudinal profiling were effective methods for evaluating explicit spatial patterns in temperature data at multiple spatial scales, and fixed temperature loggers enabled an explicit evaluation of temporal variation in stream temperature. Using this combination of data, we characterized the distribution of thermally suitable habitat during the summer and identified associated habitat attributes. Suitable thermal habitat was patchily distributed throughout the study area, and cold-water tributaries likely provide critical cold-water thermal refugia. These spatially and temporally explicit thermal data were incorporated into statistical stream temperature models, and future changes in thermal habitat were assessed based on regional climate change predictions. Under scenarios of increasing and more variable summer air temperatures, we predicted a significant increase in the occurrence of stream temperatures that exceed chronic and acute thermal tolerance thresholds for salmonids. Evaluating spatial patterns in observed and predicted stream temperatures allowed us to identify areas critical to maintaining suitable coldwater habitat in the future.

06-07 **Can warmwater fish track climate change? Identifying potential limits to range expansions in rivers**

Dan Gibson-Reinemer*, University of Wyoming, dgibsonr@uwyo.edu

Frank Rahel, University of Wyoming

Ryan Fitzpatrick, Colorado Division of Parks and Wildlife

Globally, species have responded to climate change by shifting their ranges to higher latitudes or elevations, but river fishes may not show the same pattern. For river fishes to track climate, they must be able to shift their ranges upstream; however, substantial differences in the physical habitat of upstream reaches may prevent some species from successfully tracking climate. This decoupling of thermal and physical habitat may restrict climate-induced range shifts in river fishes, particularly where strong longitudinal gradients in physical habitat exist (e.g., transition zone streams). We examine how physical habitat may limit the upstream range expansion of the relatively species-rich warmwater fish assemblages near transition zones. The current distribution of fishes in rivers on the eastern slope of the Continental Divide may serve as a surrogate for future range expansions. We present preliminary evidence that habitat decoupling will restrict the ability of warmwater river fishes to shift ranges in response to rising temperatures.

06-08 **Evaluating the factors associated with the distribution of Yellowstone cutthroat trout: a rangewide analysis**

Robert Al-Chokhachy*, U.S. Geological Survey, ral-chokhachy@usgs.gov

Bob Gresswell, U.S. Geological Survey

Brad Shepard, Wildlife Conservation Society

Steve Hostetler, U.S. Geological Survey

Understanding the factors associated with the current distribution of Yellowstone cutthroat trout is an imperative step in the design and implementation of future conservation and management strategies, particularly given emerging potential stressors associated with regional climate change. Despite substantial interagency effort to develop rangewide status assessments for Yellowstone cutthroat trout, however, these data have not been used to investigate the physical and biological factors that influence the current distribution of the subspecies. To address this need, we developed a stream temperature model for the range of Yellowstone cutthroat trout, and then use this model to predict total growth rates of Yellowstone cutthroat trout. Next, we use multiple modeling approaches to better understand how landscape attributes, natural and anthropogenic disturbance, and climate are associated with the distribution of Yellowstone cutthroat trout. The results from our modeling suggest disturbance, land use, land cover, and climate as the strongest predictors influencing the distribution of Yellowstone cutthroat trout. The impacts of climate varied considerably across how we characterized summer growing season; our results describing factors influencing the distribution of Yellowstone cutthroat trout were consistent across the different models. We place our results in the context of anticipated climate changes in the Greater Yellowstone Ecosystem as a means to highlight how these factors may change in the future. Overall, our results provide insight into the factors associated with Yellowstone cutthroat trout distribution, highlight potential gaps in currently available data, and can help direct conservation strategies for this native cutthroat trout in the near future.

06-09 **Accounting for uncertainty in species predictions under climate change: an example using bull trout**

Seth Wenger*, Trout Unlimited, swenger@tu.org

Daniel Isaak, Rocky Mountain Research Station

Helen Neville, Trout Unlimited

Charlie Luce, Rocky Mountain Research Station

Ongoing climate change is expected to alter the distribution of many organisms, including coldwater fish species such as trout. Scientists use species distribution models to better understand how species ranges may shift under future conditions and commonly produce presence/absence maps of future suitable habitat. All such predictions are subject to significant

uncertainties but predictions within certain portions of a species range may be more uncertain than others, and this uncertainty is rarely characterized. Here we introduce methods to describe and propagate the uncertainty associated with forecasts of future species occurrence probabilities, yielding site-specific probability distributions of occurrence. We illustrate the methods with bull trout (Salvelinus confluentus) in a portion of the interior Columbia River Basin in Idaho and Montana. We account for uncertainty within species models, across species models, and under different greenhouse gas emissions scenarios. Our results indicate high probabilities of bull trout declines across most of the range examined, with a 95% probability that total suitable habitat could decline by 88% by 2080 under the A1B emissions scenario. This surprisingly high certainty is due to the fact that bull trout in the region appears to be living close to the limits of its suitable climate conditions, such that even small amounts of warming are likely to cause large contractions in the species' range. However, there is considerable spatial variability, and certain localities are likely to serve as climate refuges for bull trout.

06-10 **WHERE'S THE BEEF? Why 20 Years of Predicted Global Warming Effects on Fish Distributions Remain Unsubstantiated**

Dan Isaak*, USFS, disaak@fs.fed.us

Bruce Rieman, USFS (retired)

Environmental changes associated with anthropogenic climate change are predicted to substantially degrade global biodiversity during the 21st century. This concern motivated development of numerous bioclimatic models during the last 20 years to forecast potential effects on stream fishes. Despite generally dire forecasts for many species of concern and significant resource commitments to maintaining these species, biological validation of predictions has rarely occurred and the accuracy of forecast declines is unknown. Moreover, validation is difficult because current bioclimatic models yield predictions that are either untestable or so imprecise that definitive answers will not be obtained within timescales useful for many management decisions (e.g., 10 - 20 years). Here, we develop a general framework for making stream-specific predictions of isotherm shift rates (ISRs) based on a key assumption inherent to all bioclimatic models: that a critical temperature isotherm delimits population and species boundaries and that biological distributions will track these isotherms moving to higher elevations or latitudes as the climate warms. Implementing the framework on individual streams requires only stream slope measurements from a GIS and easily collected biological and temperature survey data. Generic ISR curves developed for streams with lapse rates (~0.4 °C/100m elevation gain) and long-term warming rates (~0.1 – 0.2 °C/decade) observed in the Rocky Mountain region suggest isotherms are currently shifting at 1 – 10 km/decade and will move 4 – 40 km by the year 2050. Fish populations and species with greater mobility or large ranges may be able to adjust their distributions and track suitable isotherms if migratory corridors are not blocked, but other fishes will be vulnerable to temperature changes. Headwater populations with < 10 km of thermally suitable habitat that lack elevational refugia are at greatest risk and could be extirpated by 2050 as warming continues. A power analysis suggests the ability to detect trends in biological distributions will be greatest where ISRs are largest and streams

exhibit low inter-annual temperature variance, but even in optimal areas, monitoring for a minimum of 20 years may be required for trend detection. Although initiation of new monitoring efforts will be useful, resurveys of historical fish survey sites should be a priority to determine the rates at which biological distributions are shifting. Documenting these shifts is critical information for developing more accurate climate risk assessments and for providing managers the evidence needed to make difficult decisions regarding where resources are committed to preserve populations.

06-11 **Questioning Chicken Little: An empirically-based evaluation of shifts in bull trout migration timing in response to climate trends from 1978-2011**

Russ Thurow*, USDA-Forest Service Rocky Mt Research Station, rthurow@fs.fed.us

Dan Isaak, USDA-Forest Service Rocky Mt Research Station

John Guzevich, USDA-Forest Service Rocky Mt Research Station

Gwynne Chandler, USDA-Forest Service Rocky Mt Research Station

Within the Columbia River basin, future climate predictions suggest warming of about 2oC in mean annual or seasonal air temperatures over the next 50 years. Time trends have already documented substantial increases in water temperatures, important changes in the timing and magnitude of runoff, and changes in seasonal stream flows. Based on most modeling results and historical relationships, a changing climate is predicted to negatively affect many native coldwater fishes through effects on phenology, distribution, abundance, and persistence. Despite dire model predictions, empirically-based validation of biological predictions is rare so the accuracy of model forecasts for native fishes is unknown. Bull trout (Salvelinus confluentus) are excellent fish to assess climate affects because they have very specific habitat requirements and their optimal temperatures are substantially colder than most salmonids. In this paper, we examine a 33 year database of bull trout pre-spawning migration timing to assess possible phenologic shifts in response to climate trends. The long-term database contains a daily trap count of the number of adult bull trout annually entering a 4th order central Idaho stream from 1978-2011. More than 7,780 bull trout entered the drainage during the 33 year trapping period. We applied a series of metrics including: date of first fish, 25th percentile, median fish, 75th percentile, and date of last fish to assess migration timing. Finally, we compared the timing of bull trout migrations to trends in air and water temperatures and streamflow over the same 33 year period. We discuss whether changes in phenology have occurred and attempt to interpret the potential effects of these changes on bull trout life history and persistence.

06-12 **Sculpin as a model for climate change: Longitudinal changes, isolation and population extirpation of sculpin species in the upper Clark Fork drainage of Montana**

David Schmetterling*, Montana Fish, Wildlife and Parks, dschmetterling@mt.gov

Susan Adams, USDA Forest Service, Southern Research Station

Rocky Mountain sculpin (Cottus sp. cf. bairdii), slimy sculpin (C. sp. cf. cognatus)and longnose dace (Rhinichthys cataractae) are sympatric in the upper Clark Fork drainage of Montana. Each species' occurrence is dictated by stream temperatures. Sculpins are segregated by temperature, and they only occur syntopically over a very narrow range longitudinally. Wheras the mechanism for their allotopy is unclear and may be a result of behavioral interactions, temperatures strongly dictate each species distribution. Although longnose dace are also sympatric, they tolerate warmer water than both sculpins, when syntopic with Rocky Mountain sculpin, they occupy different habitats. Since 2001 we have been monitoring the distribution of species within stream in different zones: allotopic and syntopic. While stream temperatures have risen, we have detected the retreat of slimy sculpin, the contraction of the Rocky Mountain sculpin and even population extirpation. Dace seems to be replacing Rocky Mountain sculpin, and compared to the historic distribution from records in the early 1980's, dace have largely replaced Rocky Mountain sculpin in the Clark Fork and Bitterroot rivers. Although dace and sculpin are numerous, small- bodied, and largely confined to the benthos, they occupy different trophic positions, and perform different ecological roles. Both species are sympatric with endangered species like the bull trout (Salvelinus confluentus), whose populations are targets for protection, mitigation, and enhancement. It is unclear the effects of the replacement of sculpin by longnose dace, but since they represent the basis of the food chain for higher trophic order organisms, this change could ultimately could affect the restorative potential of the systems for target species. Furthermore, warming and species replacement may lead to a further homogenization or regional distinctive ecotones and fauna.

06-13 **Impacts of climate change and wildfire on bull trout (Salvelinus confluentus) in the Bitterroot River Basin, Montana**

Olga Helmy, University of Montana

Lisa Eby*, University of Montana, lisa.eby@umontana.edu

Mike Young, Rocky Mountain Research Station, USDA Forest Service

Lisa Holsinger, RMRS, Fire Sciences Laboratory

Mike Jakober, Bitterroot National Forest

Climate trends apparent across the Rocky Mountain region include warmer air temperatures, earlier dates for peak snowmelt, and more winter precipitation coming as rain. These factors often result in lower summertime base flows and warmer summertime water temperatures. Additionally, wildfires in the western U.S. have been more pervasive in recent years and climate change is expected to increase their severity and frequency, further affecting aquatic systems. Many tributaries within the Bitterroot River Basin have experienced general warming over the last several decades with stream temperatures increasing 0.2-0.3°C in unburned streams. In addition, a complex of wildfires burned 22% of the Bitterroot National Forest during summer

2000. Some of these watersheds had severe fires in the riparian zone resulting in maximum stream temperatures that have been elevated 1.5-2.0°C over reference streams for the last decade. In 2010 and 2011, we revisited 78 sites in tributaries of the East Fork Bitterroot River which had been previously sampled in 1993-1995 by Rich et al. (2003) to investigate differences in the occurrence of bull trout associated with these water temperature changes. We replicated his field sampling approach to detect bull trout presence. Using Program Presence, we estimated changes in bull trout occupancy between time periods considering large woody debris, temperature, elevation, brook trout presence, and fire as covariates. Elevation and temperature were correlated so were not included in the same model, but competing models. Local extinction rates were greater at low elevation sites (versus high) and in the presence of brook trout. In contrast, persistence was not substantially influenced by the presence of wildfire. Moreover, long-term data from 2000 to the present to explore changes in the fish assemblages in drainages across a range of wildfire conditions confirmed the general resilience of bull trout to wildfire.

07-01 **Limiting Factors for Trout in the Upper Clark Fork River Superfund Site, Montana: Survival, Movement, and Habitat Use**

Mariah Mayfield*, Montana State University, mariah.mayfield@gmail.com

Thomas McMahon, Montana State University

Jay Rotella, Montana State University

Robert Gresswell, USGS Northern Rocky Mountain Science Center

Large-scale heavy metal contamination of the upper Clark Fork River from mining deposits has created significant damage to aquatic habitat in the drainage. Trout are present in the system, with abundances lower than expected. The objectives of this study were to identify critical habitat areas and to identify conditions continuing to limit both native and non-native trout populations, with the focus on the lingering environmental effects caused by high heavy metal concentrations. Radiotelemetry of 269 brown trout Salmo trutta, westslope cutthroat trout Onchorhynchus clarkii lewisi, rainbow trout O. mykiss, cutthroat/rainbow hybrids, and bull trout Salvelinus confluentus from 2009 to 2011 was used to determine seasonal movement and survival in relation to heavy metals and other environmental factors, and to identify critical spawning and seasonal rearing areas. Survival analysis, using Program MARK, estimates that salmonids experience the highest mortality rates during the spring and summer months in the upper reaches of river and tributaries. Elevated mortality rates in the spring and summer may indicate fish reactions to poor water quality, such as increased heavy metal concentrations and water temperatures. Annual brown trout survival rates are estimated at 0.28 (95% confidence interval between 0.19 and 0.38) in the most contaminated reach and at 0.56 (95% confidence interval between 0.43 and 0.69) in the least contaminated reach. We observed very little movement of trout, except in relation to spawning migrations. The results from this study will help to identify areas in need of remediation for all species of trout.

07-02 **Monitoring the post-remediation recovery of aquatic biota in the Boulder River Watershed, Jefferson County, Montana.**

David Harper*, USGS CERC, david_harper@usgs.gov

Aida Farag, USGS CERC, JFRS

The Boulder River watershed in Jefferson County, Montana, contains elevated concentrations of arsenic (As), cadmium (Cd), copper (Cu), lead (Pb), and zinc (Zn) in water, sediment, and aquatic biota from historic mining activity. Abandoned mine and stream channel reclamation and remediation projects were conducted in several affected tributary streams from 1997 to 2002. To assess potential recovery, we investigated three types of parameters 1.) measured concentrations of As, Cd, Cu, Pb, and Zn in water, biofilm and macroinvertebrates, 2.) assessed macroinvertebrate assemblage and aquatic habitat quality 3.) conducted in situ survival experiments with juvenile cutthroat trout. The methods and sites were similar to the initial assessment of the site in 1997 and the first monitoring effort in 2003. When compared to previous years, biofilm and invertebrate metal concentrations significantly decreased at many tributary sites in 2009. Biofilm collected from the lower Boulder River contained significantly lower concentrations of all metals measured when compared to previous years. Metal concentrations in biofilm and invertebrates remained significantly elevated when compared to upstream reference sites for at least one metal at multiple sites. Invertebrate assemblages remains impacted at several downstream locations (as defined by number of families/site), but appear to be recovering compared to samples collected in 2003. Survival of cutthroat trout during in situ experiments was still reduced at 2 of 5 sites, but was improved at 2 of 5 sites compared to experiments conducted in 1998 and 1999. However, higher stream discharge and dilution of mine effluent may have contributed to the higher survival in 2009 when compared to previous years.

07-03 **Status of Fish Populations in Annie Creek near Lead, South Dakota Following Release of High Biological Oxygen Demand Waters**

Jeniffer Lynch*, GEI Consultants, Inc., jlynch@geiconsultants.com

Lee Bergstedt, GEI Consultants, Inc.

Aquatic populations have been monitored at three sites on Annie Creek near Lead, South Dakota since 1992 to determine if historical and current mining activities in the headwaters of this stream are impacting the aquatic communities. Over this time period, some exceedances of surface water criteria have occurred, most recently for cyanide, ammonia, and BOD. The source of the ammonia and BOD were from a permitted biological water treatment facility installed to treat selenium. The source of the cyanide is as yet unknown. The upstream monitoring site on Annie Creek does not support a fish population as it is located in the headwaters upstream of perennial fish habitat, with waterfalls present downstream that prevent fish moving upstream

from lower reaches. At the second monitoring site on Annie Creek less than 1 km downstream, a small population of mountain suckers has been discontinuously present throughout the study. Following the last major BOD event in 2007, a year in which a high flow event also occurred, mountain suckers have been rare or absent at this site. New treatment technologies were employed to rectify the water quality issues in response to the BOD event, but these fish may have temporally moved downstream of the study reach. Barriers present in the most downstream reaches of Annie Creek and the apparent lack of any upstream sources of fish may be continuing to limit recovery of this population. The most downstream monitoring site on Annie Creek is located approximately 2.6 km from the upstream site, and has supported a healthy trout population throughout the study period. The dominant trout species, as measured by biomass, shifted from brown trout in 2001 and 2002 to brook trout in all years since then. Brook trout density has shown an increasing trend since 2001, with little evidence of any effects on the trout populations from the BOD event in 2007. Brook trout density was only slightly lower in 2007 through 2009 than in 2006, and then peaked in 2010. Brook trout biomass increased steadily in 2004 through 2007, and has remained high since then, also peaking in 2010.

07-04 **Recovery of a mining-damaged stream ecosystem**

Christopher Mebane*, U.S. Geological Survey, cmebane@usgs.gov

The environmental science literature is replete with case studies of stream ecosystems damaged by pollution, but fewer case studies are available with long-term data on the recovery from effects of pollution. Panther Creek, a tributary to the Salmon River in central Idaho, is one such case with a 30-year period of record from about 1980 through 2010. Panther Creek suffered intensive damage from large-scale mining and milling operations in the Blackbird Mining District, primarily from the late 1940s to 1967. The mine drained to two tributaries of Panther Creek, Blackbird Creek and Big Deer Creek, contaminating the streams with copper, arsenic, and cobalt, as well as altering the physical channel.

From the 1960s through 1980s, no fish and few aquatic insects could be found in mine-affected sections of Panther Creek. By the early 1990s, copper concentrations had attenuated to the point that some natural production of rainbow trout occurred. However, Chinook salmon and resident fish other than rainbow trout remained rare. Species richness of aquatic insects was about half that of reference sites, and mayflies were absent or rare.

Concerted efforts to reduce mine contamination began in 1995, and by 2002 copper levels had been reduced by about 90%. As of 2010, resident fish populations in mining-influenced reaches appeared to have recovered, relative to reference reaches. Rainbow trout were early colonizers, quickly expanding their range as areas became habitable. Sculpin appeared slower to disperse and colonize; but they appeared to recover about four years after their first detections. Macroinvertebrate richness in Panther Creek sites downstream of Blackbird and Big Deer Creeks appears to have plateaued at about 70 to 90% of reference. Total abundances of mayflies in locations downstream of mine influences are as high as or higher than at reference locations. However, mayfly diversity remains lower than reference, and Heptageniids and Ephemerellids remain rare. These patterns raise questions of what it means for an ecosystem to be “recovered.”

For example, if benthic macroinvertebrates provide a sufficient food base for fish populations, is the ecosystem sufficiently recovered? Or would all major ecosystem components need to be similar to reference?

07-05 **NEPA and Energy Development**

Leanne Roulson*, HydroSolutions Inc, leanne.roulson@msu.montana.edu

Energy development across the west is rapidly expanding on both public and private lands. Developments on public lands receive environmental reviews, but the technical aspects of oil and gas are often difficult to assess for biologists. We hope to provide information on what sorts of potential impacts are commonly of concern, and examples of how agencies, states, and Tribes have set up mitigations to avoid or prevent them.

07-06 **The Potential Effects of Coalbed Natural Gas Produced Waters on Aquatic Resources**

Aïda Farag*, USGS, aida_farag@usgs.gov

David Harper, USGS

Don Skaar, MFWP

Trevor Selch, MFWP

Within the Powder River basin, Montana and Wyoming, estimated Coalbed Natural Gas (CBNG) product water has increased from several thousand cubic meters per day in the late 1990s, to hundreds of million cubic meters per day in 2007. Product water may be discharged into watersheds increasing stream flows and converting ephemeral watercourses to perennial streams; but it is also injected into deep wells, discharged to drip irrigation systems, and captured in evaporation ponds. The USGS CERC in collaboration with Montana Fish, Wildlife, and Parks has been studying the effects of CBNG produced water on aquatic resources since 2002. This project included laboratory experiments with 13 species of aquatic organisms and plants, field in situ experiments, and a field mixing zone study. Effects on acute mortality were documented in addition to chronic growth and reproductive effects along with mechanistic studies of physiological parameters. The goal of this work has been realized with the development of a database that can be used to define water quality criteria for sodium bicarbonate, a principal component of produced water in the Powder River Basin. Regardless of whether these data are used to establish criteria, the data provide management agencies and industry the science necessary on which to base their decisions regarding treatment and discharge options. Though this investigation focuses on the Tongue/Powder River basin, the information is applicable to other watersheds where sodium bicarbonate is a principle component of product water either from CBNG or from traditional oil and gas development. These data are also timely as they can

be used to separate effects of saline discharges from those potentially posed by the recent advances in hydraulic fracturing technologies. Finally, we hope that this research effort and the additional collaboration with USGS Water Resources and Mapping, Bureau of Land Management, US Environmental Protection Agency, State of Wyoming, University of Wyoming, Montana State University and others as part of a Powder River Aquatic Task Group, can be used as a model for successful approaches to studying landscapes with energy development.

07-07 **Fish community associations and thresholds with existing and projected oil and gas development, Colorado River Basin, Wyoming**

Daniel Dauwalter*, Trout Unlimited, ddauwalter@tu.org

Energy development has accelerated recently in the United States and has the potential to impact aquatic resources. I evaluated how fish communities are associated with existing and projected oil and gas development in the Colorado River Basin, Wyoming. Fish community structure was significantly associated with oil and gas well densities, but well densities explained only 6.4% of community structure when compared to other environmental factors such as stream size, stream gradient, and road densities. Threshold Indicator Taxonomic Analysis showed significant negative community threshold responses to small levels of oil and gas development (<0.15 wells km-2), whereas positive thresholds were less distinct. Flannelmouth sucker, bluehead sucker, and roundtail chub could be disproportionately affected if future oil and gas development proceeds in an unrestricted and injurious way. Although existing development has not substantially influenced regional fish community structure, it appears to affect certain members of the community. Understanding community-level responses and thresholds to development can help land managers determine appropriate development levels, prioritize areas for monitoring associated with development, and identify where land protection measures may be needed to offset potential risks.

08-01 **Bull Trout, Tribal People and the Jocko River**

Germaine White*, Confederated Salish & Kootenai Tribes, germainew@cskt.org

In an effort to benefit bull trout in the Jocko River drainage, the Confederated Salish and Kootenai Tribes have undertaken a large-scale watershed restoration project, they have also created an illustrated storybook Bull Trout's Gift, field journal Snqeymintn, and interactive DVD, Explore the River: Bull Trout, Tribal People and the Jocko River, and a curriculum, Explore the River: Integrated Multimedia Curriculum Frames by the Cultural Values of the Salish and Pend d’ Oreille People to spotlight the importance of bull trout and its relationship with the Salish and Pend d' Oreille people.

09-01 **Use of large, deep-water trap nets to combat lake trout in Yellowstone Lake**

Patricia Bigelow*, US National Park Service, pat_bigelow@nps.gov

Todd Koel, US National Park Service

Yellowstone National Park has been battling lake trout in Yellowstone Lake with an impressive gill net operation for over ten years in an endeavor to reduce this non-native, predacious fish which is threatening the native Yellowstone cutthroat trout. Despite this work, the lake trout population was continuing to expand as recently as 2009. In order to increase resources dedicated to lake trout removal, the park contracted additional fishing, using commercial-scale techniques, through the private industry. Along with gill nets, this group used large (20 to 40 ft tall), deep-water trap nets to capture lake trout. Although gillnetting removed a greater number of lake trout, trap nets appear to be more efficient at catching large, female lake trout. In 2011, large-mesh gillnets (1.75-4.5 inch bar mesh) captured 13,783 lake trout in 36 days of lifting nets while trap nets caught 10,962 lake trout in 38 days of fishing. However, trap net catches were 528 mm total length and were 56% female, whereas gillnet catches averaged 475 mm total length and were 43% female. Seven of the eight trap nets used caught more females and larger females than males. This apparent ability of trap nets to better target a different segment of the population than gill nets emphasizes the importance of the use of multiple gears in non-native fish suppression work.

09-02 **Comparison of fish abundance estimates made from two- and three-pass electrofishing data**

Nora Burbank*, GEI Consultants, nburbank@geiconsultants.com

Don Conklin, GEI Consultants, Inc

Lee Bergstedt, GEI Consultants, Inc

Stream fish population sizes are often estimated using a maximum-likelihood estimator based on the number of fish caught in multiple electrofishing passes through a reach. Three electrofishing passes are often made in a stream reach and all fish collected in each pass are weighed, measured for length, and returned to the stream once all passes have been completed. Although this method is popular, electrofishing passes are time consuming and can result in handling stress and/or electrofishing injury to the fish collected. The abundance of fish can also be calculated using two electrofishing passes, which saves time and may subject fewer fish to the handling stress and potential electrofishing injury associated with capture and reduce holding times. We estimated the abundance of trout collected in streams in the Black Hills in South Dakota streams using two-pass and three-pass depletion data and a maximum-likelihood estimator. Population estimates were similar between the two-pass and three-pass data, but the 95% confidence interval surrounding the estimates of population size based on two-pass electrofishing was always greater than the estimates based on three-pass electrofishing. The choice between using two or three-

pass electrofishing to estimate stream fish population size should be dependent upon study objectives.

09-03 **Using horizontal acoustic beaming to evaluate cutthroat trout population size in backcountry lakes**

Kevin Rogers*, Colorado Parks and Wildlife, kevin.rogers@state.co.us

Adam Hansen, University of Washington

Christopher Kennedy, USFWS

Bruce Rosenlund, USFWS

As part of greenback cutthroat trout recovery efforts, lacustrine populations require periodic monitoring mandated by the U. S. Fish and Wildlife Service's Recovery Plan. These monitoring efforts are required to determine if populations are large enough to be considered viable. Species listed under the Endangered Species Act, like the greenback cutthroat trout, present unique sampling challenges as incidental take commonly incurred with traditional sampling gear is often unacceptable. Hydroacoustic sounding systems provide fishery managers a noninvasive rapid assessment tool to evaluate population size. Traditional hydroacoustic assessments are conducted off large vessels with down-looking transducers ideally suited for monitoring pelagic fish that inhabit depths greater than 10 m. Unfortunately, cutthroat trout are surface oriented and therefore not vulnerable to down-looking gear. In addition, many of the cutthroat trout lakes we are interested in surveying are found in remote Wilderness or National Park waters with not boat access. Using an inflatable pontoon boat and a pack string, we were able to transport a scientific grade horizontal beaming system into a half dozen remote backcountry lakes averaging 8.6 km from the nearest trailhead. Given their relatively small size (0.6-13.8 ha), we were able to census the upper three meters of the water column and generate population estimates that were then compared to estimates derived from mark-recapture experiments in the same lakes. Though population estimates generated through hydroacoustic side beaming were consistently lower than those generated with mark-recapture methods, they still provide valuable information. In the case of cutthroat trout, viability is measured as a function of a threshold population size. Since population estimates generated with side-beaming hydroacoustics are conservative, exceeding that threshold then ensures a given population meets viability criteria.

09-04 **Otolith weight as a predictor of age in kokanee salmon (Oncorhynchus nerka)**

Jesse Lepak*, Colorado Parks and Wildlife, Jesse.Lepak@state.co.us

C. Nathan Cathcart, Colorado Parks and Wildlife

Mevin Hooten, Colorado Cooperative Fish and Wildlife Research Unit

Estimating ages of individuals in fish populations is crucial for determining important characteristics necessary to effectively managing sport fisheries. Fish ages can be determined using a variety of fish hard parts including otoliths, scales, fin rays, and cleithra. Currently, the most widely accepted approach for age determination in fish is using thin sectioned otoliths for interpretation. This method is considered to be the most accurate, but is labor-intensive, and requires the interpreter to be well-trained and to determine age subjectively. There are several examples from the literature showing otolith mass increases with age, yet use of otolith weights to determine fish age is a relatively underutilized approach, with only one freshwater species example in the literature of which we are aware. However, determining fish age using otolith weight is an attractive method because it requires relatively little training, is non-subjective, and is much faster when compared to other fish aging techniques. We collected kokanee salmon (Oncorhynchus nerka) in 2004 from four Colorado reservoirs, and from 2000 to 2009 in one Colorado reservoir, to evaluate the efficacy of using otolith weights to determine kokanee salmon age. Our findings suggest that this method has the potential to significantly reduce the time and financial resources required to age fish. Additionally, the precision of this method can be increased through time, as more fish are sampled. We conclude that using otolith weights to determine the age of fish may represent an efficient and accurate approach, especially when the species of interest have characteristics (relatively rapid growth and short life spans) conducive to this method.

09-05 **Separating the Good, the Bad, and the Ugly: Using an In-Channel Fish Screen as a Fish Management Tool**

Lori M. Martin*, Colorado Parks and Wildlife, lori.martin@state.co.us

Screening of reservoir inlets and outlets is becoming more prevalent as a fish management technique. Colorado reservoirs draining into critical habitat for threatened and/or endangered fishes must have screened outlets in order for Colorado Parks and Wildlife (CPW) to be able to stock non-native, non-salmonid fishes. CPW recently completed construction of an in-channel fish migration barrier (6'3" wide by 7' long with a 0.02" aperture, wedge wire screen) downstream of Juniata and Purdy Mesa reservoirs in northwest Colorado (Mesa County). The goals of the project are to: 1) preclude non-native sport fish movement from the reservoirs into downstream habitat for native fishes; and 2) provide anglers with desired, non-salmonid sport fish species that cannot currently be stocked in these two reservoirs. Juniata and Purdy Mesa reservoirs primarily serve as municipal water supplies, but both also deliver irrigation water to downstream agricultural users. These reservoirs are managed by CPW as mixed non-native, sport fisheries, providing warm water angling opportunities for largemouth bass (Micropterus salmoides) and bluegill (Lepomis macrochirus), and seasonal stocking of catchable rainbow trout (Oncorhynchus mykiss). Smallmouth bass (Micropterus dolomieu) and walleye (Sander vitreus) are also available to anglers, as a result of illicit stocking. The largemouth bass and bluegill populations have self-sustained since the initial stockings in the late 1970s, early 1980s. CPW is currently limited to stocking only salmonids into Juniata and Purdy Mesa reservoirs, as salmonid species are not considered a primary threat to native fishes downstream, including listed and non-listed species. CPW is working with anglers and other stakeholders to develop a Lake

Management Plan for approval by the U.S. Fish and Wildlife Service, and States of Utah and Wyoming. CPW cannot legally stock fish species other than salmonids into Juniata and Purdy Mesa reservoirs until such a plan is approved. This presentation will focus on the wedge wire screen design and criteria, construction process, and lessons learned from the fish migration barrier project at Juniata and Purdy Mesa reservoirs.

09-06 **New tools for high resolution mapping of stream bathymetry, aquatic habitat and floodplain topography**

Jim McKean*, US Forest Service, jmckean@fs.fed.us

Dave Nagel, US Forest Service

Philip Bailey, North Arrow Research Ltd

Carolyn Bohn, US Forest Service

Basic description of channel bathymetry and floodplain topography remains a fundamental challenge for aquatic habitat mapping, modeling flow and sediment transport, and analyzing linked aquatic-terrestrial processes. Standard field wading and boat surveys of stream topography are limited by costs and logistics to relatively small sample reaches and floodplain maps are seldom well-integrated with channel bathymetry. We have successfully tested the aquatic-terrestrial Experimental Advanced Airborne Research Lidar (EAARL) in shallow clear water streams and mapped, with high resolution and accuracy, the spatial distribution of in-channel and off-channel physical habitat over tens-of-kilometers of stream length. EAARL data also defined channel topographic boundary conditions sufficiently to support a 2D fluid dynamics model prediction of flow and sediment transport over kilometric-scale domains.

We have also developed the River Bathymetry Toolkit (RBT) to efficiently describe and analyze extensive channel high resolution digital maps derived from airborne sensors such as the EAARL or boat-mounted multi-beam sonars. The RBT is an Arc-based toolkit and freely available from a dedicated website. The toolkit includes a module to automatically extract hydraulic geometry metrics, such as width/depth ratio, from channel DEMs and display the information either at local cross sections or as they vary along the length of a stream. Development is ongoing to automatically map habitat units, such as pools-bars-riffles, and habitat complexity. A further module is near release that interrogates short field-surveyed channel reach DEMs.

We are using the combination of EAARL data and the RBT to investigate climate change effects on fish habitat, hyporheic exchange in a regulated river, and sand transport/deposition in a salmon bearing gravel-bed stream. New tools such as the EAARL and the RBT may potentially revolutionize mapping of streams and aquatic habitat and analyses of channel-floodplain biophysical processes.

09-07 **Multistate Modeling Approach for Analyzing Survival and Movement of Radio Frequency Identification (RFID) PIT Tagged Trout in Rivers**

Eric Fetherman*, Colorado Parks and Widlife, Eric.Fetherman@state.co.us

Dana Winkelman, Colorado Cooperative Fish and Wildlife Research Unit, Colorado State University

George Schisler, Colorado Parks and Wildlife

Larissa Bailey, Colorado State University

William Kendall, Colorado State University

Passive Integrated Transponder (PIT) tags allow individual identification, have an infinite life, are easily applied and well retained, and have minimal effects on growth and survival. Currently, stationary Radio Frequency Identification (RFID) PIT antennas are widely used to detect PIT tagged fish; however, estimating population parameters of interest, such as survival and movement, from RFID detections can be challenging. We describe a multistate modeling approach used to obtain estimates of apparent survival (S) and movement probabilities (ψ) for brown trout and rainbow trout populations in the Cache la Poudre River, Colorado. This approach was used to estimate the impact of brown trout removal on survival and retention probability of introduced whirling disease (WD) resistant rainbow trout. In one section of the river, we removed brown trout (removal section; 0.6 mile), and in a second section, located five miles downstream, we did not (control section; 0.8 mile). Brown trout upstream and downstream of the removal section, as well as upstream, within, and downstream of the control section, were RFID PIT tagged during removal operations. After removal, two thousand PIT tagged, WD resistant rainbow trout were stocked into both the removal and control sections. Paired RFID flat-bed loop antenna arrays, for determining directionality of movement, were deployed at the upstream and downstream ends of both sections (8 antennas) and were used to monitor movement of PIT tagged fish. We empirically estimated detection probability at several water depths and velocities using PIT tagged fish in hatchery raceways; detection probability was also estimated weekly for each antenna loop in the river. Using estimates of movement direction and assuming a detection probability of one, a detected individual could be assigned with certainty to a given transition state. However, situations where this assumption is not met and individual state uncertainty exists will also be discussed.

09-08 **Development and evaluation of a boat-mounted RFID antenna for monitoring freshwater mussels**

Travis Neebling*, Wyoming Game and Fish Department, travis.neebling@wyo.gov

Jesse Fischer, Iowa State University

Michael Quist, Idaho Cooperative Fish and Wildlife Research Unit

Development of radio frequency identification (RFID) technology and passive integrated transponder (PIT) tags has substantially increased the ability of researchers and managers to

monitor populations of aquatic organisms. However, use of transportable RFID antenna systems (i.e., backpack-mounted) is currently limited to wadeable aquatic environments (<1.4 m water depth). We describe the design, construction, and evaluation of a boat-mounted RFID antenna to detect individually PIT-tagged benthic aquatic organisms (mussels). We evaluated the effects of tag orientation on detection distances in water with a 32-mm half-duplex PIT tag. Detection distances up to 50 cm from the antenna coils were obtained, but detection distance was dependent on tag orientation. We also evaluated detection distance of PIT tags beneath the sediment to simulate detection of burrowing mussels with 23- and 32-mm tags. In sand substrate, the maximum detection distance varied from 3.5 cm and 4.5 cm (vertical tag orientation) to 24.7 cm and 39.4 cm (45 degree tag orientation) for the 23- and 32-mm PIT tags, respectively. Our results suggest a 1.4-m total detection width for tagged mussels on the substrate surface by the boat-mounted antenna system regardless of tag orientation. However, burrowed mussels may require multiple passes to increase detection that would be influenced by depth, tag orientation, and tag size. Construction of the boat-mounted antenna was relatively low in cost (<500 USD) and had several advantages (less labor and time intensive, increased safety) over traditional mussel sampling techniques (diving, snorkeling) in non-wadeable habitats.

10-01 **Describing the swimming and jumping capabilities of invasive burbot (Lota lota) to guide the design of fish barriers**

Eric Gardunio*, Colorado State University, eigardun@gmail.com

Christopher Myrick, Colorado State University

Rachel Ridenour, Colorado State University

Craig Amadio, Wyoming Game and Fish Department

Burbot (Lota lota) have recently invaded the Green River basin (WY) and are poised to extend their distribution into the Upper Colorado River system downstream of Flaming Gorge Reservoir on the Wyoming/Utah border. Burbot have the potential to impact native and sport fisheries through direct predation and competition for resources, so limiting their spread, particularly into areas where sensitive native species are present, is a primary goal of resource management agencies. Burbot may have the ability to move upstream from presently-invaded areas to colonize new habitats, and it is important to restrict or prevent such movements. We identify the Big Sandy River as one of the vulnerable areas of the Green River system upstream of Flaming Gorge Reservoir and describe an ongoing laboratory study on burbot swimming and jumping performance that is designed to aid in the design of fish barriers both on Big Sandy River and throughout the Upper Colorado River Basin. Preliminary data from trials conducted using burbot and white suckers (Catostomus commersonii), another invasive species in the Green River system, will be presented.

10-02 **Population Status and Management of Illegally Introduced Burbot in Flaming Gorge Reservoir**

Craig Amadio*, Wyoming Game and Fish Department, craig.amadio@wyo.gov

Burbot (Lota lota) are native to the Wind River - Bighorn watershed in Wyoming, but not to drainages west of the Continental Divide. They were illegally introduced to the upper Green River system in the 1990s and rapidly established populations throughout the drainage, including Flaming Gorge Reservoir. Flaming Gorge is an interstate fishery with high recreation value and outstanding angling opportunities.

Burbot are now well established in the reservoir and have caused concerns about potential impacts to the sport fishery. Regarded as an aggressive predator, burbot have the potential to negatively affect other fish and invertebrate prey populations. A monitoring program was established in 2006 using trammel nets to assess distribution, relative abundance, population structure and fall diet of burbot. Food web research has also been conducted to assess forage preferences and seasonal diet variation. The information gathered in recent years indicates a robust, naturally reproducing population with a diverse diet consisting of invertebrates, fish and fish eggs. In addition to monitoring, managers have taken aggressive steps to suppress this exotic predator and minimize impacts to sport fish populations. These actions include unlimited harvest regulations, promotion of harvest contests and substantial outreach efforts to increase angler exploitation.

10-03 **Toxicity of Rotenone to Burbot**

Bobby Compton*, Wyoming Game and Fish Department, Bobby.Compton@wyo.gov

Rotenone treatments are planned for the Big Sandy River, Wyoming, to restore native and genetically pure populations of bluehead sucker Catostomus discobolus and flannelmouth sucker Catostomus latipinnis. Eradicating invasive white sucker Catostomus commersoni and burbot Lota lota will be necessary to consider the treatments successful. While an effective dose (active rotenone concentration producing 100% mortality) is generally known for white sucker, it is not known for burbot. A bioassay on burbot using Big Sandy River water was conducted to determine toxicity and application dose. Concentrations tested included 0.00, 0.05, 0.10, 0.15, and 0.20 ppm of active rotenone (or 0, 1, 2, 3, and 4 ppm of product; 5% active ingredient). Twenty-seven burbot were placed in 122L tanks with appropriate rotenone concentrations; survival and water quality was monitored every 30 minutes over an eight-hour period. Water temperatures ranged from 9-11oC. All control fish (N=5) survived the 480-minute experiment. At the highest concentration level (0.20 ppm) all burbot were dead at 90 minutes, whereas all burbot were dead at 150 minutes at the lowest concentration level (0.05 ppm). Typical duration of flowing-water rotenone treatments conducted by Wyoming Game and Fish Department personnel is at least eight hours. Therefore, an effective dose of 0.05 ppm will be adequate for future burbot treatments.

10-04 **Burbot stock assessment in Bead and Sullivan lakes, Pend Oreille County, Washington.**

Jason McLellan*, Colville Confederated Tribes, jason.mclellan@colvilletribes.com

Stephen Hayes, Gonzaga University

Burbot sampling was conducted on Bead and Sullivan lakes, Pend Oreille County, Washington as part of a project to develop a standardized stock assessment protocol and to describe the status of the burbot populations in those lakes. Baited burbot traps were deployed in the spring to capture burbot. Adult (□ 450 mm TL) and juvenile catch-per-unit-effort (C/f) and proportion of positive trap events (Ep: proportion of traps that caught one or more burbot during a set period) were estimated to determine if abundance varied significantly between 2006 and 2010. Adult C/f rank and Ep did not vary significantly from 2006 to 2010 at Bead Lake; however, juvenile C/f rank was significantly lower in 2010 versus 2009. Adult C/f rank and Ep varied significantly at Sullivan Lake from 2006 to 2010. The Tukey multiple comparison test indicated that mean C/f rank was significantly higher in 2006 and 2007, than in 2009 and 2010. Similarly, 2006 and 2007 odds ratios for adult Ep were significantly different than 2009 and 2010. Juvenile C/f rank and Ep did not vary significantly from 2006 to 2010 at Sullivan Lake. The set-period effect was significant for adult burbot in Bead Lake, but not in Sullivan Lake. Despite the set-period effect, the C/f and Ep data indicated that the abundance of adult burbot was not changing significantly in Bead Lake, but declining significantly in Sullivan Lake. Indices of size structure indicated that the proportion of large burbot declined significantly between 2006 and 2010 in both lakes. Condition of burbot was relatively low in Bead Lake, but relatively "good" in Sullivan Lake. The majority of burbot captured in both lakes exhibited external symptoms of barotrauma. Low numbers of recaptures prevented an evaluation of survival rates.

10-05 **A Synthesis of Kootenai River Burbot Stock History and Future Management Goals**

Ryan Hardy*, Idaho Department of Fish and Game, ryan.hardy@idfg.idaho.gov

Vaughn Paragamian, Codfather Fisheries Consulting

The burbot Lota lota maculosa is common in the upstream reaches of the Columbia River Basin in the northwestern USA and Canada. In Idaho, burbot are endemic only to the Kootenai River, while they also occur in this same river system in British Columbia, as well as Kootenay Lake. The Kootenai River and Kootenay Lake once provided a popular sport and commercial fisheries for burbot. However, soon after the formation of Lake Koocanusa and the completion of Libby Dam in 1972, the respective burbot fisheries in the Kootenai River below Libby Dam collapsed. Burbot represent a significant historical and cultural resource to the local region. The status and population characteristics of which have been examined through capture-recapture data from 1993 to 2011. This research has provided information on stock origin, effects of a changing ecosystem, and limiting factors to natural recruitment. This research has also provided critical

information for the development of effective conservation and rehabilitation measures that are currently being implemented to restore burbot to a sustainable level. One such conservation measure discussed is the use of culture in the form of intensive and extensive methods and the means by which we will determine the success of stocking events on improving natural recruitment to this impaired ecosystem. This paper synthesizes results of this long – term sampling program and what specific measures are on the horizon for long term management.

10-06 **Evaluation of Artificial Markers for Monitoring Releases of Burbot (Lota lota) in the Kootenai River**

Neil Ashton*, University of Idaho, asht5445@vandals.uidaho.edu

Ken Cain, University of Idaho

Conservation aquaculture is part of a collaborative strategy to restore imperiled burbot (Lota lota) populations in the lower Kootenai River. Effective tagging methods are needed to monitor hatchery releases of juveniles, but a detailed assessment of tags suitable for burbot is currently absent from the literature. A preliminary short-term (28 days) experiment evaluated seven tags plus a control treatment for effects on fish survival, growth, and mark retention. The variety of artificial markers studied included fin clips, freeze brands, visible implant elastomer (VIE) and passive integrated transponder (PIT) tags. No significant differences were found in measured variables across all treatments, confirming these tested markers are harmless to juvenile burbot and exhibit retention of 99.4% ± 0.3 after one month. Subsequent ongoing research is evaluating long-term (365 days) retention of 16 tags of the same artificial variety, but with additional VIE colors and body locations. At 290 days post-tagging, the majority of tags have been retained at 90% or above. However, tag retention in four markers has dropped below 90%: thoracic VIE green (83%), dorsal fin clip (77%), ventral VIE green (66%), and dorsal freeze brand (0%). Pectoral fin clips, ventral freeze brands, and fluorescent red VIE tags are exhibiting superior retention to their counterparts (dorsal fin clips, dorsal freeze brands, fluorescent green VIE tags). Early indications are that long-term tag retention for the tested variety of artificial markers will be significantly different and dependent upon tag type, color, fish body location, and tissue characteristics.

10-07 **Suppression of cannibalism during larviculture of burbot (Lota lota maculosa) through size grading**

James Barron, University of Idaho

Paul Anders, Cramer Fish Sciences

Josh Egan*, University of Idaho and Cramer Fish Sciences, egan6168@hotmail.com

Ken Cain, University of Idaho

Cannibalism is a significant source of mortality during larviculture of burbot (Lota lota maculosa). This presentation summarizes a two-year study conducted at the University of Idaho's Aquaculture Research Institute (UI-ARI) that investigated size grading as a means of suppressing larval burbot cannibalism. Year one investigated survival and cannibalism of early and late stage burbot larvae reared for 15 days following size grading. One way analysis of variance (ANOVA) of variance was used to compare post grading TL, post grading width, post grading CV, the arc sine square rooted proportion surviving and the arc sine square rooted proportion cannibalized among treatments. A Tukey post hoc analysis was used to test for differences between treatments. Statistical significance was defined at $P< 0.05$ for all comparisons. Grading produced distinct size groups of early larvae (11.8 ± 2.4 mm total length). Grading also reduced size heterogeneity; retained fish had a significantly lower coefficient of length variation than control fish. Survival was significantly greater for graded fish than for control fish (averaging 74.3% in the passed fish and 93.3% in the retained fish compared to 59.3% in the control). Grading also significantly reduced cannibalism in graded groups relative to control groups (averaging 14.3% in the passed fish and 1.0% in the retained fish compared to 29.0% in the control). However, grading did not significantly affect total length, width, or coefficient of length variation of late stage larvae (21.0±2.4 mm total length), nor did it significantly improve survival or significantly reduce cannibalism relative to control groups. Year two of this study assessed the feasibility of grading larger quantities of fish in a production setting. Although not statistically tested, grading greatly reduced cannibalism relative to previous production cycles at the UI-ARI when grading was not implemented. Based on these results, size grading appears to be a valuable tool for burbot conservation and commercial aquaculture operations.

10-08 **Use of strontium stable isotopes to differentiate populations of burbot (Lota lota) in the Wind River drainage**

Scott Carleton*, United States Geological Survey, carleton@nmsu.edu

Paul Gerrity, Wyoming Game and Fish Department

Differences in the age and type of geologic formations often translate into differences in their strontium isotope signatures. As water erodes rock or percolates through the ground, it begins to resemble and integrate the signature of the geologic formation(s) it passes over or through. In turn, fish living in these waters incorporate this signature and become a record of seasonal changes in the source of surface waters (i.e. runoff versus groundwater inputs) or record seasonal and lifetime movement patterns permanently in tissues such as otoliths, scales, fin rays, or dorsal spines. The Wind River drainage in central Wyoming is characterized, along its length, by five major tributaries that arise from different geologic formations. We hypothesized that this geologic diversity would translate into contrasting strontium isotope signatures that we could use to differentiate populations and track seasonal and life time movement patterns. To test this, we collected water samples and burbot otoliths across the Wind River drainage and analyzed them for their strontium isotope signatures. As hypothesized, we found large differences that allowed us to differentiate burbot populations by tributary. Additionally, we were also able to track one

fish, entrained in an irrigation canal, back to its origins in the Wind River drainage. This study highlights the usefulness of strontium isotopes to inform fisheries managers and ecologists about the life histories of burbot in the Wind River drainage.

10-09 **Burbot Bioenergetics: Implications for fisheries management in the Wind River Drainage**

Michael Mazur*, USFWS, michael_mazur@fws.gov

Bioenergetics-based models provide a reliable, predictive approach for evaluating the spatio-temporal trade-offs between food types, feeding, temperature, and growth. Similarly, bioenergetics models account for the non-linear influences of fish body size and water temperature on the feeding demand and growth process of fishes. Growing conditions for fish in large aquatic systems often vary considerably through space and time, and these differences confound our ability to arrive at meaningful conclusions regarding fish growth and its influence on recruitment processes. Fish are also highly mobile and capable of experiencing a wide variety of growing conditions over relatively short temporal periods. In the Wind River drainage of Wyoming variations in abiotic and biotic conditions across the distribution of native burbot populations provides a wide variation in potential life history patterns. Bioenergetics modeling was used to identify potential factors associated with the observed differences in burbot body condition, growth, and size structure throughout the Wind River Drainage. Currently, the factors that limit burbot condition and growth and influence size structure in Wind River drainage lakes are unknown.

11-01 **The steelhead half-pounder life history: paradox or hedge bet?**

Brian Hodge*, Trout Unlimited, bhodge@tu.org

Peggy Wilzbach, USGS California Cooperative Fish and Wildlife Research Unit

Walt Duffy, USGS California Cooperative Fish and Wildlife Research Unit

Steelhead are widely recognized for their phenotypic plasticity, yet some expressions of life history defy what is already a flexible mold of expectations. In rivers of Northern California and Southern Oregon, for example, steelhead exhibit the half-pounder life history, a pathway characterized by a return to freshwater in the year of initial ocean entry. In contrast to the typical adult steelhead, half-pounders feed extensively, but rarely spawn, while overwintering in freshwater. In the Klamath and Rogue rivers, incidence of the half-pounder life history approaches 100% in fall-run stocks. To date, an explanation for this energetically-costly and seemingly amphidromous migration remains elusive, yet evolutionary theory suggests that for such a life history to exist, it must confer some advantage to fish exhibiting the trait. We evaluated incidence of sexual maturity in half-pounders and compared length-at-age, growth,

reproductive history, and estimated fecundity of steelhead that differed in the presence and absence of a half-pounder stage. Then, we examined the half-pounder life history in the context of fitness (i.e., survival and breeding success). Factors linked to incidence of the half-pounder life history were sub-basin of origin and age at ocean entry. Adult steelhead that displayed the half-pounder phenotype were smaller and less fecund at age than adults that displayed the ocean contingent phenotype (i.e., remained at sea in the year of initial ocean entry). However, results suggest that fish of the half-pounder phenotype display some level of compensatory growth, as well as a greater degree of iteroparity. Approximately 8% of half-pounders (male and female) reached maturity in their first year at sea. Our findings suggest that persistence of the half-pounder phenotype is favored by precocious maturation and enhanced survival relative to the ocean contingent phenotype. Identifying trade-offs associated with the half-pounder life history contributes to a framework for exploring the adaptive significance of this geographically unique pathway.

11-02 **Using the Juvenile Salmon Acoustic Telemetry (JSATS) system to evaluate adult Pacific lamprey movements and fate in Columbia River reservoirs**

Chris Noyes*, University of Idaho, noye4730@vandals.uidaho.edu

Christopher Caudill, University of Idaho

George Naughton, University of Idaho

Dan Joosten, University of Idaho

Background: Declining numbers of adult Pacific lamprey in the Columbia River basin highlight the need for a greater understanding of their movement and behavior, particularly in reservoir and tailrace habitats because substantial number of adult lamprey have had final records in the Bonneville reservoir in past radiotelemetry studies. Acoustic telemetry is well suited for deep reservoir habitats, provides longer battery life and may reduce tag effects. In this study, we evaluated the effectiveness of the Juvenile Salmon Acoustic Telemetry System (JSATS) for monitoring the migration of JSATS-tagged adult Pacific lampreys through reservoir, tailrace, and tributary habitats.

Methods: We tagged 85 adult lampreys with JSAT tags from 11 June through 3 September 2011 with tags rated for 60 days (n = 20) or 400 days (n = 65). Lampreys were released into Bonneville reservoir at Stevenson, WA (rkm 243; n = 62) or below Bonneville Dam (rkm 232.3; n = 23). We established gates using one or two autonomous receivers at nine locations from the Bonneville Dam tailrace to The Dalles Dam tailrace (rkm 305).

Results/Management Action: The 23 adults released to the Bonneville Dam tailrace have been last detected in the Bonneville tailrace (n = 15; 65%), in the Bonneville reservoir (n = 5; 22%), or above The Dalles Dam (n = 3; 13%). Mean migration rate from release to first detection in The Dalles tailrace was 15.2 km/d (median 10.6 km/d, range 5.4-32.3 km/d). All 62 fish released at Stevenson were detected on at least one receiver in the array and 58 (94%) were first detected on the Stevenson receivers. Twenty-two (35%) were last detected in The Dalles tailrace and 4

(6%) were last detected in the Klickitat River. The mean migration rate from release to the first detection in the tailrace of The Dalles was 29.7 km/d (median 34.7 km/d, range 2.6-56.5 km/d).

Continued monitoring of the 400-day tags through winter and spring 2011-2012 will provide important information on the final distribution of adult lamprey and help determine to what degree adult lamprey overwinter in reservoirs prior to spawning in reservoir tributaries.

11-03 **Patterns and drivers of juvenile steelhead survival throughout a stream network**

Rick Hartson*, University of Idaho, Department of Fish and Wildlife Resources, richard.hartson@vandals.uidaho.edu

Brian Kennedy, University of Idaho, Department of Fish and Wildlife Resources

Knut Marius Myrvold, University of Idaho, Department of Fish and Wildlife Resources

When managing and conserving migratory populations, it is important to consider population parameters at each location or life history stage. For anadromous fish, the freshwater rearing phase can be important to population regulation and persistence, yet is often overlooked. Both natural and anthropogenic factors can drive survival of rearing juvenile fish, impacting the number of outmigrating individuals and ultimately population fecundity in terms of the number of returning adults. Over a four year period we measured demographic and habitat variables of a population of juvenile steelhead, Oncorhynchus mykiss, in an anthropogenically altered headwater rearing system. During base flow season when we expected anthropogenically reduced flows to reduce habitat quality and create population bottlenecks, we repeatedly sampled sites located throughout the stream network (6 sites the first two years, 16 sites the second two years). We used mark-recapture analyses and information theoretic model selection to quantify spatial and temporal patterns of apparent survival and suggest drivers of these patterns. Specifically, we considered sampling location, sampling time period, density, elevation, temperature and presence of water withdrawal as potential drivers/correlates of survival. Additionally, we considered individual covariates of body length and condition factor. We found variation in the patterns of survival both within and among years. In some years survival varied spatially, whereas in others temporally. And the locations or time periods of relatively high or low survival were not necessarily similar among years. Also, individual covariates were highly useful predictors in some years, whereas other years body size or condition had little effect. Furthermore, we identified different drivers/correlates of survival dependent upon conditions in a given year. Survival was often lower in relatively high density sites or years, but density was a less important predictor in relatively low density years. In some years density was associated with anthropogenically reduced instream flow, suggesting the potential for interactions between natural and anthropogenic drivers to complicate survival patterns. Taken together, our results suggest that juvenile steelhead survival is both spatially and temporally variable, but it is possible to develop useful predictors of survival through intensive sampling and modeling analyses.

11-04 **Ecological differences of juvenile steelhead produced by natural origin and local hatchery origin adult steelhead spawning in the wild**

Ben Kennedy*, USFWS-Abernathy Fish Tech Center, benjamen_kennedy@fws.gov

William Simpson, U.S. Fish and Wildlife Service- Abernathy Fish Tech Center

Christopher Taylor, U.S. Fish and Wildlife Service- Abernathy Fish Tech Center

Recent data suggest that steelhead produced from local hatchery origin (HOR) steelhead spawning in the wild have lower fitness than their natural origin (NOR) counterparts. Despite this pattern, the mechanisms behind this phenomenon remain poorly understood. To increase our understanding of this pattern we investigated possible differences in important life history traits related to fitness between juvenile steelhead produced by local HOR and NOR steelhead spawning in the wild. By integrating genetic parentage assignment and ecological data, we examined differences in fish length, weight, condition, spatial distribution, and migration timing among each parent type. Juveniles produced by HOR adults were on average 6 mm shorter in length and 2.5 g less in weight than juveniles produced by NOR adults while juveniles produced by one HOR and NOR adult were intermediate in length and weight. Condition factor was similar among juveniles produced by each parent type. In one year we found that most juveniles produced by HOR adults were found near the location of adult release whereas juveniles produced by NOR adults were found to be much more broadly distributed throughout the creek. Although in the other two year distribution was similar. Additionally, some fish from HOR parents moved downstream in the fall to areas where juvenile HOR smolts are released, whereas this pattern was not observed for NOR produced fish. Based on these data we surmise that smaller size of juveniles produced by HOR adults may play a role in the pattern of decreased fitness for HOR steelhead spawning in the wild.

11-05 **Determining the survival consequences of alternate juvenile salmon life history strategies**

Brian Kennedy*, University of Idaho, kennedy@uidaho.edu

Jeff Reader, University of Idaho

Nick Gayeski, Wild Fish Conservancy

Identifying how different habitats confer a survival advantage is crucial for protecting threatened species, conserving critical habitat and understanding the adaptive basis for life history variation under changing climates and environments. Juvenile Chinook salmon (Oncorhynchus tshawytscha) in the Cedar River basin (Seattle, WA, USA) are known to use either river habitats or Lake Washington as their primary pre-smolt rearing environment. However, the relative representation of either life history strategy in the annual smolt cohort is not known. More importantly, we have no means by which to relate the specific juvenile strategy employed with

its representation in successfully returning adult Chinook salmon. Knowledge of both pieces of information is important for assisting resource managers to determine how best to invest limited funding for habitat preservation and salmon conservation. Furthermore, the ability to link survival to juvenile has rarely been demonstrated for any animal population. Smolt trapping was used to quantify patterns of outmigration and otolith microchemistry of returning adults was used to quantify how these patterns of outmigration strategies relate to the representation of returning adults. We evaluated isotopic ratios (87Sr/86Sr) and elemental ratios (Ba, Sr, K, Mg and Na to Ca) in water samples from throughout the watershed using ICP-MS and thermal ionization mass spectrometry (TIMS). Sr:Ca and Mn:Ca ratios showed significant and consistent interannual differences among juvenile salmon that were reared in either lake or river rearing sites. Based upon the ability to discriminate juvenile strategies, we analyzed otoliths from adult spawners from the 2002 and 2003 brood years that provided an unambiguous classification as river- or lake-rearing using discriminant function analysis. Our results suggest that parr migrants, or river rearing juveniles, are represented 4 times as frequently as lake rearing migrants in both age 3 and age 4 returns. Maximum likelihood approaches estimate the relative survival probability of lake vs. river rearing strategies. Neither age at return nor sex were significant factors in survival probability. These results underscore the importance of considering the relative fitness of alternate life history strategies and for understanding the interactions between life history variability and environmental variation when designing conservation strategies.

11-06 **Impacts of Snowmaking on Brook Trout (Salvelinus fontinalis) Populations at Arapahoe Basin Ski Area, Colorado**

Morriah Cowden*, GEI Consultants, MorriahF@live.com

Water withdrawal from the North Fork of the Snake River in Colorado began in October of 2002 for the purpose of snowmaking at Arapahoe Basin Ski Area. Biological monitoring has been conducted annually at two sites on the North Fork of the Snake River and at a nearby reference site on Deer Creek by GEI Consultants since 2001. Deer Creek was chosen as a reference site to determine whether observed year-to-year trends and differences in fish, macroinvertebrates, and aquatic habitat were attributable to natural environmental variation (i.e. periods of drought, flood, etc.), or from effects of snowmaking water withdrawal. Brook trout Salvelinus fontinalis is the predominant species inhabiting all sites. T-tests were conducted to determine if significant differences existed between pre-withdrawal and post withdrawal populations. In addition to assessing the effects of water withdrawal, monitoring two sites on the North Fork and one site on Deer Creek since 2001 has provided some insight into how populations of S. fontinalis fluctuate with alternating periods of increased runoff and drought. Substantial variability has been observed in the total number of fish collected, including young-of-year since monitoring activities began; however, variations in fish population structure and abundance have been linked to natural, interannual environmental change and not to the effects of water withdrawal. In all years Fulton condition factors were at or near 1.0, indicating healthy populations persisted among all sites. Density and biomass of brook trout appear to be negatively related to the magnitude of spring runoff, particularly for the North Fork sites.

11-07 **Jeep in a Creek: A pilot study on the effects of riparian OHV roads on a headwater trout stream in Colorado**

Matt Fairchild*, Arapaho & Roosevelt National Forest and Pawnee National Grassland, mfairchild@fs.fed.us

Christopher Carroll, Arapaho & Roosevelt National Forest and Pawnee National Grassland

Off-highway vehicle (OHV) use has grown in the Front Range Mountains of Colorado, while the funding to manage roads and recreation on public lands has declined. OHV roads along stream corridors are considered a primary threat to riparian ecosystems in the western U.S., yet few studies have empirically quantified the effects of these roads on aquatic habitats and biota. We examined the impacts of a rugged, high-clearance vehicle road on the fish community and physical habitat of a Rocky Mountain stream using an upstream-downstream comparison of eight systematically-stratified study reaches categorized into three groups: (1) reaches where the road was in the stream, (2) reaches adjacent to the road, and (3) reaches buffered by at least 50 meters of intact riparian area. In this pilot study, parameters of the local trout population, physical stream attributes, and riparian buffer widths were measured and compared using standard methods. Fish density, average fish size, size of largest fish, and mean fish condition was lower in reaches with jeep trails in the stream than in reaches adjacent to roads and control reaches. Pool frequency and volume of large wood were also significantly lower in reaches with jeep trails in the stream than in other reaches. Although we anticipated that streambed composition would be coarser in the reaches with jeep trails in the stream than other reaches due to mechanical action on the streambed, differences could not be detected with our sample sizes. The primary factor driving reduction in trout density was pool frequency (r2=0.75), suggesting that loss of pools is a critical impact of OHV use in streams. In turn, riparian buffer width explained 63% of between reach variation in the volume of large wood and 38% of the variation in pool frequency, which suggests that OHV use and expanding trail networks along riparian corridors may also alter some of the processes that form stream habitats. Our pilot study documents specific impacts riparian OHV roads can have on a small, montane stream; but also provides some insight into mechanistic understanding that may aid in the effective restoration of such sites.

12-01 **Nutrient Supplementation in Dworshak Reservoir, Idaho: Can it Improve a Kokanee Fishery?**

Andy Dux*, Idaho Fish and Game, andy.dux@idfg.idaho.gov

Sean Wilson, Idaho Department of Fish and Game

Darren Brandt, Advanced Eco-Solutions

Dworshak Reservoir, located in Idaho's Clearwater River basin, is an 86 km long reservoir with a surface area of 6,916 ha at full pool. The reservoir has undergone oligotrophication since impoundment and both nutrient levels and nitrogren to phosphorus (N:P) ratios have declined substantially. An important sport fishery for kokanee Oncorhynchus nerka exists in the reservoir, but is limited by reservoir productivity. In 2007, a nutrient supplementation pilot project was initiated with the goal of increasing productivity and, ultimately, enhancing the kokanee fishery in Dworshak Reservoir. During 2007-2010, a nitrogen-based fertilizer was added to the reservoir annually during thermally stratified conditions. In conjunction, monitoring of limnological conditions and the kokanee population was conducted. Nitrogen supplementation resulted in immediate increases in densities of picoplankton, the base of the reservoir food web. The proportion of nitrogen-fixing cyanobacteria was reduced, concurrent with an increased proportion of edible phytoplankton. The biomass of Daphnia, the preferred food of kokanee, increased from pre-treatment years. The kokanee population initially responded with increased growth rates. By 2010, kokanee biomass had nearly doubled from recent years and fish were larger than in a pre-treatment year with similar abundance. Nutrient supplementation did not result in the violation of any water quality standards that were established by the Idaho Department of Environmental Quality. The project was interrupted by a legal challenge and no nutrients were added during the end of the 2010 season or during 2011. While not intended, this provided an opportunity to evaluate the reservoir response to ceased nutrient supplementation. Extreme spring inflows in 2011 limited the ability to evaluate the response to some extent, but cumulative improvements to the food web from the previous four years appeared to be lost. Results from four years of nutrient supplementation were similar to those observed for reservoirs in British Columbia and showed promise for improving the kokanee population in Dworshak Reservoir. This pilot project is scheduled to resume in 2012 and further evaluation will be conducted.

12-02 **Lake Shore and Littoral Habitat Structure: precision and biological relevance of a field survey method**

Philip R. Kaufmann, U.S. Environmental Protection Agency

Bob Hughes*, Amnis Opes Institute, hughes.bob@epa.gov

Until recently, lake physical habitat assessment has been an underemployed tool for assessing lake and reservoir ecological condition. We outline and evaluate a rapid field sampling and analytical approach for quantifying near-shore physical habitat. We quantified the repeatability of physical habitat metrics based on a random subsample of 90 lakes from a national probability sample of 981 lakes (NLA) and a random subsample of 50 lakes from a probability sample of 185 Northeast USA lakes (NE). We assessed the precision of littoral physical habitat complexity, fish cover, substrate, aquatic macrophytes, riparian vegetation, and shoreline human disturbances. Of the 46 NLA metrics examined, more than 65% had repeat measurement standard deviations <10% of their observed ranges. The NLA metrics were twice as precise as the NE metrics because of the greater number of NLA % areal cover classes. We evaluated the biological relevance of the habitat sampling approach by examining the association of habitat

metrics with near-shore assemblages of fish and birds in NE. Intolerant fish species richness decreased and tolerant fish species increased with increased anthropogenic disturbances and reductions in the abundance and structural complexity of riparian vegetation and littoral cover. The percentage of neotropical migrant birds decreased and the richness of tolerant birds increased with increased anthropogenic disturbances and reductions in the abundance and structural complexity of riparian vegetation and littoral cover. We conclude that the NLA physical habitat assessment produced metrics and indices with precision adequate for regional and national assessments of lake condition. Furthermore, the response of very similar NE habitat metrics to anthropogenic stressors and their clear association with biotic assemblage composition and structure indicate that the habitat assessment approach and its metrics quantify biologically relevant characteristics of near-shore lake environments.

12-03 **Wyoming's Native Freshwater Mussels**

Phil Mathias*, Wyoming Game and Fish Department, philip.mathias@wyo.gov

Wyoming is still in a discovery phase for its native mussels. There have been seven species identified statewide none of which have a protected status under the Endangered Species Act, though western drainage species are beginning to receive attention from conservation groups. Recent efforts have focused on the western drainages in Wyoming: Bear and Snake Rivers. Systematic surveys were performed at 24 sites throughout the two drainages; both mussel and habitat data were collected. Two species were found in the Bear River drainage: California floater (Anodonta californiensis) and western pearlshell (Margaritifera falcata), with a range expansion in Wyoming for the California floater. The Snake River only had western pearlshell, but where present, the individuals were in large abundances: 500-800+ individuals. Habitat data is currently being looked at for trends with the mussel distribution and work will continue to document the distribution of Wyoming's native freshwater mussels statewide.

12-04 **The effects of large-scale predator suppression in Lake Pend Oreille, Idaho**

Andy Dux*, Idaho Department of Fish and Game, andy.dux@idfg.idaho.gov

Nicholas Wahl, Idaho Department of Fish and Game

James Fredericks, Idaho Department of Fish and Game

Predation became the primary factor limiting kokanee Oncorhynchus nerka recovery in Lake Pend Oreille, Idaho after an increase in lake trout Salvelinus namaycush abundance from 1999-2005. In response, a predator removal program was developed to target long-term suppression of the lake trout population and short-term reduction of rainbow trout Oncorhynchus mykiss. These efforts began in 2006, using both anglers and a contract netting operation. Since 2006, anglers have removed 41,651 rainbow trout and 65,156 lake trout, while netting has removed 68,956

lake trout. The combined angling and netting approach has substantially reduced the lake trout population. Mature lake trout (>600 mm) declined most rapidly, including a >75% decrease since 2008. Juvenile (<400 mm) abundance remained high initially, but the netting catch rate declined 56% in the spring of 2011 from the previous year. This suggests that juvenile abundance is also decreasing. A compensatory response by lake trout to increased mortality has not occurred. The rainbow trout population has responded differently than lake trout. This population has remained stable, primarily because annual exploitation rates have been low (<30%) despite incentivized harvest. Kokanee abundance has steadily increased since reaching an all-time low in 2007, indicating predation has been reduced. To date, predator removal efforts have effectively allowed a nearly collapsed kokanee population to rebound. Further, results continue to support the hypothesis that suppression of lake trout in a large, deep lake is achievable.

13-01 **Understanding the effects of management actions on bull trout populations in a fragmented landscape**

Robert Al-Chokhachy*, U.S. Geological Survey, ral-chokhachy@usgs.gov

Mike Ebinger, Montana State University

Joe Dossantos, Avista Corporation

Fragmentation of landscapes has been identified as one of the major factors contributing to the declines in abundance, distribution, and loss of life-history variability for bull trout throughout much of the Pacific Northwest. For extant populations, managers are often confronted with the task of identifying the most effective means for managing and conserving populations; this can be incredibly challenging, however, given the uncertainties environmental and demographic stochasticity. In Cooper Gulch, MT, a small tributary to the Clark Fork River, the USFWS has recently initiated a program where bull trout are actively trapped in Cooper Gulch and hauled downstream below two hydropower impoundments to Lake Pend Oreille, ID; large, adult fluvial bull trout are then returned when recaptured and genetically assigned to Cooper Gulch. Here we develop an individual-based model (IBM) to evaluate the risks of varying levels of management activities on the persistence of the small bull trout population in Cooper Gulch. Using field-based measures of demographic and vital rates to fit the IBM, we consider two main objectives: 1) the long-term risk of this population with no management activities; and 2) the risks of removing different age classes from Cooper Gulch with various return rates as adults. Despite a small population size (n = 40 adults), we find little evidence of demographic stochasticity leading to extirpation of this small bull trout population. With added environmental stochasticity, the risk of extirpation increases, particularly with long-term environmental perturbations (e.g., drought). Our results suggest the impacts of actively removing individuals from this small population vary considerably by age class, and that even modest levels of return rates of large, adfluvial bull trout (e.g., 3%) ameliorate any detrimental effects of the removal of juvenile bull trout. With increasing strength in environmental perturbation, our results highlight the resiliency of long-lived species and the importance of conserving connectivity and multiple life-history forms.

13-02 **Introduction of Whirling Disease Resistant Rainbow Trout in the Gunnison River, Colorado**

Dan Kowalski*, Colorado Parks and Wildlife, dan.kowalski@state.co.us

Eric Fetherman, Colorado Parks and Wildlife

Geroge Schisler, Colorado Parks and Wildlife

Barry Nehring, Colorado Parks and Wildlife

The Gunnison River in southwest Colorado supported a robust wild rainbow trout population before the introduction of Myxobolus cerebralis in the mid 1990's. The parasite increased mortality of age 0 rainbows and poor recruitment led to the near complete collapse of the population. Colorado Parks and Wildlife has experimented with whirling disease (WD) resistant strains of rainbow trout in a variety of management and research applications. To evaluate these fish in the wild, resistant strains were bred with wild strain rainbows and the progeny were experimentally stocked in three reaches of the Gunnison River. The objectives of this study were to evaluate the growth, survival, reproduction and whirling disease infection of the experimental fish and attempt to re-establish wild rainbow trout reproduction in the Gunnison. German or Hofer strain fish were bred with wild type rainbows and stocked in three reaches of the Gunnison River from 2004 to 2010. Adult fish were monitored with annual mark recapture population estimates and reproduction was monitored with multiple pass removal estimates of age 0 fish. Tissue samples were analyzed to determine the presence of microsatellite genetic markers associated with the resistant strain. Tag loss, emigration and low survival of stocked fish complicated survival comparisons in some years, but the resistant strains had higher survival and growth than wild strain fish. Pepsin-trypsin digest analysis revealed that resistant strain fish developed a less severe WD infection than the wild strain and that overall infection rates have declined over time where resistant fish have been stocked. Genetic analysis has confirmed that the resistant strain fish have successfully reproduced and their progeny comprise a small but variable proportion of rainbow fry samples. The stocking of resistant strain fish has not increased the biomass of rainbows in areas with high brown trout densities but has increased rainbow numbers where browns are less prevalent. The experimental fish have successfully reproduced and have likely introduced some resistance to Myxobolus cerebralis into the rainbow trout population of the Gunnison. Multiple year classes of wild rainbows are now present in the population for the first time in over a decade.

13-03 **PHABSIM – What is it and how is it applied?**

Jason Mullen*, GEI Consultants, jmullen@geiconsultants.com

Don Conklin, GEI Consultants

Craig Wolf, GEI Consultants

Physical Habitat Simulation System (PHABSIM) modeling is a tool that allows the user to evaluate changes in fish habitat availability as a function of changes in stream flow. PHABSIM was first developed in the late 1970's and early 1980's as part of the Instream Flow Incremental Methodology (IFIM). PHABSIM has evolved over the years to include both one and two dimension applications. While PHABSIM is still a common tool for assessing changes in habitat availability as a function of stream flow, workshops teaching PHABSIM are uncommon compared to in the past and PHABSIM is rarely mentioned in most fisheries management programs. Accordingly, many young practicing biologists have little knowledge or experience in PHABSIM modeling, unless directly involved in projects that incorporate PHABSIM. In this presentation, I will describe the basics of PHABSIM modeling, advantages, limitations, and several examples of how PHABSIM can be applied, including in developing minimum flow recommendations and evaluating impacts under alternative flow regimes.

13-04 **Introduced pike predation on salmonids in Southcentral Alaska**

Adam Sepulveda*, US Geological Survey, asepulveda@usgs.gov

David Rutz, Alaska Dep. Fish & Game

Kristine Dunker, Alaska Dep. Fish & Game

Jackson Gross, US Geoligocal Survey

Northern pike (Esox lucius) are generalist predators that can switch to alternative prey species after preferred prey have declined. This trophic adaptability allows invasive pike to have catastrophic effects on native biota. In Southcentral Alaska, invasive pike are a large concern because they have spread to important spawning and rearing habitat for native salmonids. In this study, we described the relative importance of salmonids and other prey species to pike diets in the Deshka River and Alexander Creek, tributaries to the Susitna River. Salmonids were once abundant in both rivers, but they are now rare in Alexander Creek. In the Deshka River, we found Chinook salmon (Oncorhynchus tshawytscha) and coho salmon (O. kisutch) dominated pike diets in May, June, and August 2011 and that the relative importance of salmonids was greater for small pike than large pike. In Alexander Creek, pike diets in May and June 2011 reflected the distribution of spawning salmonids, which decrease with distance upstream. Salmonids dominated pike diets in the lower reaches and the relative importance of salmonids was greater for small pike. Arctic lamprey (Lampetra camtschatica) and slimy sculpin (Cottus cognatus) dominated pike diets in the middle and upper reaches. In both rivers, pike density did not influence diet and pike consumed smaller prey items than predicted by their gape-width. Our data suggest juvenile salmonids are a preferred prey item for pike, that small pike are the primary consumers of juvenile salmonids, and that pike will select alternative prey items that include other native fish species, when juvenile salmonids are less abundant or no longer available. Implications of this trophic adaptability are that invasive pike can drive multiple species to low abundance and possible extirpation.

P-01 **A Large-Scale Field Assessment Using Underwater Epoxy to Permanently Install Sensors for Full Year Temperature Monitoring in Mountain Streams**

Dona Horan*, USFS, dhoran@fs.fed.us

Sherry Wollrab, USFS

Dan Isaak, USFS

Brett Roper, USFS

Stream temperature regimes are fundamentally important to understanding pattern and process in aquatic communities. Modern digital sensors can provide accurate and repeated temperature measurements that span multiple years, but are rarely deployed for more than a few summer months in mountain streams due to logistical constraints with seasonal stream access and concerns that large annual floods will destroy sensors. We developed a rapidly applied protocol (sensor installation takes ~20 minutes) that uses underwater epoxy to attach sensors to large rocks that makes full year stream temperature monitoring feasible and cost effective. Initial field trials during the winter of 2009/2010 suggested temperature measurements were not biased by attachment to rocks and 82% of epoxied sensors (9 of 11) were retained through spring floods. A larger scale field assessment was initiated during the summer of 2010 wherein 300 temperature sensors were deployed in streams ranging in channel slope from 0.1% - 16% across the northwest U.S. Eighty-six of these sites were checked for sensor retention after the large spring flood in 2011 and 74% (64 of 86) of sensors remained in place recording stream temperatures. Retention success was inversely related to channel slope and averaged 85% where slopes were < 3% that are typical of most fish-bearing streams. Our results indicate that the underwater epoxy technique is viable for installing temperature sensors in a wide range of mountain streams where large substrates and suitable attachment sites are common. Moreover, the technique reduces the cost of temperature monitoring by reducing the number of site visits to < 1/year rather than the current norm of 2/year for summer data and 5 years of temperature measurements may be obtained for $130 in equipment costs (primarily the cost of the sensor) given current memory and battery capacities of temperature sensors. More than 400 additional stream sites were instrumented with temperature sensors using underwater epoxy during the summer and fall of 2011 to continue expanding the regional temperature monitoring network. Data from this network will contribute in future years to improved understanding of stream thermal regimes, alterations associated with climate change, and the thermal ecology of aquatic organisms.

P-02 **Survival and retention rates for burbot (Lota lota) following surgical implantation of passive integrated transponders**

Eric Gardunio*, Colorado State University,

Zack Underwood, Colorado State University

Christopher Myrick, Colorado State University

Passive integrated transponder (PIT) tags are commonly used in the field of fisheries to individually identify fish for growth or mortality studies or for population estimates. High survival and tag retention rates are important assumptions of such studies. PIT tags have been used in a variety of studies of burbot (Lota lota) which are widely studied for conservation as a native and as an invasive. Despite this use, descriptions of PIT tag retention and survival rates are lacking for burbot. The current study provides estimates of survival and retention over a 60-day period for burbot surgically implanted with 23-mm PIT tags in the peritoneal cavity and compares these rates to a control group. Over the course of the study, a 100 percent retention rate was observed. Survival rates at day 60 were 93% for the tagged and 96% for the control groups, respectively. A survival analysis was conducted with a log-rank test for equality of survival that indicated no significant difference between survival rates for the control and treatment groups (p=0.69).

P-03 **Colorado River cutthroat trout habitat resiliency to climate change**

Kate Olsen*, Utah State University and USDA Forest Service, K08Olsen@gmail.com

Brett Roper, USDA Forest Service and Utah State University

Rick Henderson, USDA Forest Service, Routt National Forest

Colorado River cutthroat trout (CRCT), Oncorhyncus clarki pleuriticus, currently occupy less than 12% of their native range. Anthropogenic climate change is increasing the earth's temperature and shifts in thermal habitat distribution of fish have begun. Cutthroat trout, metabolically driven by temperature, rely heavily on the cold-water of their native habitat. The impacts of human-induced climate change are predicted to reduce thermally suitable habitat by 50% in the Rocky Mountains. For CRCT, 29% of currently occupied habitat is at high risk of deterioration from climate change. Although the United States Fish and Wildlife Service (USFWS) has not listed CRCT as an endangered species, the Colorado Division of Wildlife (CDOW) and the United States Forest Service (USFS) have designate them as a species of special concern. The goal of this work is to provide guidance to managers in prioritizing CRCT projects, using GIS habitat characteristics to determine stream resilience to temperature fluctuation. Temperature data will be collected at 50 sites across the Upper Colorado River basin. Each site will have three temperature loggers, one each in the water, riparian zone and upland. Deploying loggers at three locations will enable us to better understand the relationship between air and water temperatures as well as between stream side and uphill air temperatures. A better understanding of the relationship between riparian and upland air temperatures may allow for better application of regional climate predictions on smaller scales. A cluster analysis of the 125 current CRCT patches was completed using summary statistics of six GIS-derived habitat characteristics (solar insolation, elevation, air temperature, forest cover, groundwater, and drainage area). Cluster analysis identified four groups and four unique sites. Temperature loggers have been sent to 50 sites. These include the four unique sites and a random sample of 46

selected proportionally from each of the groups. Temperature data from these sites will be analyzed to determine relationships between stream temperature resilience and habitat characteristics. Determination of habitat characteristics that provide resiliency to climate change will allow fisheries managers to better prioritize restoration and conservation decisions regarding Colorado River cutthroat trout.

P-04 **Evaluating Tiger Muskellunge to Remove Brook Trout from Idaho Alpine Lakes**

Eric Herrera*, Idaho Department of Fish and Game, eaherrera8@gmail.com

Martin Koenig, Idaho Department of Fish and Game

Nonnative brook trout Salvelinus fontinalis populations in alpine lakes threaten the persistence of native cutthroat trout Oncorhynchus clarki and bull trout Salvelinus confluentus in downstream Idaho streams. Using predatory fish to manage brook trout populations is an attractive alternative to other techniques such as gill-netting, electrofishing, or chemical treatments, particularly in remote wilderness settings. Stocking tiger muskellunge Esox luscious x E. masquinongy may be an efficient means for eliminating some brook trout populations. Study lakes were initially surveyed in 2005 or 2006 to characterize the resident brook trout populations. In 2007, nine alpine lakes containing brook trout populations were planted with tiger muskellunge at 40 fish/ha density. Lakes were surveyed from 2008 through 2011 to compare changes in brook trout size and relative abundance before and after stocking tiger muskellunge. Relative abundance of brook trout declined substantially in most lakes, while average length and weight increased following stocking. Mean catch rates of brook trout declined from 22.8 per net-night before planting tiger muskellunge, to 2.6 per net-night in 2011. Prior to tiger muskellunge, mean brook trout length was 212 ± 3 mm (n = 519). After stocking, mean brook trout length was 246 ± 6 mm (n=132) in 2008, 264 ± 7 mm (n = 138) in 2009, 237 ± 7 mm (n = 84) in 2010, and 256 ± 10 mm (n=76) in 2011, indicating a consistent increase in mean size. Catch rates of brook trout declined slightly in control lakes, while size remained unchanged. Brook trout may overcome eradication efforts by recolonizing lakes from refuge habitats or through density-dependent recruitment success. However, this study shows tiger muskellunge can improve the size structure of brook trout populations. While it appears tiger muskellunge may be successful in eliminating brook trout in some lakes, we recommend combining introductions with other control methods to increase the chances of success.

P-05 **Brown trout (Salmo trutta) spawning patterns in an urban stream.**

Phil Gaskill*, University of Wyoming, pgaskill@uwyo.edu

Eriek Hansen, University of Wyoming, Program in Ecology, Department of Zoology & Physiology

Steve Gale, Wyoming Game and Fish Department

Urbanization places many demands on aquatic ecosystems often altering natural processes to the detriment of the biota. Traditionally urban stream management focuses on storm-water runoff and public recreation, but ignores aquatic biota. Spring Creek, in Laramie, Wyoming is a first order spring-fed urban tributary to the Laramie River. The primary function of Spring Creek and the riparian zone is to facilitate storm-water runoff. In addition, Spring Creek provides spawning habitat for brown trout (Salmo trutta). In efforts with the Wyoming Game and Fish Department and the Student Subunit of the American Fisheries Society at the University of Wyoming, a monitoring program was initiated in 2008 to document brown trout spawning activity in Spring Creek. The goal of this monitoring is to promote interactions among students and fisheries professionals while further enabling the effective, cooperative management by city officials and state fisheries managers. This year we expanded our monitoring efforts and installed a fish trap to quantify the number of brown trout migrating upstream into Spring Creek from the Laramie River. Prior to the spawning season we mapped available spawning habitat in Spring Creek to monitor potential changes in habitat availability. Consistent with previous years, spawning occurred from mid October through early November. This year we identified 56 redds within the survey reaches, a number similar to previous years: 59 in 2008, 64 in 2009 and 53 in 2010. The fish trap collected 36 brown trout over 25 cm, including 14 females and 22 males. Female brown trout can create 2-4 redds, accounting for approximately 50% of redds identified this year. This project highlights the opportunities for interactions among students and fisheries professionals. During this monitoring, 44 students have participated and gained experience in the fisheries field.

P-06 **Current and Future Impacts of Energy Development on the Fishes of the Wyoming Range**

Carlin Girard*, University of Wyoming, carlingirard@gmail.com

Dr. Annika Walters, University of Wyoming Coop Unit

Wyoming has experienced a significant increase in energy development in the last two decades. One such area is the eastern front of the Wyoming Range. Oil and gas extraction is currently occurring throughout the southern extent of this region, and proposed expansion to the northern portion of the Wyoming Range threatens to undermine the area's ecological integrity and biodiversity. In the summer months of 2012 and 2013, a study conducted by the University of Wyoming's Fisheries and Wildlife Cooperative Research Unit will assess the current and future impacts of energy development on the fishes of the Wyoming Range. We hypothesize that the structure of fish assemblages relates to habitat conditions which may be altered by drilling practices and associated infrastructure. Ecological disturbances associated with energy development include but are not limited to: increased road densities and vehicle traffic; fragmentation of terrestrial and aquatic habitats; pollution of air, water and soil; and alterations of patterns of use by a variety of biota. Large information gaps exist regarding these impacts and their disturbances on aquatic ecosystems. By comparing fish assemblages, riparian condition, sedimentation rates, and water quality and quantity between active energy development sites and

“undisturbed” sites we will evaluate the impacts of resource extraction on the fish communities of the Wyoming Range. “Undisturbed” sites will be chosen to intentionally include proposed drilling areas. This will benefit our study in two ways; first, it will allow us to forecast impacts related to oil and gas development in the future, and it will provide an excellent baseline data set for comparison post-drilling. Our overall goal is document current ecological impacts that are affecting fish assemblages as well as predict how future development will impact presently undisturbed areas.

P-07 **Restoration of Native Fish to Clear Creek: Kendrick Dam Fish Bypass Channel**

Travis Cundy*, Wyoming Game and Fish Department, travis.cundy@wyo.gov

Bill Bradshaw, Wyoming Game and Fish Department

The mainstem of Clear Creek meanders a 112 mile course through northeast Wyoming to the Powder River. The Powder River in turn meets the Yellowstone River in Montana an additional 240-miles downstream. Fish can move freely along the entire 433-mile long mainstem of the free-flowing Powder River. However, until 2010, Kendrick Dam blocked fish passage beyond the lowest seven miles of Clear Creek. A fish bypass channel now allows fish to access 36 additional miles of Clear Creek above Kendrick Dam. Fishes that have or are expected to benefit from the Kendrick Dam Fish Bypass Channel include shovelnose sturgeon, channel catfish, sauger, goldeye, river carpsucker, plains minnow, western silvery minnow, and sturgeon chub. A poster is presented that summarizes the Clear Creek and Powder River stream network, history and water use at the Kendrick Dam Irrigation Diversion, function of the bypass channel, maintenance and operation needs at the bypass, and fish passage use determined to date through the bypass channel. Many thanks to the Pee Gee Ranch of Arvada, WY for this fish bypass channel would not have been possible without their ongoing cooperation.

P-08 **Bankfull-Channel Geometry and Discharge Curves for the Rocky Mountains Hydrologic Region in Wyoming**

Katharine Foster*, USGS, kafoster@usgs.gov

Regional curves relate bankfull-channel geometry and bankfull discharge to drainage area in regions with similar runoff characteristics and are used to estimate the bankfull discharge and bankfull-channel geometry when the drainage area of a stream is known. One-variable, ordinary least-squares regressions relating bankfull discharge, cross-sectional area, bankfull width, and bankfull mean depth to drainage area were developed from data collected at 39 streamgages in or near Wyoming. Watersheds draining to these streamgages are within the Rocky Mountains Hydrologic Region of Wyoming and neighboring states.

Data collected at each streamgage reach included one longitudinal profile of bankfull features, water surface and channel-bed elevations, one or more riffle cross-section surveys of channel geometry, and riffle and reach-average pebble counts. Various indicators were used to determine bankfull-channel geometry. Field data were analyzed to determine bankfull area, bankfull width, bankfull mean depth, D50- and D84-particle size for each pebble count, bankfull discharge and return interval at each site.

Two sets of regional curves were developed; one for streamgages representing the range of mean annual precipitation and one for streamgages with greater than 25 inches mean annual precipitation. Drainage area explains most of the variability in cross-sectional area for all streamgages and for streamgages with greater than 25 inches mean annual precipitation (R2 = 0.83, and 0.91 respectively). Drainage area explains less of the variability in bankfull discharge for all streamgages and streamgages with greater than 25 inches mean annual precipitation (R2 = 0.74 and 0.87, respectively), bankfull with (R2 = 0.81 and 0.83, respectively) and bankfull mean depth (R2 = 0.44 and 0.64, respectively). Residual standard error ranges from 28 to 65 percent for all streamgages and from 20 to 41 percent for streamgages with greater than 25 inches mean annual precipitation. Some streamgages exhibited influence, leverage, or both on all regional curves developed for the Rocky Mountains Hydrologic Region. Regional curves presented here are not intended for use as the sole method for estimation of bankfull-channel geometry characteristics; however, they may supplement identification of the bankfull channel when used in combination with other supporting evidence.