
# 2019 Annual Meeting

## Fort Collins, Colorado
## February 26 - February 28, 2019

## PROGRAM

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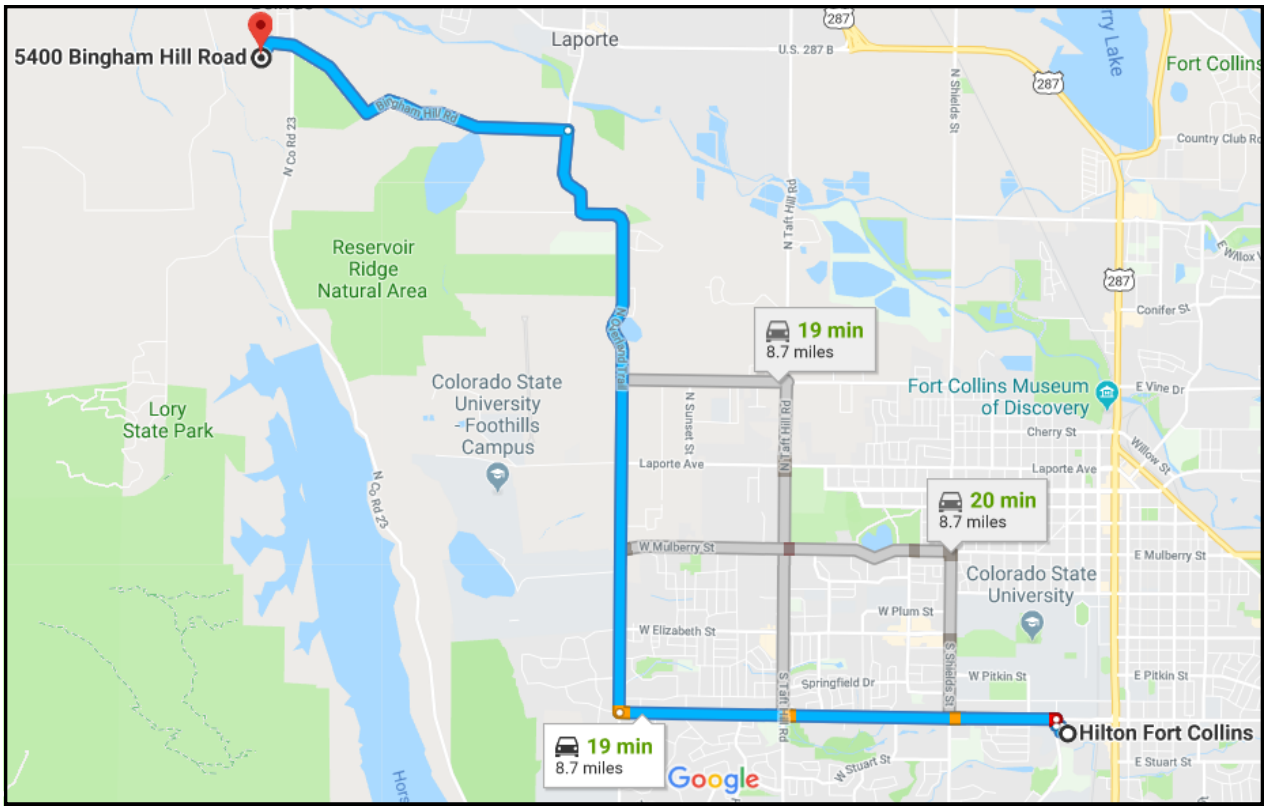
# Schedule at a Glance

| Time | Event | Location |
|---|---|---|
| **Tuesday, February 26** | | |
| 8:30 AM - 12:00 PM | Continuing Education - Introduction to Program R and Data Management in R | CSU Campus |
| 12:00 PM - 1:00 PM | Lunch - on your own | |
| 1:00 PM - 5:00 PM | Continuing Education - Introduction to Program R and Data Management in R | CSU Campus |
| 1:00 PM - 5:00 PM | Continuing Education - Making Sense of the Federal Process | The Legends Room |
| 1:30 PM - 3:30 PM | Continuing Education - Tour of CPW Bellvue Fish Research Hatchery and Bellvue-Watson Hatchery | Bellvue-Watson Fish Hatchery |
| 12:00 PM - 7:00 PM | Registration and Presentation Download | Salon Hallway |
| 6:00 PM - 10:00 PM | Welcome Social | CSU Campus |
| **Wednesday, February 27** | | |
| 7:00 AM - 5:00 PM | Registration and Presentation Download | Salon Hallway |
| 8:10 AM - 8:20 AM | Welcome, Presidential Message and Introduction to the Opening Session by Eric Fetherman | Salons 1/5, 2, 3 |
| 8:20 AM - 11:50 PM | Opening Session on Aquaculture | Salons 1/5, 2, 3 |
| 11:50 AM - 12:00 PM | Video: Benefits of AFS Membership | Salons 1/5, 2, 3 |
| 12:00 PM - 1:30 PM | Lunch - on your own | |
| 1:30 PM - 3:30 PM | Contributed Papers - Concurrent Sessions | Salons 1/5 and 2 |
| 3:30 PM - 4:50 PM | Poster Session | Atrium |
| 5:00 PM - 5:30 PM | Kokanee Spawning Video Screening | Salons 1/5 |
| 6:10 PM - 7:00 PM | Student Mentoring Presentation and Job Fair | Atrium |
| 6:00 PM - 10:00 PM | Student-Hosted Social | Atrium |
| **Thursday, February 28** | | |
| 7:00 AM - 5:00 PM | Registration and Presentation Download | Salon Hallway |
| 8:00 AM - 11:20 AM | Contributed Papers - Concurrent Sessions | Salons 1/5 and 2 |
| 11:30 AM - 1:00 PM | Business Meeting Luncheon | Salons 3, 4/6 |
| 1:00 PM - 5:00 PM | Contributed Papers and Boreal Toad Session | Salons 1/5 and 2 |
| 6:00 PM - 10:00 PM | Awards Banquet and Raffle | Salons 3, 4/6 |
| **Friday, March 1** | | |
| 8:00 AM - 12:00 PM | Boreal Toad Session | The Legends Room |

# Continuing Education - Directions

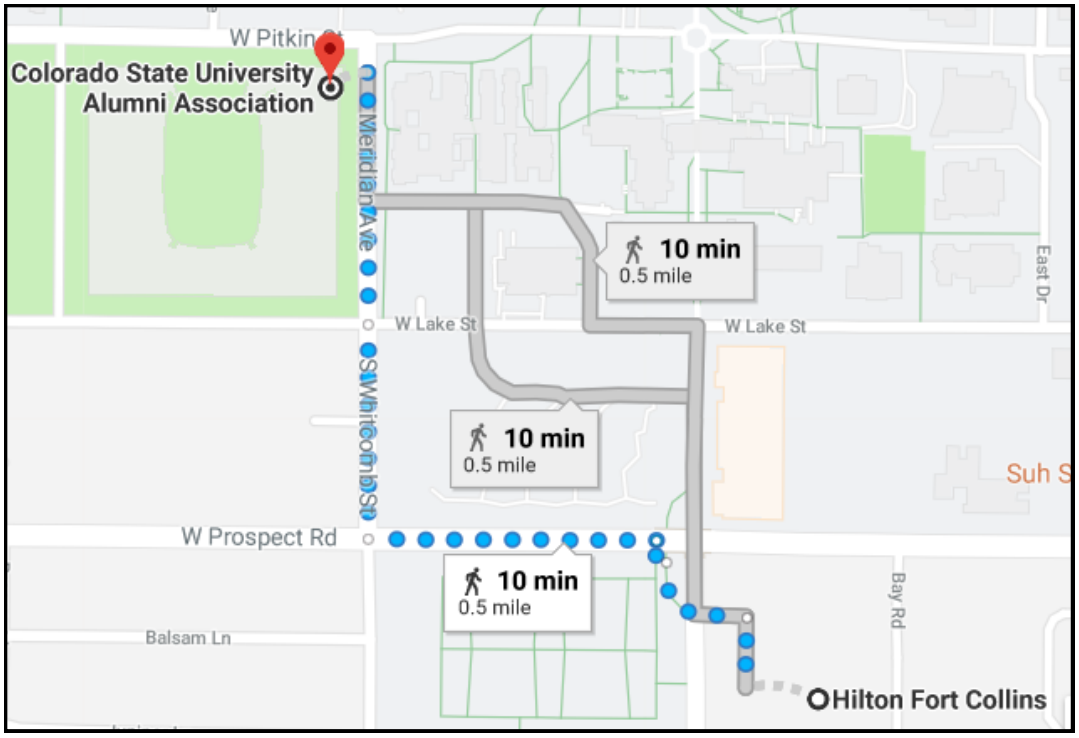
Bellvue-Watson Fish Research Hatchery Tour - Tuesday, February 26




Take west exit out of Hilton parking lot. Take a right onto Center Avenue and an immediate left onto Prospect Road. Take Prospect Road west for 2.6 miles. Take a right onto Overland Trail. Head north on Overland Trail for 3.8 miles. Take a left onto Bingham Hill Road and take west for 2.1 miles. Go straight onto the dirt road at the intersection of Bingham Hill Road and N County Road 23, which will put a field and yellow Quonset hut on your left as you enter the hatchery. The first unit you come to is the Bellvue-Watson Unit. Follow the road as it curves around the unit to the right, and head for the white raceway covers behind the lower unit. This is the Fish Research Hatchery and where the tour will begin.

# Socials

**Welcome Social -** Come kick off the annual meeting from 6PM - 10PM on Tuesday, February 26 at the Iris and Michael Smith Alumni Center on the CSU Campus. The center is located on the Northeast corner of Canvas Stadium and is a 10 minute walk from the Hilton Hotel.




**Student-Hosted Social - Hosted by the Colorado State University Student Subunit**

**When: Wednesday, February 27**
Location: Hotel Atrium

6:10 PM - 6:20 PM: Mentoring Program Presentation
6:20 PM - 7:00 PM: Job Fair
6:00 PM - 10:00 PM: Pizza, salad and Free Beer

# AGENDA

**Wednesday, February 27**

| | | |
|---|---|---|
| 8:10 - 8:20 | **Eric Fetherman** Welcome, Presidential Message, and Introduction to the Opening Session | |
| | ***Opening Session on Aquaculture: "We All Need a Little Culture"***<br>***See Page 11 for biographies of opening session speakers***<br>***Room: Salons 1/5, 2, 3***<br>***Moderator: Eric Fetherman*** | |
| 8:20 - 8:50 | **Jim Bowker** Why keep hatcheries? | |
| 8:50 - 9:20 | **Jesse Trushenski** Aquaculture myths and myth busting | |
| 9:20 - 9:45 | **Carl Kittel** Introduction to the Fish Culture Section and its role in AFS | |
| 9:45 - 10:05 | **Guy Campbell** Hatchery production in Wyoming | |
| 10:05 - 10:30 | BREAK | |
| | ***Opening Session on Aquaculture Continued***<br>***Room: Salons 1/5, 2, 3***<br>***Moderator: Kevin Gelwicks*** | |
| 10:30 - 10:50 | **Riley Morris** Hatchery production in Colorado | |
| 10:50 - 11:10 | **Kendra Holmes** Introduction to the Colorado Aquaculture Association and involvement with the Fish Health Board | |
| 11:10 - 11:30 | **John Drennan** Hatchery disease concerns/fish health management | |
| 11:30 - 11:50 | **Toby Mourning** ISO unit use in Cutthroat Trout wild spawns or recovery efforts | |
| 11:50 - 12:00 | Video: Benefits of AFS Membership | |
| 12:00 - 1:30 | LUNCH - on your own | |
| | **Session 1A: Species Interactions**<br>**Room: Salon 1/5**<br>**Moderator: Brody Garner** | **Session 1B: Diversity and Distributions**<br>**Room: Salon 2**<br>**Moderator: Beth Bear** |
| 1:30 - 1:50 | **Dan Cammack** Are Sauger larvae feeling the heat? | **Oliver Wilmot** Using eDNA to investigate native freshwater mussel distribution in eastern Wyoming |
| 1:50 - 2:10 | **Brendan Sucher** Evaluating thermal tolerance in Colorado's native Cutthroat Trout | **Lusha Tronstad** How do geology and water quality influence the distribution of amphibians in the Rocky Mountains of Wyoming? Combining visual and eDNA surveys to investigate amphibian occupancy |
| 2:10 - 2:30 | **Seoghyun Kim** Spawning phenology and factors affecting nest size variation of Bluehead Chub and utilization by a nest associate, Yellowfin Shiner | **Evan Booher** Islanders of the High Plains: Finescale Dace conservation and management in Wyoming |
| 2:30 - 2:50 | **Chance Kirkeeng** Adapting to conditions and opinions to manage Saratoga Lake | **Elizabeth Krone** Interannual fluctuations in hydrology and the Suckermouth Minnow population in the lower South Platte River: a 17 year retrospective evaluation |
| | Sessions 1A and 1B continued on Page 8 | |

## Wednesday, February 27 - Continued

| | | |
|---|---|---|
| 2:50 - 3:10 | **Kurt Fausch** Dolly Varden jaw morphology shifts when together with Whitespotted Charr in Hokkaido streams: another mechanism for coexistence of close competitors? | **Kasey Pregler** Demographic response diversity among stream fishes as a mechanism to maintain species diversity |
| 3:10 - 3:30 | **John Woodling** Natural hybridization of Golden Shiner (*Notemigonus crysoleucas*) and Rudd (*Scardinius erythrophthalmus*) in a Colorado USA Reservoir | **Daniel Brauch and Russell Japuntich** Using passive integrated transponders and portable antenna arrays to determine seasonal movements of trout in two small streams impacted by dewatering and elevated stream temperatures |
| 3:30 - 3:50 | BREAK | |
| 3:30 - 4:50 | Poster Session - Atrium | |
| 5:00 - 5:30 | Kokanee Spawning Video Screening - Salons 1/5 | |
| 6:00 - 10:00 | Student-Hosted Social - Atrium | |

# POSTERS

**Samantha Alford "**Evaluating colonization of fish in the Wyoming Range "

**Jeff Baldock** "Evaluating the use of redd counts in monitoring Snake River Cutthroat Trout in spring-fed tributaries of the upper Snake River watershed"

**Katrina Cook** "Do larger and more Daphnia reduce the presence of chytrid fungus?"

**Dustin Cram** "Wyoming Game and Fish Department, truck fish stocking program"

**Kyle Dick** "Otolith microstructure analysis informs timing of nonnative Northern Pike removal in the Yampa River, Colorado"

**John Fennell** "Exploring mechanisms underlying the persistence of Yellowstone Cutthroat Trout despite hybridization in the North Fork Shoshone River drainage"

**Brody Garner** "Application of Bismarck Brown Y dye as a short-term biological marker"

**Dominique Lujan "**Effects of Lake Trout suppression methods on nutrient cycling and lower trophic levels in Yellowstone Lake"

**William M. Pate** "Status of the opossum shrimp (*Mysis diluviana*) in Colorado and Wyoming: introduction success and invasions"

**Ashley Pilkerton** "Spatiotemporal patterns of hybridization of Walleye and Sauger in the Bighorn and Wind River Sauger populations"

**William Rosenthal** "Effects of hybridization on fitness in *Oncorhynchus* of the North Fork Shoshone River drainage"

**Lusha Tronstad** "An invertebrate multimetric index for Wyoming's wetlands: using invertebrates to assess

## Thursday, February 28

| | ***Session 2: Making Eggs***<br>***Room: Salons 1/5, 2, 3***<br>***Moderator: Samantha Alford*** | |
|---|---|---|
| 8:00 - 8:20 | **Kristopher Holmes** Wyoming's Statewide Spawning Crew - Highlighting the processes, evolution, and challenges to collect and spawn wild fish to benefit the fisheries of Wyoming | |
| 8:20 - 8:40 | **Seth Firestone** Making every egg count: improvements to the Roaring Judy Hatchery Kokanee Salmon (*Oncorhynchus nerka*) production program | |
| 8:40 - 9:00 | **Bryan Johnson** Culturing Colorado's Native Greenback Cutthroat | |
| 9:00 - 9:20 | **Tom Mix** Captive propagation of Plains Minnow, *Hybognathus placitus* | |
| 9:20 - 9:40 | **Joe Marrinan** Spawning Northern strain Largemouth Bass using spawn mats | |
| 9:40 - 10:00 | BREAK | |
| | ***Session 3A: Looking Back to Move Forward***<br>***Room: Salon 1/5***<br>***Moderator: Evan Booher*** | ***Session 3B: Stream Restoration***<br>***Room: Salon 2***<br>***Moderator: Eric Eberhard*** |
| 10:00 - 10:20 | **Douglas Silver** We asked a question | **Erin Leonetti** The million dollar irrigation diversion: Harmony |
| 10:20 - 10:40 | **Jacob Ruthven** O Snake River Cutthroat, Where Art Thou? An evaluation of the success of Snake River Cutthroat Trout in Colorado waters | **Justin Terfehr** Harmony Ditch fish passage/ screening - overview and lessons learned |
| 10:40 - 11:00 | **Travis Trimble** Wyoming Game and Fish aerial fish stocking program | **Kennard Lai** Stream restoration techniques for The Yellowstone Hydroelectric Decommissioning Project in Duchesne County, Utah |
| 11:00 - 11:20 | **Christopher Kopack** Can training species of conservation concern prior to release increase survival? | **Ashley Ficke** Stream quantification tools: the challenge of merging biology and regulation? |
| 11:30 - 1:00 | Business Meeting Luncheon - Salons 3, 4/6 | |

## Thursday, February 28 - Continued

| | ***Session 4A: Upper Colorado Natives***<br>***Room: Salons 1/5***<br>***Moderator: Colton Webb*** | ***Session 4B: Challenging Diseases***<br>***Rooms: Salon 2***<br>***Moderator: Anne Temple*** |
|---|---|---|
| 1:00 - 1:20 | **Kevin Thompson** Manipulation of spawning to favor Colorado River basin native suckers | **Tawni Riepe** The past, present, and future of bacterial kidney disease |
| 1:20 - 1:40 | **Kevin Thompson** Spawning stream fidelity of Bluehead and Flannelmouth Sucker in a tributary network of the Gunnison River | **Dan Kowalski** Prevalence and distribution of *R. salmoninarum*, the causative agent of bacterial kidney disease, in Colorado's wild trout and stocked sport fisheries |
| 1:40 - 2:00 | **Jessica Dugan** Current status of Roundtail Chub in the Blacks Fork drainage of Wyoming | **Brandon Taro** Do you know what's killing these fish? |
| 2:00 - 2:20 | **Edward Kluender** Response of the Green River fish community to changes in flow regimes from Flaming Gorge Dam: 2002-2017 | **Colby Wells** Environmental skin disease: how to identify, treat, and prevent this significant health issue in toad conservation breeding programs |
| 2:20 - 2:40 | **Cameron Walford** Nonnative predators and declining status of Roundtail Chub, Yampa River, Colorado | **Daryl Trumbo** Conservation genomics and Bd resistance of Boreal Toads in the Southern Rocky Mountains |
| 2:40 - 3:00 | BREAK | |
| | **Session 5A: New Approaches**<br>**Room: Salons 1/5**<br>**Moderator: Sasha Maxey** | **Session 5B: Boreal Toad**<br>**Room: Salon 2**<br>**Moderator: Harry Crockett** |
| 3:00 - 3:20 | **Elizabeth Mandeville** Fine-scale genetic patterns in Yellowstone Cutthroat x Rainbow Trout hybrids in the North Fork Shoshone River, Wyoming | **Wendy Estes-Zumpf** Habitat use and movements of super toads in Ryan Park, Wyoming |
| 3:20 - 3:40 | **Catherine de Vlaming** Laboratory and field evaluation of a new LED-lighted light trap for sampling Razorback Sucker larvae | **John Crockett** Survival to metamorphosis of Boreal Toads in Rocky Mountain National Park |
| 3:40 - 4:00 | **Collin Farrell** Induced triploidy for managing invasive Walleye: study overview and preliminary findings | **Brad Lambert** Estimating the probability of movement and seasonal survival in a Boreal Toad metapopulation |
| 4:00 - 4:20 | **Pete Starr** Public outreach at Wyoming Game and Fish Department fish hatcheries | **Sarah Corey-Rivas** Dysregulation of immune gene expression explains tolerance vs susceptibility to Bd fungus in two Boreal Toad populations |
| 4:20 - 4:40 | **Brian Avila** Culturing *Flavobacterium psychrophilum* and standardization of experimental exposures | **Timothy Korpita** Using probiotics as a tool to mitigate chytridiomycosis in wild Boreal Toad populations |
| 4:40 - 5:00 | **Luke Schultz** Using genetic pedigree reconstruction to estimate effective spawner abundance from redd surveys: an example involving Pacific Lamprey | **Boyd Wright** A continuum of risk tolerance: reintroductions of toads in the Rockies |
| 6:00 - 10:00 | Awards Banquet and Raffle | |

# *Opening Session on Aquaculture - We All Need a Little Culture*

***Invited Speaker Biographies***

## Jim Bowker

Jim recently retired from the US Fish and Wildlife Service after 34 years where he spent 10 years as a chemist/research chemist in Ann Arbor, MI, and 24 years in Bozeman as a charter member and research program manager for the Aquatic Animal Drug Approval Partnership program. He's very proud that the AADAP program was instrumental in every new drug added to our fish medicine chest over the last 20 years. Knowing that he simply couldn't walk away from fisheries just because he was retiring, he took a part -time position as the Director of Research and Animal Welfare with Spring Salmon LLC, parent company of Riverence (a salmonid breeding company in Washington) and Evaqua Farms (a trout farming operation in Idaho). Jim also stays involved in fisheries by being an active member of AFS where he serves on a couple of committees and presents at a couple of fisheries conferences throughout the year.

## Jesse Trushenski

Jesse Trushenski is the Director of Science for Spring Salmon LLC, the parent organization for Evaqua Farms (second largest producer of farmed trout and steelhead in the USA, located in Idaho) and its sister company, Riverence (a salmonid breeding company based in Washington). In this role, she provides science leadership and research project management support for Spring Salmon's various aquaculture-related endeavors. Before joining the private sector, Jesse was an Associate Professor at Southern Illinois University and Fish Pathologist Supervisor for the Idaho Department of Fish and Game. Beyond research and teaching, Jesse has fulfilled numerous leadership roles within the fisheries and aquaculture communities. She has chaired or served on multiple advisory panels and other committees addressing aquaculture research, regulation, and policy on a national scale, and is the current President of the American Fisheries Society. She holds a B.S. degree from Western Washington University and a Ph.D. from Southern Illinois University. Whether it's fish nutrition, physiology, or health, Jesse has always been driven by the practical applications of science, going from data to information and information to action.

## Carl Kittel

Carl Kittel is currently the Past-President of the Fish Culture Section (FCS) of AFS, having served as the Secretary-Treasurer, President-Elect, and President of the Section. While serving as President of the FCS, Carl was a member of the Executive Committee and Governing Board of AFS. He has served as Fish Hatchery Program Director with Texas Parks and Wildlife Department for the last 11 years. Carl has worked in Asia, the Pacific, and North America growing over 30 species of aquatic organisms over the last 40 years. His previous work included consulting for Aquatic Farms, Ltd. as a Shrimp Hatchery and Aquaculture Specialist on several development projects in Indonesia, Bangladesh, and India as well as private sector projects in the Philippines, Indonesia, and Malaysia. Carl managed the Guam Aquaculture Development and Training Center, was President and CEO of a coldwater fish production company in West Virginia, and was the Hatchery Program Coordinator for the North Carolina Wildlife Resources Commission before moving to Texas. He has a B.S. degree in Marine Biology from Texas A&M University. Carl is a member of the World Aquaculture Society, the US Aquaculture Society, and the National Aquaculture Association.

## Guy Campbell

Guy is the Fish Culture Supervisor for the Wyoming Game and Fish Department. He graduated from Washington State University with a degree in Wildlife and Fisheries Management. Guy began his fish culture career with Washington Department of Fish and Wildlife where he worked at six different facilities in eleven years which included managing both the Spokane and Colville Trout Hatcheries in his last three years with that agency. In January 2010, he got an itch for a new challenge and adventure and left Washington for Wyoming where he accepted the superintendent position at the Dubois Hatchery. After a little over four years as superintendent, Guy stepped away from hatchery life on-station to become an administrator promoting to the Assistant Fish Culture Supervisor of the Culture Section. He held this position for four years before being selected to his current position as Fish Culture Supervisor last April.

# *Opening Session on Aquaculture - We All Need a Little Culture*

***Invited Speaker Biographies, continued***

## Riley Morris

Riley Morris attended Beloit College in Wisconsin where he received a Bachelor of Science degree in Environmental Biology in 1993. After college he spent five years in Alaska counting and tagging salmon for various USFWS projects. In 1999 Riley moved to Colorado and in May of 2001 was hired at CPW's Rifle Falls State Fish Hatchery as a Technician III. In 2005, he promoted to Assistant Manager at the Durango State Fish Hatchery where he spent 11 years before being hired as the Hatchery Operations Program Manager for CPW in July of 2016. In December of 2018, Riley was hired as the Statewide Chief of Hatcheries for Colorado and since then has vowed never to try for another promotion.

## Kendra Holmes

Kendra Holmes is the President of Aqua Sierra, Inc., a fisheries and water quality consulting firm in Morrison, Colorado, where she leads a team of biologists in executing multifaceted management plans for a variety of complex aquatic resource issues. Kendra graduated from Ball State University with a Bachelor of Science in Aquatic Biology and Fisheries. As part of her undergraduate work, she collaborated with both Ball State and Penn State University in their fisheries and water quality monitoring programs. Kendra began her career working for the public sector at the Bureau of Quality in Muncie, Indiana where she spent several summers evaluating stream characteristics, fish populations, and aquatic invertebrate health. After moving to the west and being responsible for the transportation and stocking of live fish throughout the state, Kendra became involved with the private aquaculture sector. By 2011, Kendra was elected to both the Colorado Aquaculture Association board and Colorado Aquaculture Board where she has served several positions and is board President and Chair, respectively. Most recently in 2017, she was appointed to the Fish Health Board. Throughout her career, Kendra has shown strong leadership skills and passion for promoting the protection of Colorado's natural resources and waters of the US.

## John Drennan

John Drennan is a State Fish Pathologist for Colorado. His duties involve conducting troubleshoots on suspected disease outbreaks at state hatcheries and conducting fish health inspections of hatcheries and wild/feral fish populations throughout the state of Colorado. In addition, John is responsible for the optimization and development of diagnostic assays for bacteriology, virology, parasitology, and PCR laboratories at the Colorado Parks and Wildlife – Aquatic Animal Health Laboratory. He also performs these diagnostic assays for each of these laboratories as well as reviews fish health policy and regulations for the state of Colorado. John has been in the fish health profession for the past 24 years. John received his Master's degree (1998) in Microbiology from Oregon State University that was focused on viruses important to salmonid fish species and received his PhD (2006) in Natural Resources from University of Idaho that further increased his professional development in fish health management, diagnostics, and fish immunology while conducting research on White Sturgeon iridovirus (WSIV). He was also employed in the private industry where he was responsible for the research and development of fish vaccines against a variety of viral and bacterial pathogens. John's diverse experience provides him the opportunity to enjoy training/education of CPW staff and students at Colorado State University on fish health related issues.

## Toby Mourning

Toby Mourning has been the Superintendent at the Durango State Fish Hatchery for the last 14 years with Colorado Parks and Wildlife. Toby worked at the Rifle Falls and Finger Rock Fish Hatcheries before coming to Durango in 2005. Toby has been in the fisheries and aquaculture fields for the last 26 years, starting as a seasonal with CDOW and the USFWS, working with Cutthroat Trout surveys, reptile and amphibian surveys and the Colorado River endangered species program. He holds a B.S. from Colorado State University and is driven by his ability to be a part of conserving our native fishes and producing recreational fish for all to enjoy. Toby is also quite the "rock hound" and an expert of the local mining history.

# 2019 CO/WY AFS Contributed Papers – Abstracts

## By order of presentation followed by posters

### Why keep hatcheries

**Jim Bowker**, Retired - work part time, 87 Rustler Trail, jim3180bowker@gmail.com

Jesse Trushenski, SpringSalmon LLC, jtrushenski@springsalmonllc.com

Gary Whelan, Michigan Department of Natural Resources, whelang@michigan.gov

**Abstract:** The size of the budgetary 'pie' for fisheries management and conservation in the United States has not grown substantially over the years, and there is ongoing debate on how best to slice it up to create, maintain, and restore fisheries. Hatcheries have been a part of fisheries enhancement and recovery for nearly 150 years, but their organization and roles are not widely understood or appreciated and critics suggest that they are ineffective, unnecessary, too costly to operate, or do more harm than good to wild populations. After some years of 'hatchery bashing', the fisheries community came together to thoughtfully assess the uses of hatchery-origin fish, resulting in hatchery reforms and more effective propagation programs. This presentation will elaborate on integrated use of harvest control, hatcheries, and habitat rehabilitation/restoration—the three-legged stool of fisheries management—to better manage fisheries resources. In particular, the role of hatcheries, including their economic costs and benefits relative to habitat rehabilitation efforts and other activities, will be discussed.

### Is Aquaculture Sustainable? Mythbusting Fish, Food, and the Future

**Jesse Trushenski**, Spring Salmon LLC, 87 Rustler Trail, jesse@springsalmonllc.com

**Abstract:** Aquaculture is a modern imperative, for food security, economic development, and conservation and recovery of aquatic resources, but popular media includes considerable mis- and disinformation about the science and practice of aquaculture. The public—including, many fisheries professionals—are unfamiliar with aquaculture and uncertain as to its economic and environmental sustainability. This presentation will articulate the challenge of seafood security, the mandate for aquaculture as a conservation tool and one of the most important sources of protein now and in the future, and address several of the most common sustainability concerns and misconceptions about aquaculture, including use of wild fish as feed inputs, water usage, and the health and safety of farmed fish.

### Introduction to the Fish Culture Section and its role in AFS

**Carl Kittel**, Texas Parks and Wildlife Department, 507 Staples Road San Marcos, Texas 78666, Carl.Kittel@tpwd.texas.gov

**Abstract:** The American Fisheries Society (AFS) is the world's oldest and largest association of fisheries professionals. Within AFS, there are regional Divisions, more localized Chapters and subject specialized Sections. Among the sections, the Fish Culture Section (FCS) is; "concerned with advancing cultivation technology of aquatic organisms for food, commercial and recreational fisheries enhancement, ornamental purposes, and conservation. The Section represents fish culturists and those involved in allied fields such as nutrition, physiology, toxicology, drug development, genetics and breeding, bioengineering, economics, fish ecology, and everything in between. The Section disseminates information about fish culture, and supports the fish culture programs of private, governmental, and

international entities." The FCS provides service to members in the following ways; advancing science and technology, making expertise available and providing community for people in the aquaculture field. One way that FCS advances science is through the North American Journal of Aquaculture. The FCS is very involved in publishing NAJA. The FCS is also very involved in several annual conferences to advance aquaculture science. Expertise is available through the FCS web page and by interacting with presenters at symposia sponsored by FCS our just through interactions of FCS members. FCS also provides a community for people with a common interest. It is useful to interact with a group like this just to see that our problems are not completely unique. Also, by working together we can be a big enough group to have a voice that can affect public policy at least on some occasions. And the relationships we start at a conference like this can continue through future communication and collaboration. It is possible that the Fish Culture Section can provide services to you.

## Overview of the Wyoming Game and Fish Department's Fish Culture Section

**Guy Campbell**, Wyoming Game and Fish Department, 3030 Energy Lane, Casper, Wyoming, 82604, guy.campbell@wyo.gov

**Abstract:** The Wyoming Game and Fish Department maintains ten fish hatcheries and rearing stations. These are managed together as one statewide system collectively meeting production requests by species, number, size and timing. The ten facilities are an integral part of the department's efforts to provide quality fishing, native species restoration and fisheries management. They deal with complex issues, including water management, production management and disease treatment and control. Within the culture section there is also a statewide fish spawning and distribution crew. The spawning crew is responsible for monitoring and spawning wild stocks and the distribution crew for transporting large loads of fish from hatcheries to their designated waters. In recent years, many of the department's fish culture facilities underwent extensive renovations to protect water supplies and improve rearing units. Moving towards the future, the section will need to continue to address facility renovations as well as finding solutions for other challenges which include: fish disease, biosecurity, cool/warm water fish, production demand, etc.

## Hatchery Production in Colorado

**Riley Morris**, Colorado Parks and Wildlife, 6060 Broadway, Denver, CO 80216, william.morris@state.co.us

**Abstract:** The Colorado Parks and Wildlife (CPW) Fish Hatchery Section contributes to the agency's overall mission by providing recreational fishing opportunities to the public and by producing native fish and amphibians in need of conservation. On an annual basis, the hatchery system endeavors to produce approximately 90 million fish of about 40 different species. To achieve this goal, CPW operates 19 fish hatcheries located around the state: 15 coldwater salmonid hatcheries; two warm and coolwater facilities; one facility that produces coldwater and warmwater species; and a facility dedicated to native species restoration. A number of the coldwater hatcheries raise fish from egg to stocking, while others conduct spawn operations, both wild and domestic, to provide eggs for themselves and for other hatcheries within the CPW system. The warm and coolwater facilities conduct pond culture operations, allowing fish to reproduce under natural conditions. The native species restoration facility uses a variety

of aquaculture techniques to maintain or reestablish native species populations in their original habitats. While largely successful in meeting production goals, Colorado's state hatcheries face a number of challenges including increasing demands for sport fish, fish health issues, budgetary constraints, drought, and loss of fish to predators. With the passage of the Future Generations Act last year in Colorado, increases in funding will help address these challenges. As we move forward, Colorado hatcheries will use proactive aquaculture techniques and innovations in hatchery technology to continue to meet the recreational fishing and wildlife conservation needs of the State of Colorado.

## Introduction to the Colorado Aquaculture Association and the Private Sector

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**Abstract:** Did you know that Colorado has a rich history in aquaculture development and production? Most are not aware of the significance Colorado has on aquaculture since it is landlocked; however, the semi-arid climate has driven fish farmers to develop innovative strategies and technologies for augmentation and recirculating aquaculture systems. In 1992, the Colorado Aquaculture Association was formed to provide a unified voice for the collective views of the private sector. This organization, comprised of fish farmers, researchers, educators, consultants, and brokers, is actively engaged in the promotion and improvement of aquaculture across Colorado. The Association meets annually to provide legislative updates and educational opportunities on fish health and propagation advancements. Additionally, private aquaculturists participate on other statutory boards created to review permitting procedures, and/or to initiate or review regulations on fish health, the spread of aquatic disease, or the distribution of any exotic species. Understanding the vested interest of the private industry and bridging fisheries professionals together is key to aquaculture growth in our state.

## Hatchery Disease Concerns/Fish Health Management

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**Abstract:** The economic impact of disease in a hatchery can be additive. Treating diseased fish with therapeutants is expensive but the cost is compounded when there is a loss of production due to mortality. Costs are greater still when growth performance and feed conversion are analyzed. The economic impact of disease can also affect the quality of the product as well as the producer's reputation. The goal, or measure of success, in any fish health management program is the prevention of disease rather than the treatment of clinical disease. Ultimately, this is more rewarding and cost-effective than having to treat sick and moribund fish. Prevention can be complicated, especially if a combination of factors need to be identified in order to implement an effective strategy. In many cases, unfavorable water quality parameters, nutrition, and/or husbandry practices subject fish in a hatchery environment to stressful conditions that lead to disease outbreaks. Therefore, a fish health management plan must focus on optimizing environmental conditions for fish production. Infectious and non-infectious diseases have been an issue since the advent of aquaculture. Understanding the complex interactions between the host (fish), pathogen, and environment is essential for disease prevention in lieu of total reliance on diagnostics and treatment of clinical disease. In addition, keeping

good records of daily mortality, water quality, feed and growth monitoring, and disease and treatment logs, can help with solving current and future problems when they arise as well as predict the health and performance of your fish. In some cases, the occurrence of disease is seasonal or follows the movement of fish. Having these types of records allows for preparedness. Maintenance of quality records also fosters communication and teamwork among hatchery staff. A brief overview of infectious and non-infectious diseases in a hatchery environment and the utility of keeping good records that allows predicting onset of disease will be discussed.

## A Case Study: The Utility of Isolation/Quarantine Facilities for Managing Colorado's Native Cutthroat Trout

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**Abstract:** Wild spawns and fish rescues are key elements to the conservation of Colorado's native species. The purpose of an isolation/quarantine facility is to give aquatic and hatchery managers the means by which they can temporarily hold wild fish and/or fertilized eggs while protecting hatchery fishes from diseases inadvertently transferred from the wild. Progeny from these wild spawn takes are used for starting new conservation populations and hatchery brood stocks. Through rigorous disease testing, these facilities play a large role in Colorado's mission to protect its wild fish populations from disease while at the same time addressing conservation needs. Fertilized eggs (San Juan Lineage Cutthroat Trout, Oncorhynchus clarki pleuriticus) collected from Grayhackle Lake in 2018 were brought into the Durango Hatchery Quarantine facility (DUQ) in early May. A small portion of the progeny underwent lethal sampling for a complete inspection of regulated and prohibited pathogens. In addition, two more populations of wild San Juan Lineage Cutthroat Trout were brought into DUQ during and just after the 416 wildfire in 2018. These wild fish will add to the San Juan Cutthroat Trout brood stock. Colorado's hatchery best management and disease regulatory procedures will be described. The ability to hold wild fish and gametes in Isolation/Quarantine facilities, while not jeopardizing the health of fishes in the hatchery and wild, are critical to conserving native Cutthroat Trout in Colorado.

## Are Sauger larvae feeling the heat?

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**Abstract:** Like other fishes in the family Percidae, Sauger populations of the Wind and Bighorn River drainages of Wyoming exhibit boom and bust recruitment dynamics. Protracted population declines in the early 2000s raised concerns over the fate of this native piscivore and triggered efforts to supplement populations via artificial spawning and stocking operations. These efforts experienced variable production success, prompting a need to understand the underlying ecological factors impacting recruitment, including investigating how temperature influences early life history of this species. We conducted a series of experiments in 2017 and 2018 to evaluate how temperature affects various phases of Sauger reproduction and development, including determining how temperature influences the survival and rates of development in the period from hatch to the onset of exogenous feeding of

larval Sauger. To test this question we incubated Bighorn River Sauger eggs at 14.5°C before transferring the newly-hatched prolarvae to six temperature treatments: five steady (12, 15, 18, 21, 24°C) and one fluctuating on a diel cycle from 17-22°C. We detected significant differences in survival to exogenous feeding (Kruskal-Wallis ANOVA, $P<0.001$), with the 12 and 15°C treatments exhibiting lower survival than all other treatments. Larval development rates were positively correlated with rearing temperature. Most striking were the different endogenous yolk utilization rates, leading to stark contrasts in starvation-related mortality. We developed a regression model to estimate the timing of exogenous feeding (a critical period in development) as a function of environmental temperatures. This predictive tool could be used in conjunction with other types of ecological monitoring to better predict recruitment strength in this valuable species.

## Evaluating thermal tolerance in Colorado's native Cutthroat Trout

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**Abstract:** With stream temperatures expected to rise across the southern Rocky Mountains, the ability of native fishes to tolerate warming temperatures has become a critical concern for those tasked with preserving coldwater species. We used common garden experiments to evaluate critical thermal maximum (CTM), ultimate upper incipient lethal temperature (UUILT), and optimal growth temperature of Cutthroat Trout fry from five populations, representing three subspecies. Neither CTM values (mean ± SD: 27.9 ± 0.35ºC; acclimated at 13ºC), nor UUILTs (mean: 4.4ºC at 7 and 21 days) and optimal growth temperatures (mean:16.2 ± 0.64ºC) measured over 21 days at static temperatures of 11, 14, 17, 20, 23, and 26ºC varied substantially between populations. However, we found that growth differed significantly across populations in the 20ºC treatment, and that fitting a quadratic function, as is the standard, may not be the best practice to represent the temperature-growth data. As such, we also used generalized additive models (GAMs) to suggest that optimal growth temperatures were substantially lower in Greenback Cutthroat Trout (GBCT) from Zimmerman Lake and Colorado River Cutthroat Trout (CRCT) from Lake Nanita (15.1-15.4ºC), than for CRCT from Milk Creek, Yellowstone Cutthroat Trout (YSCT) from the Yellowstone River, and admixed CRCT/YSCT from Trappers Lake (18.5-18.9ºC). All families perished at 26ºC and all but one failed to grow at 23ºC. Peak relative growth however was highly variable ranging from <1% wt./d in the Zimmerman Lake GBCT to > 4% wt./d in the Trappers Lake trout. Knowledge of these thermal tolerance thresholds will not only help identify suitable habitats for repatriation projects, but also for setting water quality temperature standards to help protect these fish into the future.

## Spawning phenology and factors affecting nest size variation of Bluehead Chub and utilization by a nest associate, Yellowfin Shiner

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**Abstract:** Knowledge of reproductive ecology is crucial for understanding the life history of stream fishes, but little is known about daily-scale spawning pattern and intra-species variation in nesting behavior and reproductive interactions with other species. We studied daily spawning phenology and nest size variation of bluhead chub (Nocomis leptocephalus) and utilization by a nest associate, yellowfin shiner (Notropis lutipinnis), at three streams in the upper Piedmont region of South Carolina, USA. A total of 92 nests were located in three streams and we recorded the number of active nests, size of nest, number and size of male bluehead chub, number of yellowfin shiner, and environmental variables for 89 consecutive days during the 2016 spawning season. Spawning activities spanned between April and June and exhibited a periodic pattern. The generalized linear auto-regressive and moving average model showed that the periodic spawning pattern was caused by variation in water temperature, but the effect of water level and photoperiod varied by stream. The path analysis showed that larger males spawned earlier and male size was positively related to various biotic variables including the number of males that shared a same nest, the duration of spawning and parental care, and re-use of nesting sites. Larger male size ultimately led to larger nest size and attracted more yellowfin shiner, which can benefit bluehead chub in this system known as reproductive mutualism, where additional eggs of yellowfin shiner provide a dilution effect when a predator invades the nest. This study suggested that fine-scale spawning phenology was affected by local environmental cues associated with weather conditions, and male body size of bluehead chub was likely a phenotypic trait that mediated nest size variation and interactions with nest associates, with potential consequences for evolution of life history, reproductive behavior and inter-specific interactions.

## Adapting to conditions and opinions to manage Saratoga Lake

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**Abstract:** Saratoga Lake is a popular community fishery outside of Saratoga, WY and visitors to the lake are important for the local economy. The annual ice fishing derby attracts around 750 participants each year, including many that come from other towns or states. Maintaining a fishery with desired species of

large size is important for the lake to remain an attractive destination. To improve Rainbow Trout growth, Saratoga Lake was chemically treated to decrease sucker abundances in 1998. Unfortunately, trout growth has slowed in recent years so an investigation of environmental factors that may be limiting growth was conducted in 2017. Diet overlap between Brown Trout and White Sucker was less than between Rainbow Trout and White Sucker. There was a high frequency of occurrence of zooplankton in Rainbow Trout and White Sucker stomachs (~40%) and a high frequency of occurrence of fish spp. in stomachs of Brown Trout (~50%). In addition, summer water temperatures were warm and above optimal growth conditions (> 65°F) for trout for nearly three months. An angler survey conducted in January 2018 showed that decreasing sucker abundances and diversifying the fishery would improve angler satisfaction the most, but that a chemical treatment was not a preferred management strategy. Based on the available science and input of the community, future management will include stocking predatory fishes and working with a local bait dealer and anglers to target large-sized suckers.

## Dolly Varden jaw morphology shifts when together with whitespotted charr in Hokkaido streams: another mechanism for coexistence of close competitors?

**Kurt Fausch**, Kyoto University, Kyoto, Japan, (deceased)

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**Abstract:** Similar species that come into contact in sympatry may diverge in morphological characters like jaw morphology that are related to resource use, owing to evolution or phenotypic plasticity. Dolly Varden (Salvelinus malma) and whitespotted charr (S. leucomaenis) overlap in distribution along streams in Hokkaido Island, northern Japan, and compete by interference for positions from which to capture drifting invertebrates. Previous research showed that as drifting prey declined during summer, Dolly Varden shifted foraging modes to range widely across the stream bed and capture benthic prey, a behavior facilitated by their subterminal jaw morphology. Here we compare key morphological characters of Dolly Varden in sympatry with whitespotted charr versus those in allopatry in two watersheds draining to different seas bordering Hokkaido, to test for morphological divergence. Statistical analysis showed significant divergence of Dolly Varden morphology in sympatry versus allopatry, in one case in nearby streams and in the other at locations <2 km apart in the same stream. Divergence occurred primarily in jaw characters related to resource acquisition by foraging, and were correlated with charr diets. Dolly Varden in sympatry had shorter lower jaws than those in allopatry (i.e., more subterminal mouths), and fed less on drifting terrestrial invertebrates but more on benthic aquatic invertebrates. These results indicate that Dolly Varden show phenotypic plasticity similar to other charr, allowing a rapid response in morphology to the presence of competitors. Coupled with adaptive shifts in foraging behavior, these morphological shifts likely help them coexist with

whitespotted charr in Hokkaido streams by allowing alternate foraging strategies when food resources are scarce.

## Natural hybridization of Golden Shiner (Notemigonus crysoleucas) and Rudd (Scardinius erythrophthalmus) in a Colorado USA Reservoir

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**Abstract:** Golden shiner (Notemigonus crysoleucas, Mitchill) and rudd (Scardinius erythrophthalmus, L.) were hybridized in laboratory experiment and in a hatchery setting, but had not been reported in wild populations. Here we report the presence of Golden shiner x rudd hybrids in a wild population where both parental species and hybrids inhabit Lake San Isabel in the Wet Mountain Range in Colorado. the hybrid was identified based on intermediate squamation of the keel (cultrate abdomen) and gill raker count. the keel of the hybrids were mostly covered by scales. However, a small fleshy ridge was present at the posterior edge of the keel adjacent to the vent. in contrast, the keel of rudd is completely scaled while the keel of Golden shiner is scaleless. rudd have fewer gill rakers than Golden shiner while gill raker count of hybrids is similar in Range to the Golden shiner. the hybrid phenotype varied from one hybrid that appeared to be much like a Golden shiner to a fish that looked like a rudd. in addition, one hybrid looked like a Golden shiner but had fin coloration exactly like a rudd and a Golden color in the eyes.

## Using eDNA to investigate native freshwater mussel distribution in eastern Wyoming

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**Abstract:** Freshwater mussels are declining worldwide due to impacts from invasive species, polluted aquatic ecosystems, reorganized fish faunas, damming of streams and channelizing of waterways. Seven mussel species are native to Wyoming and we have only recently begun to understand their distribution throughout the state. Currently, none of the mussels in Wyoming are listed under the Endangered Species Act, but six species are listed Endangered in surrounding states. We sampled for environmental DNA (eDNA), trace amounts of genetic material released into an organism's habitat, to investigate the status and distribution of two apparently rare mussels in Wyoming. The Plain Pocketbook (Lampsilis cardium; PPM) is native to the North Platte River drainage in Wyoming and the last live PPM was

observed in the lower Laramie River in 2008. The Giant Floater (Pygaodon grandis; GFM) is native to the Belle Fourche, Little Missouri, and Niobrara River drainages in Wyoming. The distribution of GFM is not refined in Wyoming and only three live individuals were documented since 2008. In 2017 we collected 170 water samples in the North Platte River and its tributaries, but no samples were positive for PPM eDNA. In the Belle Fourche, Little Missouri and Niobrara River drainages we collected 27 water samples and eight showed positive eDNA results for GFM. Although none of our eDNA samples from the Platte River drainage were positive for PPM, we surveyed seven sites in 2018 in the Laramie River near the confluence with the Platte River. We found only old weathered shells and no live mussels. We surveyed 48 sites in the Belle Fourche, Little Missouri and Niobrara River drainages in 2018 and we detected GFM at 29 sites total, including three of the eight sites positive for eDNA. We found a total of 1,263 live GFM ranging in size from 34-164mm. We conclude that PPM are likely either present in very low abundances or extirpated from Wyoming. Conversely, GFM in Wyoming seem to be locally abundant and exhibit wide ranges of shell length, suggesting recruitment is likely occurring.

## How do geology and water quality influence the distribution of amphibians in the Rocky Mountains of Wyoming? Combining visual and eDNA surveys to investigate amphibian occupancy

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**Abstract:** Amphibian diversity is lower in the Wind River Mountains compared to other mountain ranges in western Wyoming, despite the availability of apparently suitable wetland habitat. Low species diversity in the Wind River Range could be the result of historical natural processes (e.g., glaciation, limited dispersal) and conditions (e.g., bedrock geology), recent habitat changes (e.g., novel pathogens, changes in water quality), or a combination of these factors. During 2017 and 2018, we surveyed amphibians using visual and environmental DNA (eDNA) methods and measured water quality, geology, and habitat characteristics at 69 wetland sites in the Wind River, Gros Ventre and Teton Mountain Ranges. We detected all of our focal species (boreal chorus frog (Pseudacris maculata), boreal toad (Anaxyrus boreas), Columbia spotted frog (Rana luteiventris), and tiger salamander (Ambystoma mavortium)) with both survey methods, but our preliminary results suggest detection efficiency was higher for double-observer visual surveys than eDNA sampling. Geology differed among mountain ranges with the western Wind Rivers and Tetons dominated by granite and the Gros Ventre and eastern Wind Rivers with more limestone. Wetlands in granite dominated watersheds tended to have lower ion concentrations (e.g., specific conductivity, Na, Mg and Ca) and lower acid neutralizing capacity compared to limestone dominated watersheds. We are currently evaluating our hypothesis that amphibians are more likely to occur in watersheds with higher ion concentrations, where they may also have lower rates of infection by the fungal pathogen Batrachochytrium dendrobatidis. We are currently completing analyses to investigate how amphibian occupancy and detectability relate to geology, water

quality and other habitat characteristics. Our results will be useful to inform management by clarifying the key factors influencing amphibian distributions in western Wyoming.

## Islanders of the High Plains: finescale dace conservation and management in Wyoming

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**Abstract:** Finescale Dace is a species of greatest conservation need in Wyoming and adjacent states on the Great Plains, where they occur as isolated climate relict populations within the Belle Fourche River and Niobrara River watersheds. The island biogeographic distribution pattern of these populations presents a risk of decline or extirpation within their native range on the High Plains. Translocation actions dating to the 1970's have influenced their distribution within Wyoming, but systematic efforts to evaluate the status of these populations have not occurred in the past. During the 2018 field season we sampled fish community and habitat characteristics at 52 sites within our study area. Sites within the Niobrara watershed were visited during an early season (June – early July) and late season (September) to evaluate potential seasonal shifts in habitat condition and occupancy by Finescale Dace. Extant populations were documented in six distinct drainages in the Belle Fourche River watershed, as well as throughout the Wyoming portion of the Niobrara River. Generalized linear modeling was used to identify patterns in presence and abundance of Finescale Dace related to local habitat and fish community characteristics. Modeled species-environment relationships will aid in the evaluation of translocation suitability for present and future study sites and provide insight into important factors that drive persistence of a rare minnow in river systems of the High Plains.

## Interannual fluctuations in hydrology and the Suckermouth Minnow population in the lower South Platte River: a 17 year retrospective evaluation.

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**Abstract:** Due to a paucity of historical sampling in warmwater plains streams of the South Platte basin, the distribution and population dynamics of less common species, such as Suckermouth Minnow Phenacobius mirabalis, have been poorly understood. Following a comprehensive inventory of South Platte River fishes in the mid-1990s, in which Suckermouth Minnow demonstrated an apparent range contraction and were found at only one location, the species was listed as Endangered by the state of Colorado. Starting in 2001, sampling in potential Suckermouth Minnow habitat of the lower South Platte River generally increased, revealing marked fluctuations in distribution of the species. Following a period of suppressed distribution and abundance, the population appeared to begin expanding in 2009.

The historic September 2013 flood and subsequent increased runoff in spring of 2014 and 2015 appeared to further bolster distribution and abundance of the species, culminating in furthest upstream documentation of the species over the study period. Examination of sampling data and hydrological gage data from 2001 to present indicates that changes in Suckermouth Minnow abundance and distribution were closely linked to trends in annual hydrology. We suggest future research to characterize Suckermouth Minnow movement patterns with an eye toward identifying critical refuge habitat in dry years and barriers to upstream migration. Further, annual monitoring should incorporate collection of more detailed physical habitat measurements to better elucidate causal mechanisms associated with population fluctuations.

## Demographic response diversity among stream fishes as a mechanism to maintain species diversity

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**Abstract:** The southeastern United States retains some of the highest freshwater fish diversity in North America, however it's unclear how this diversity is maintained over ecological timescales. Maintenance of fish assemblages may be facilitated when different species respond differently to temporal variation in abiotic factors at sympatric sites. We investigated demographic response diversity as a potential coexistence mechanism in two piedmont streams in South Carolina using a mark-recapture study to examine temporal variation in survival. Study species included Bluehead Chub (Nocomis leptocephalus), Mottled Sculpin (Cottus bairdii), Creek Chub (Semotilus atromaculatus), and Striped Jumprock (Moxostoma rupiscartes). Bi-monthly apparent survival was estimated using a Cormack-Jolly Seber model between September 2015 – March 2018. Bi-monthly survival ranged from 0.24-0.98 across species, and while bi-monthly survival was often high, the overall mean survival (range = 0.74-0.77) was driven by a select few low bi-monthly survival estimates (e.g. 2 or 3 bi-monthly occasions out of the 15 possible occasions, where minimum survival ranged 0.24-0.54 across species) that may be attributable to seasonal differences (e.g. flow and temperature variation). While we detected seasonal differences in bi-monthly survival, the timing in these patterns differed among species, and demographic response diversity was more apparent in one stream versus the other. Inter-species and spatial variation in population dynamics can buffer species against environmental change and maintain diversity. Evidence of seasonal variation in survival is important given that human-induced changes have resulted in shifts away from historical baselines for aquatic ecosystem functions. Changes in the timing and magnitude of intra-annual environmental conditions can be important in influencing vital rates and may not be adequately captured by annual averages.

## Using passive integrated transponders and portable antenna arrays to determine seasonal movements of trout in two small streams impacted by dewatering and elevated stream temperatures

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**Abstract:** Knowledge of salmonid movement and habitat utilization within a stream system is important to provide agencies the best available information for decision-making. Trout species can travel long distances when finding suitable habitats in streams where water levels and temperatures fluctuate greatly. The degree of trout movement may be an important factor when prioritizing funding between trout habitat improvement and irrigation diversion fish passage projects. In May to November 2018, 11 portable PIT tag antennas were used to track 2578 Brown Trout Salmo trutta and 60 Rainbow Trout Oncorhynchus mykiss in Cochetopa and Tomichi Creeks located in the Gunnison Basin of Colorado. Fish were collected by electrofishing and were tagged in spring and fall time periods at 11 sites. This also allowed a secondary assessment of movement of marked fish. Low water due to drought and irrigation diversions limited summer movements of trout throughout the system. Limited movement was documented in Cochetopa Creek with three percent of tagged trout moving upstream or downstream primarily in the late fall and early winter time period. Four percent of trout moved in Tomichi Creek, primarily upstream in spring, early summer and late fall. Maximum documented distance travelled was over 27 miles upstream in Tomichi Creek and 14 miles downstream in Cochetopa Creek. Utilization of pit tags in this fish movement study also allowed for an assessment of great blue heron Ardea herodias predation on trout within the study area. Two heron rookeries were scanned for Pit tags in November and December 2018. At the Tomichi Creek rookery, approximately 2 percent of PIT tags implanted into Brown Trout in Cochetopa and Tomichi Creeks during spring 2018 were detected. This provides a minimum estimate of great blue heron predation on trout during the heron breeding and nesting season.

## Wyoming's Statewide Spawning Crew- Highlighting the processes, evolution, and challenges to collect and spawn wild fish to benefit the fisheries of Wyoming

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**Abstract:** Geographically speaking Wyoming is fortunate to be a headwaters state. What comes with this is a state that is home to many native and distinct fish populations. When fish hatcheries were established in Wyoming, the Wyoming Game and Fish Department has employed a specialized crew to investigate, collect, and spawn wild fish for building and maintaining wild genetics in Wyoming's captive brood stocks. The presentation will show the challenges, evolution, and techniques the Spawning Crew uses to benefit fisheries in Wyoming and surrounding states.

## Making every egg count: improvements to the Roaring Judy Hatchery kokanee salmon (Oncorhynchus nerka) production program

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**Abstract:** The Roaring Judy State Fish Hatchery, located on the East River is home to the largest kokanee salmon (Oncorhynchus nerka) run in Colorado. Eggs collected during the spawn ensure that 3.5 million kokanee can be restocked into Blue Mesa Reservoir, providing for recreational fishing and future spawning runs. East River kokanee eggs are also utilized by other state fish hatcheries to restock additional Colorado reservoirs. During this presentation Seth Firestone, the manager of the Roaring Judy Fish Hatchery, will provide an overview of the kokanee production program and recent improvements made at the Roaring Judy facility to enhance production. He will share information about the successful use of water chillers, egg treatment systems, and upwelling hatching jars. During this talk Mr. Firestone will also discuss the use of a 400 foot migration barrier on the East River to reduce the number of kokanee that bypass the spawntake facility and the addition of a new release pipeline to deliver kokanee fry directly from the hatchery to the river.

## Culturing Colorado's Native Greenback Cutthroat

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**Abstract:** In 2007, new genetic research, out of the University of Colorado, was used to analyze the DNA of Colorado's native cutthroats to a sub-species level. The analysis determined what were once thought to be pure greenback cutthroats, native to the eastern slope, were in fact Colorado River cutthroats, native to the western slope. It also determined there was one remaining population of pure greenback cutthroats existing in Bear Creek, a small stream west of Colorado Spring.

In 2008, 66 adult greenback cutthroats were removed from Bear Creek to the Salida Isolation Unit. These adults were used to begin the development of a wild and domestic brood stock; to begin reintroductions into their native range. The cutthroats are from a small population isolated for nearly 100 years and have proven challenging to rear in a hatchery setting. This presentation will cover a brief history, culture techniques used and some of the future goals for the greenback cutthroat.

## Captive Propagation of Plains Minnow, Hybognathus placitus

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**Abstract:** The history of artificial propagation of Plains Minnow, Hybognathus placitus, in Colorado began in 2000 with the construction of the Native Aquatic Species Restoration Facility by Colorado Parks and Wildlife. A limited knowledge base was available for the culture and propagation of this species. The first decade was a period of trial and error. Methodologies were researched and field trials conducted to ascertain suitable water quality, nutrition, spawning and habitat requirements unique to this species. A breakthrough occurred in 2011, with the production and stocking of 38,000 Plains Minnow into the Arkansas River basin in eastern Colorado. Today, nearly 750,000 fish have been produced and stocked.

Hatchery, nursery and grow-out phases in the captive propagation of Plains Minnow will be discussed in this presentation.

## Spawning Northern strain Largemouth Bass using spawn mats.

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**Abstract:** The Las Animas Hatchery is located in southeastern Colorado in the lower Arkansas River basin. Built in 1937 by WPA, Las Animas Hatchery is Colorado oldest warm water hatchery.

In 2016 after years of struggling to consistently produce adequate numbers of Largemouth bass fry and fingerlings to support the objectives of the Colorado Parks and Wildlife's Aquatic Biologists, the Las Animas Hatchery began tests on the feasibility of using spawning mats in lined ponds. Two years of trial and error and the staff at Las Animas felt they were ready to go hatchery wide with the SOP they had developed.

The purpose of this presentation is to talk of the procedures we developed, the struggles we faced, the successes we had, and the challenges we still face.

## We asked a question

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**Abstract:** The opossum shrimp (Mysis diluviana) is an aquatic invasive species first introduced in Colorado in 1957. Records are sketchy, but we believe more than 50 Colorado waters were stocked, and we have identified another 50 or so downstream waters that Mysis could have subsequently invaded. In 2013 we began a statewide study to determine the outcome of all Mysis introductions and invasions. In 2017 we also sampled all the waters in Wyoming that were stocked with Mysis. Besides being the first ever comprehensive assessment of Mysis introductions and invasions in the two states, this research has developed a massive database on Mysis population biology, zooplankton assemblages, and limnological conditions which can be used for studying the impact of this invasive species on aquatic ecosystems. Furthermore, the creation of these "mega-data sets" creates a valuable platform available for future researchers. The integration of mega-data collection systems utilizing citizen scientists is a cost-effective way of maintaining or expanding research productivity during times of austerity.

## O Snake River Cutthroat, Where Art Thou? An evaluation of the success of Snake River Cutthroat Trout in Colorado waters

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**Abstract:** Snake River Cutthroat Trout Oncorhynchus clarkii behnkei have been stocked by Aquatic Biologists in Colorado for over 30 years. Colorado Parks and Wildlife often stock these fish in order to diversify angling opportunities and use them to create hybrid strains of Rainbow Trout Oncorhynchus clarkii behnkei x Oncorhynchus mykiss. Despite being heavily stocked, Snake River Cutthroat Trout have become less prevalent in recent standardized sampling efforts. We use historic and current stocking and standardized sampling data to evaluate the success and persistence of Snake River Cutthroat Trout in Colorado lakes and reservoirs. Further, we assess the efficacy of raising and stocking Snake River Cutthroat Trout in Colorado. Our results pose a question for fishery managers: are Snake River Cutthroat Trout a species worth stocking?

## Wyoming Game and Fish Aerial Fish Stocking Program

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**Abstract:** This presentation summarizes the Wyoming Game and Fish Department's aerial fish stocking program. It covers the history of our high mountain lake stocking program from when it was started back in the 1940's to where we are now, including the trials and tribulations we went through over the years. It will encompass our different aerial fish tank designs, past to present, and highlight how GPS and mapping/software technology has positively impacted our program.

## Can training species of conservation concern prior to release increase survival?

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**Abstract:** As global species diversity declines, hatcheries are a valuable tool for supplementing populations at risk of extirpation. However, post-stocking survival of hatchery-reared fishes is often low. Predation, and fish that are unprepared for the environments to which they will be stocked, are thought to be major contributors to mortality after stocking. As such, rearing fish in abiotically-enriched environments and training them to recognize predators prior to release has been proposed as a potential way to increase survival. Although many studies have quantified antipredator behaviors in response to cues of predation, very little attention has been given to what role the abiotic environment plays in shaping these phenotypes, as well as how they may affect survival when encountering a novel predator for the first time. In this study, we used a genotype by environment approach to determine if differences exist between three populations of the Colorado state-threatened Arkansas darter (Etheostoma cragini) in response to abiotic and biotic training. We also tested whether training could increase the chances of survival during first, second, and third encounters with a novel predator. We found evidence of variation in responses to abiotic and biotic training among the populations, differential survival between treatments, and evidence of social learning. We suggest tank enrichment and predator training methods be considered at the hatchery level as a potentially effective way to increase survival of fish stocked for conservation purposes and provide thoughts for how this might be accomplished.

## The Million Dollar Irrigation Diversion: Harmony

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**Abstract:** It all started back in early 2000 with an instream diversion that was a partial to complete passage barrier on the Nowood River known as the Harmony Diversion. In 2006 and 2007 an entrainment study was conducted during the irrigation season showing an estimated 55,000 fish, 16 species including, 4 sensitive species being entrained each season. Sensitive species captured in the canal included burbot (Lota lota), sauger (Sander Canadensis), flathead chub (Platygobio gracilis), and mountain sucker (Catostomus platyrhynchus). Work began in 2009 to explore options that would allow year round upstream passage and prevent fish entrainment. The original design alternative chosen included a new headgate structure with fish screens, a permanent concrete diversion dam with a fish ladder, and sediment sluiceway. Construction was completed in 2014 that included the new headgate structure with two cone fish screens. Unfortunately, the concrete dam, fish ladder and sluiceway plans were developed before issues related to shovelnose sturgeon (Scaphirhynchus platorynchus) passage, ice jams, and long-term maintenance of the adjacent highway were fully evaluated. After considering these issues, engineers went back to designing and finding new alternatives. The new preferred and recently constructed design consisted of moving the diversion upstream, abandoning the newly built headgate, and replaced it with a similar headgate and fish screens at a new site. The new instream structure consists of 5 rock weirs in the stream channel and moving a portion of the irrigation ditch. These designs provided the greatest benefit to the stream, fish populations, and landowner while favorably addressing long-term maintenance and channel stability.

## Harmony Ditch Fish Passage/Screening - Overview and Lessons Learned

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**Abstract:** The Harmony Ditch Fish Passage and Screening Project is a great example of incorporating natural channel design principles with conventional fisheries engineering (and plenty of lessons learned along the way!). The Wyoming Game and Fish Department sponsored project included goals of providing fish passage at the existing rubble diversion and prevent fish entrainment down a 40-cfs irrigation diversion. Specific design criteria were established for passage of all species, screening and irrigation. In 2014, the first phase of construction was completed including a screened irrigation intake. A concrete diversion dam and dual-slot, step-pool fish ladder was scheduled for construction in 2015. After the intake structure was constructed; design criteria, project partners and public perception changed. These changes all led to the concrete diversion/ fish ladder project cancellation. At that time, our design team regrouped (added expertise) and identified a series of eight alternatives to meet all design criteria. A preferred alternative was identified, and full implementation was completed in the Spring of 2018. The project included installation of an irrigation intake structure with fish screens, an instream grade control structure to allow fish passage, 1,900-feet of stream restoration and irrigation improvements. This presentation will touch on the project highlights and lessons learned

## Stream Restoration Techniques for The Yellowstone Hydroelectric Decommissioning Project in Duchesne County, Utah

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**Abstract:** Moon Lake Electric Association, Inc. (Moon Lake), is applying to the Federal Energy Regulatory Commission (FERC) for a surrender of license for the Yellowstone Hydroelectric Project. The Yellowstone Hydroelectric Project is located on the Yellowstone River in Duchesne County, Utah. Originally licensed in 1943, the Yellowstone Hydroelectric Project consists of a 4.6 meter-high, 113-meter long timber, rock, and steel composite dam that impounds a reservoir, a 4,307-meter long penstock pipeline, and a powerhouse with a capacity of 900 kilowatts. Based on findings during the relicensing process, a determination was made that the costs to operate and repair infrastructure, in addition to the low power generation, it is in the best interest of Moon Lake to decommission the project and to satisfy their customers from other sources of power. The project area is on lands managed by the U.S. Forest Service (USFS) in the Ashley National Forest (ANF) Duchesne Ranger District and on private land owned by Moon Lake. This project created a unique opportunity to restore the historic multi-thread channel configuration and restore fish passage. This presentation focuses on the stream restoration components of the project. Reference reaches were identified and surveyed to define design parameters. The stream restoration design restores the historic valley floor by re-establishing a main channel, side channel, and riparian and wetland floodplain habitats. The design optimizes the geomorphic and hydrologic processes to maintain existing hyporheic conditions of the spring feed channels and wetland habitats at the head of the reservoir. Natural analog in-stream structures are

planned to maintain vertical and horizontal stability utilizing local natural materials and maximizing transplanting to provide a cost-effective design. In-channel structures include toe wood, log j-hooks, sod mats, log-boulder riffles and boulder grade control structures.

## Stream Quantification Tools: the Challenge of Merging Biology and Regulation?

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**Abstract:** The science of stream restoration is a relatively new endeavor, specifically as it relates to aquatic habitat improvement and concurrent biological response. The ability to assess changes in habitat quality and aquatic communities following restoration projects allows continual improvement of restoration methods, but post-restoration assessments are rare. Community responses to restoration activities are typically uncertain, resulting in limited inclination to incorporate habitat requirements into design and reduced interest in monitoring aquatic communities before and after restoration. As a result, the biological sciences have been marginalized in many restoration projects in the Rocky Mountain Region. A standardized, consistent and appropriate framework for success measures would facilitate easier project assessment. But these measures must also be acceptable to regulatory agencies. The draft Wyoming and Colorado Stream Quantification Tools (SQTs) provide a means to achieve this consistency, but the challenge of adapting them to the Rocky Mountain Region remains. This is in part due to naturally low fish diversity in many streams, which limits the utility of many standardized fish metrics as measurements of success, particularly indices of biotic integrity. Development of clear and relevant measures of habitat and community health is critical to the successful use of SQTs in the Rocky Mountain region and will require use of the best available science from aquatic ecology and biology. Once developed, these SQT's will provide a consistent and appropriate means of assessing restoration success and informing future restoration designs.

## Manipulation of spawning to favor Colorado River basin native suckers

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**Abstract:** Bluehead Sucker Catostomus discobolus and Flannelmouth Sucker C. latipinnis are species of considerable conservation concern and interest in Colorado and Wyoming. One threat to their continued existence is the spread and proliferation of non-native suckers – especially White Sucker C. commersonii – that both compete and hybridize with the native suckers. Over three years we sought to control a spawning run in Cottonwood Creek, a Gunnison River basin tributary, with a picket weir to favor reproduction by native fishes. Cottonwood Creek is dry the majority of the year, and has no

resident sucker populations, allowing us to gauge success via the genetic purity of larvae ascertained by evaluation of six microsatellite loci. We coupled the effort in Cottonwood Creek with similar evaluation of the spawning run in Potter Creek, a tributary in which we made no effort to control spawning. Large numbers of suckers used each stream, but Potter Creek saw little use by non-native fishes possibly because of further distance from the Gunnison River. We experienced debris-laden runoff conditions each year that compromised the integrity of the weir and thus were unable to completely control access by non-native suckers. Larval genetics largely matched the composition of the adult spawning population in Potter Creek each year, but larval genetics didn't consistently match the composition of the adult spawning population in Cottonwood Creek. In one of the spawning manipulation years, over half of the larvae tested were judged to be White Sucker whereas that species and its hybrids accounted for about 6.5% of adults encountered at our weir location. Despite the occasional incongruence of adult and larval species identity proportions, access control strategies similar to this one may prove useful in facilitating the removal of many suckers that may otherwise contribute to the degradation of genetic purity among Colorado River basin native suckers.

## Spawning stream fidelity of Bluehead and Flannelmouth sucker in a tributary network of the Gunnison River

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**Abstract:** Bluehead Sucker Catostomus discobolus and Flannelmouth Sucker C. latipinnis are the focus of considerable conservation effort. Of the many threats facing these species, hybridization with non-native White Sucker C. commersonii is especially concerning because these invaders are now present in most habitat occupied by the native suckers. One potential action to limit hybridization is to provide spawning locations in isolation of non-native suckers. Colorado Parks and Wildlife researchers have had variable success using a weir to exclude non-native suckers from an intermittent spawning tributary in the Gunnison River basin, and future projects may be implemented on other tributaries. One key assumption of these projects is that the native sucker species possess some degree of spawning tributary fidelity. If these species indeed repeatedly return to their natal stream to spawn, annual exclusion of non-native sucker in certain streams may protect sub-populations from hybridization long-term – even if non-native sucker genetics proliferate range-wide. Over the last several years CPW and other agencies have PIT-tagged thousands of native, non-native, and hybrid suckers throughout the Gunnison River basin, many of which were tagged in the Roubideau Creek tributary drainage. We installed a passive interrogation array (PIA) in spring 2015 near the mouth of Roubideau Creek, and deployed submersible PIT-tag readers at different locations throughout the Roubideau Creek drainage during the 2016-2018 spawning seasons. Redetections of PIT-tagged Bluehead and Flannelmouth sucker at the PIA over multiple years indicated that between 69 and 78% of individuals detected in the Roubideau basin were redetected the following year. Additionally, fish generally return to the specific tributary within the basin that they were originally tagged in if conditions allow. Bluehead and

Flannelmouth sucker exhibit substantial spawning tributary fidelity in this tributary of the Gunnison River, which is encouraging for the success of future non-native sucker exclusion projects.

## Current Status of Roundtail Chub in the Blacks Fork Drainage of Wyoming

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**Abstract:** The Blacks Fork drainage holds the largest contiguous population of Roundtail Chub in Wyoming. Since 2004, little sampling has been conducted to monitor this population, and Burbot have invaded the system. A survey was conducted in 2018 to determine the current status of Roundtail Chub in the Blacks Fork drainage, which includes the Blacks Fork, Hams Fork and Muddy Creek sub-drainages, and evaluate the predation threat of invasive Burbot on native fishes. Roundtail chub greater than 4 in were tagged with Full Duplex 12mm Passive Integrated Transponder Tags for future movement studies. Roundtail Chub were widespread in 2018 and the Blacks Fork sub-drainage supported the highest catches of Roundtail Chub and small Roundtail Chub (<3”). Roundtail Chub catches were second highest in the Hams Fork sub-drainage, and the largest Roundtail Chub were collected in this sub-drainage. The fewest Roundtail Chub were sampled from the Muddy Creek sub-drainage. Of the 560 Roundtail Chub tagged, only five fish were recaptured. Burbot were common throughout the Blacks, Smiths, and lower Hams forks but absent from Muddy Creek, its tributaries, and upper Blacks and Smiths forks, despite the presence of suitable habitat and absence of barriers limiting upstream migration. A sheet piling structure was identified in the Hams Fork that may be acting as a barrier to upstream migration of Burbot. Crayfish were the most common prey item in BBT diets, but fish made up a small proportion (n=174). Native fish were identified in BBT stomach contents, but none were conclusively identified as Roundtail Chub. There was no evidence of Burbot impacting Roundtail Chub through direct predation during this study; however, Burbot predation threat during other seasons and potential to compete with Roundtail Chub for resources is unknown. Dewatering, reduced high flows that create pool habitat, and stream fragmentation likely limit the Roundtail Chub population in the Blacks Fork drainage.This survey was successful at determining the current status of Roundtail Chub in the Blacks Fork drainage and laid the ground work for future studies of Roundtail Chub seasonal habitat use and movements within this system.

## Response of the Green River Fish Community to Changes in Flow Regimes from Flaming Gorge Dam: 2002-2017

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**Abstract:** The upper Green River in Colorado and Utah provides an opportunity to study effects of different levels of flow regulation and water temperature on the fish community due to the moderating input of unregulated Yampa River flows in the middle of the reach. Green River hydrology upstream of the confluence of the Yampa River is mostly regulated by upstream Flaming Gorge Dam, and flows are typically cooler. Downstream of the confluence, the Yampa River contributes a substantial portion of Green River flow in that partially regulated reach, diminishing effects of Flaming Gorge Dam on flows that are typically warmer. Consequently, responses of some species to regulation and water temperature differences may vary upstream and downstream of the Yampa River. We sampled small-bodied fishes in backwaters of the Green River upstream and downstream of the Yampa River confluence using seines during summer and autumn each year from 2002 through 2017. Young-of-year catostomids and native cyprinids and all life stages of nonnative cyprinids were the primary taxa sampled. Including hybrids, 34 taxa were sampled, 11 of which were native. Since 2002, both mean spring and summer flows have increased throughout the reach, especially upstream of the Yampa River. Bluehead Sucker, White Sucker, Flannelmouth x White Sucker hybrid, and native cyprinid densities in the regulated reach were positively correlated with both higher spring peak flows and higher summer base flows. Densities of those same taxa showed weak or no relationship, or were slightly negatively correlated with spring and summer flows in the partially regulated reach. Densities of nonnative cyprinids were negatively correlated with both higher peak and base flows both upstream and downstream of the Yampa River and were typically highest in the partially regulated reach. Higher Green River spring peak and summer base flows since 2011, and associated cooler water temperatures, may benefit reproduction by native species in the Green River upstream of the Yampa River, while disadvantaging nonnative cyprinids throughout the study reach.

## Nonnative predators and declining status of Roundtail Chub, Yampa River, Colorado

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**Abstract:** Roundtail Chub Gila robusta distribution and abundance has declined by more than 50% throughout their native Colorado River Basin range and are a Species of Special Concern in the State of Colorado. To better understand reasons for their decline, we investigated temporal and spatial variation

in population abundance and structure in a 83-mile reach of the Yampa River, Colorado over a 16-year period (2003–2018). Roundtail Chub were captured and marked with PIT tags and capture-recapture data were used to assess population trends and size structure. We documented a dramatic decline in Roundtail Chub distribution and abundance in the Yampa River during the study period. Population structure of Roundtail Chub has shifted and now all life stages are largely absent in upstream reaches. However, one downstream reach still supports juvenile, subadult, and adult Roundtail Chub, but in reduced numbers. We attribute the decline to introduction and expansion of two nonnative piscivores, Northern Pike Esox lucius and Smallmouth Bass Micropterus dolomieu.

## The past, present, and future of bacterial kidney disease

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**Abstract:** Research on bacterial kidney disease (BKD) in salmonids during the last decade has improved our understanding of the biology and regulation of Renibacterium salmoninarum bacterium in aquaculture facilities. However, many questions still remain regarding the prevalence, virulence, and severity in inland salmonids. From the first description of R. salmoninarum in the 1930s, the bacterium was recognized as a highly problematic pathogen in both wild and cultured salmonids. During the early 1940s and 50s, R. salmoninarum was widely disseminated throughout the United States by the transfer of positive eggs and the use of contaminated feed. Currently, the bacterium is widespread throughout populations of salmonids in the United States, with the greatest incidences of disease in cultured fish from the Pacific Northwest and Great Lakes region. Detections in Colorado have been infrequent since the 1960s, but R. salmoninarum has recently been detected again with greater frequency in Colorado state and national hatcheries. Current management efforts have been focused on reducing the overall prevalence of the pathogen in aquaculture facilities and have included depopulation of a unit, the use of erythromycin, and lethal spawning. Depopulation and lethal spawning have limited the rate of transmission of R. salmoninarum in aquaculture facilities; however, both management strategies can result in the loss of valuable or irreplaceable brood stock. Additionally, the bacterium appears to be widespread in wild populations of salmonids and other fish species. Therefore, the major goal of this research is to address the relative importance of vertical and horizontal transmission, and the potential consequences of using infected brood stock for management.

## Prevalence and distribution of R. salmoninarum, the Causative Agent of Bacterial Kidney Disease, in Colorado's Wild Trout and Stocked Sport Fisheries

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**Abstract:** After going undetected in Colorado hatcheries for 18 years, Renibacterium salmoninarum has been found at four state hatcheries, one federal hatchery, and one wild broodstock lake since 2015. The objective of this study was to document the distribution and prevalence of R. salmoninarum in Colorado's wild and stocked sport fisheries and investigate if fish stocking practices have influenced that distribution. Second to fifth order wild trout streams were randomly selected in each major river basin and total of 68 streams were sampled. To investigate if stocking practices have affected the distribution of R. salmoninarum, waters stocked by hatcheries with recent positive tests for were matched with nearby waters with similar management and a total of 75 different stocked sport fisheries were sampled. Kidney samples were collected from up to 60 fish from all waters and samples were tested by ELISA, real-time PCR, nested PCR, and DFAT according to AFS Blue Book standards. Stocking data was compiled for all waters for two 10 year periods, one when hatcheries were free from positive tests and one when positive tests were more common. Results indicate that the prevalence of R. salmoninarum is high in both wild trout and stocked waters by ELISA but that bacteria levels are generally low and not commonly detected by DFAT and PCR assays. Only two cases of clinical disease were observed, one wild trout stream and one stocked lake. Ninety-three percent of all waters tested positive by ELISA, 12% tested positive by both qPCR and nPCR and 13% tested positive by DFAT. Eighty-seven percent of cases that tested positive by ELISA were below detection levels of the DFAT assay. All wild trout waters had some fish test positive by ELISA but there was no difference in the average OD values of stocked and unstocked waters. None of the regression models explained substantial variation in bacteria levels and there was no indication that stocking practices were more associated with ELISA scores than stream order or lake elevation. Renibacterium salmoninarum appears common and widely distributed in Colorado's wild and stocked trout fisheries but at low levels that rarely cause disease.

## Do you know what's killing these fish?

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**Abstract:** There are many things that can cause mortality events in fish. Determining the cause of these events is not always as clear and precise as we would like. Whether these fish are cultured or feral, there are several factors that can either help or hinder obtaining an accurate diagnosis. This presentation will address the limitations of diagnostics, how a fish health pathologist works through a submitted sample, and how to collect a sample that will help lead to an accurate diagnosis. We'll look at basic anatomy, identifying clinical signs, collection and submission of a sample, as well as what information to include with the submission. In short this will be a brief overview of fish health as it directly relates to fish managers and fish culturists.

## Environmental Skin Disease: How to Identify, Treat, and Prevent this Significant Health Issue in Toad Conservation Breeding Programs

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**Abstract:** Environmental diseases cause significant morbidity and mortality in amphibian captive breeding programs. Due to the fragile nature of amphibian skin and its importance in several physiologic functions, even seemingly mild insults, such as dust in the enclosures and suboptimal water quality, can lead to pathologic changes in the skin and severe disease. Awareness of the causes of environmental skin disease is essential for those involved in Boreal Toad and Wyoming Toad conservation breeding programs. This presentation will highlight clinical signs of skin disease in toads and review several case reports in captive toads to demonstrate potential areas of improvement in husbandry. Clinical examination of moribund toads and appropriate diagnostics are essential to properly diagnose skin disease and identify any possible concurrent diseases. Secondary bacterial and fungal infections are common with husbandry-related skin disease, therefore proper treatment with antibiotics and anti-fungal agents are frequently warranted. Histopathology is important for cases that have resulted in mortalities, as they may guide treatment for other ill toads and influence husbandry decisions. An understanding of environmental skin disease facilitates better management efforts for toads in conservation programs.

## Conservation Genomics and Bd Resistance of Boreal Toads in the Southern Rocky Mountains

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Meghan Mahoney, Colorado State University

Harry Crockett, Colorado Parks and Wildlife

Erin Muths, U.S. Geological Survey

Larissa Bailey, Colorado State University

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**Abstract:** Boreal toads (Anaxyrus boreas) have undergone extensive population declines in the southern Rocky Mountains due in large part to skin infections by the chytrid fungus Batrachochytrium dendrobatidis (Bd). As such, the species is listed as Endangered in Colorado and New Mexico, and as a Species of Special Concern in Wyoming. We are performing a conservation genomics study of boreal toads across their range in the southern Rocky Mountains of Colorado, as well as sampling closely related populations in Wyoming and Utah that have not undergone documented Bd related declines, to help conserve and manage the species. We are using restriction site-associated DNA sequencing (RADseq) to genotype thousands of single nucleotide polymorphism (SNP) markers across the genome. This will give us high power to assess population structure, identify conservation units, estimate

effective population sizes, and characterize genetic diversity of boreal toad populations across Colorado. Moreover, dense sampling of SNP loci across the boreal toad genome will also allow us to investigate portions of the genome that may confer resistance to Bd infections, by targeting known disease resistance genes like the Major Histocompatibility Complex (MHC), as well as using a genome-wide association study (GWAS) approach to detect additional genes that may be associated with Bd load. Ultimately, our conservation genomics study will help inform conservation managers tasked with developing management units for boreal toads across the state of Colorado, as well as providing information to help guide potential reintroduction of boreal toads to extirpated populations and supplementation of declining populations.

## Fine-scale genetic patterns in Yellowstone cutthroat x rainbow trout hybrids in the North Fork Shoshone River, Wyoming

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**Abstract:** Hybridization represents a porosity of genetic boundaries between species, and we now know that hybridization dynamics can vary substantially across locations where a pair of species come into contact. In fish, hybridization commonly occurs when a native species hybridizes with an introduced species. This scenario has led to concerns about the conservation of native fish taxa in the US mountain west, as hybridization could lead to extinction or extirpation of native species through demographic processes or loss of genetic identity through hybridization. Our previous genetic studies in the North Fork Shoshone River basin in northwest Wyoming have revealed extensive, but variable, hybridization between Yellowstone Cutthroat Trout and Rainbow Trout. However, the specific types of hybrids we sampled in the North Fork Shoshone suggest that some non-neutral processes are acting to constrain the range of hybrids present, resulting in over-representation of parental species and backcrossed hybrids, and under-representation of later-generation intermediate hybrids. While this pattern might result from assortative mating connected with environmental variables, selection might also play a role. While selection could operate on a per-individual basis, determining which individuals survive and reproduce, selection can also determine which regions of the genome are inherited from each parental species. Additionally, genome structure could skew patterns of ancestry at a particular location in the genome. We re-analyzed data from over 1,000 juvenile trout sampled from the North Fork Shoshone River basin to quantify locus-specific ancestry. We found that genomic regions with unusual ancestry in hybrids are localized in areas of the genome potentially associated with sex determination. This has implications for the fate of hybrid individuals, and in turn for the long-term effects of hybridization on native trout in Wyoming.

## Laboratory and Field Evaluation of a New LED-Lighted Light Trap for Sampling Razorback Sucker Larvae

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**Abstract:** Detection of endangered Razorback Sucker Xyrauchen texanus larvae by light traps is used to prompt flow releases from Flaming Gorge Dam to inundate Green River floodplain wetlands, habitat which may increase survival of those early life stages. However, little is known about the efficacy of light traps to capture or retain larvae. Laboratory experiments have shown strong effects of life stage and light trap set time on capture probabilities, and turbidity may cause declines in capture probabilities for protolarval Razorback Sucker (7-11 mm TL). The standard light source for light traps is a 24-hr chemical light stick. Unlike chemical light sticks, new LED-lit traps have greater light intensities, which are more consistent over time. Laboratory experiments revealed that LED lit light traps captured similar or greater numbers of Razorback Sucker larvae than traps with chemical light sticks, and preference tests revealed larvae preferred the LED-lighted traps. Field tests using releases of marked Razorback Sucker larvae also showed LED lit traps may have greater capture probabilities than traps with chemical light sticks; light traps with either light type detected larvae at low densities in a large floodplain wetland. Results of 2018 Green River larval Razorback Sucker sampling which incorporated LED-lighted traps provide additional support LED lit traps may sample a greater number of larvae than chemical light stick lit traps. However, LED lit traps captured greater numbers of larger non-native predatory minnow species thought to predate on larvae within light traps.

## Induced triploidy for managing invasive Walleye: study overview and preliminary findings

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**Abstract:** Walleye Sander vitreus is a widely distributed and important recreational fish species throughout North America, but they are not native to the western United States. Walleyes can negatively impact native species in their introduced range. Stocking is prohibited in many parts of the West, yet illegal introductions and natural dispersal are common, and managers need a means to limit the impact of introduced Walleyes. Some agencies, including Colorado, Montana, and Utah, have begun stocking triploid Walleyes, which are much less fertile than diploid (normal) fish. Lower fertility could help prevent the establishment of new Walleye populations in sensitive areas, and triploids may interfere with natural reproduction of undesirable diploid populations. However, very little is known

about how triploid Walleyes perform in the wild. In this talk, we outline our plan to investigate how triploid Walleye life history, diet, growth, and survival compare to diploid Walleyes, and present preliminary results from 2018 field sampling.

## Public Outreach at Wyoming Game and Fish Department Fish Hatcheries

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**Abstract:** Often the work conducted by wildlife conservation agencies across the nation is misunderstood due to the technical work that is being completed. This is no different for the Wyoming Game and Fish Department. The 10 fish hatcheries within Wyoming Game and Fish Department have taken strides to increase its public outreach to educate their 40,000 plus visitors per year.

## Culturing Flavobacterium psychrophilum and standardization of experimental exposures

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**Abstract:** Infectious diseases are a major concern in the production, management and conservation of wildlife and fisheries. Hatchery production is an important tool for both management and conservation of fishes and bacterial and parasitic pathogens are an important problem that needs to be addressed. Two important fish pathogens are Myxobolus cerebralis and Flavobacterium psychrophilum that cause whirling disease (WD) and bacterial coldwater disease (BCWD), respectively. Both diseases have profound effects on wild populations of Rainbow Trout and salmonid hatchery production. One successful option for managing WD is the use of genetically resistant fish strains and this is being pursued by Colorado Parks and Wildlife (CPW). Management for controlling BCWD is the use of antibiotics but has the potential for the development of antibiotic resistance in the bacteria. In 2005 the US Department of Agriculture (USDA) developed a Rainbow Trout strain that is genetically resistant to BCWD. However, this BCWD resistant strain is not resistant to WD and any potential benefits in the hatchery could be lost after stocking due to mortality associated with WD. A potential option for management of both diseases is to create hybrid Rainbow Trout that is resistant to both WD and BCWD. We are proposing to evaluate a hybrid of the two strains. This requires development of a reproducible

experimental exposure protocol to test for both WD and BCWD resistance. Our experimental protocol for F. psychrophilum exposure will be discussed. To develop our experimental exposure protocol, we exposed BCWD susceptible Hoffer x Harrison (HxH) Rainbow Trout of different weights to varying concentrations of F. psychrophilum (CSF 259-93 strain) using subcutaneous injections. Results demonstrate a reproducible dose dependent response. The bacterial dose causes an increased probability of mortality and the weight of fish has a negative effect. Our method provides an alternative option for conducting F. psychrophilum experimental exposures compared to previous methods in the literature and we believe is a better option.

## Using genetic pedigree reconstruction to estimate effective spawner abundance from redd surveys: an example involving Pacific lamprey

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**Abstract:** Redd surveys are a commonly used technique for indexing the abundance of sexually mature fish in streams; however, substantial effort is often required to link redd counts to actual spawner abundance. In this study, we describe how genetic pedigree reconstruction can be used to estimate effective spawner abundance in a stream reach, using Pacific lamprey (Entosphenus tridentatus) as an example. Lamprey embryos were sampled from redds within a 2.5 km reach of the Luckiamute River, Oregon, USA. Embryos were found in only 20 of the 48 redds sampled (suggesting 58% false redds); however, multiple sets of parents were detected in 44% of the true redds. Estimates from pedigree reconstruction suggested that there were 0.48 (95% CI: 0.29â€“0.88) effective spawners per redd and revealed that individual lamprey contributed gametes to a minimum of between one and six redds, and in one case, spawned in patches that were separated by over 800 m. Our findings demonstrate the utility of pedigree reconstruction techniques for both inferring spawning-ground behaviors and providing useful information for refining lamprey redd survey methodologies.

## Habitat use and movements of Super Toads in Ryan Park, Wyoming

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**Abstract:** Boreal Toad (Anaxyrus boreas) populations in the southern Rocky Mountains are highly susceptible to the amphibian chytrid fungus (Batrachochytrium dendrobatidis; Bd). Following the arrival of Bd to an area, most populations decline precipitously and many become locally extinct. Only three known breeding sites remain in the Medicine Bow and Sierra Madre mountain ranges of southeastern Wyoming, and only one of these consistently has breeding and relatively high numbers of toads despite being Bd positive since at least 2004. However, substantial beetle-kill surrounding Ryan Park, Wyoming necessitates fuels reduction treatments in the forest adjacent to this Bd-resistant population of Boreal Toads. To better understand habitat use by Ryan Park toads and inform treatment methods, biologists radio-tracked adult toads from mid-June through mid-September 2018. Of the seven toads with >10 relocations, five were tracked to the end of the season in September. The largest distance moved by a toad between relocations was 537 m and the largest cumulative distance moved was 945 m. Toads primarily remained in the riparian corridor throughout much of summer. Willows were the most important habitat component associated with toads; toads were relocated within 1 m of willows 63% of time. Toads also stayed close to refugia. On average, toads were found 0.5 m from burrows or dense shrub cover and were tracked to small mammal burrows 30% of the time. The largest movements occurred in late August when the majority of toads moved out of the riparian corridor toward upland forest winter hibernation sites. Upland sites used by toads were typically downed logs, burrows, or leaf litter near seeps, springs or streams, but several toads also used slash piles in forest clearings. Hibernation sites included a cut bank with a seep along a small tributary approximately 300 m from the main riparian corridor, a decomposing slash pile in a forest clearing, and burrows under a stump approximately 15 m from the main creek channel. Untagged toads were also found at the two upland hibernation sites. Results will help inform fuels treatment methods implemented adjacent to this important breeding site.

## Survival to metamorphosis of boreal toads in Rocky Mountain National Park

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**Abstract:** Boreal toads (Anaxyrus boreas boreas) are in decline throughout the Southern Rocky Mountains and face a serious threat from chytrid fungus (Batrachochytrium dendrobatidis [Bd]), which leads to severe reductions in adult survival. In addition to conservation efforts such as reintroductions, there is a need to expand our knowledge of the biology of the species. Previous demographic studies, focused on the adult life stage, reveal high and consistent survival probabilities in healthy populations, but low and variable recruitment rates into the adult stage. Focusing on specific components of recruitment, such as early life stage survival, will help us better understand the limitations on recovery faced by this species as well as providing benchmarks of success of reintroduction sites.

We studied early life stages of boreal toads in RMNP to determine factors influencing variation in survival of aquatic stages. Specifically, we censused the number of eggs laid at four breeding sites in RMNP across 5 years and estimated the number of surviving metamorphs by batch marking captured

individuals using VIE. We combined these data in a multi-state closed robust-design model and explored differences among sites grouped by the presence or absence of Bd, the presence or absence of trout, wild vs reintroduction sites, and permanence. Survival to metamorphosis was highly variable (range: 0.03 - 0.64). None of the factors that we investigated influence variation in survival from egg to metamorphosis.

## Estimating the probability of movement and seasonal survival in a boreal toad metapopulation

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**Abstract:** We estimated the probability of movement (breeding dispersal and permanent emigration) in a metapopulation of 16 breeding sites for boreal toads in central Colorado. We used a multi-state mark-recapture approach unique in its complexity (16 sites over 18 years) to address questions related to these movements and variation in resident survival. We found that individuals had a 1-2% probability of dispersing in a particular year and that approximately 10-20% of marked individuals were transient and observed in the metapopulation only once. Resident survival probabilities differed by season, with 71-90% survival from emergence from hibernation through early post-breeding and > 97% survival from mid/late active season through hibernation. Movement-related probabilities are useful in predicting species range expansions and contractions, estimating population and metapopulation dynamics, and evaluating the relative effects of proposed management actions.

## Dysregulation of immune gene expression explains tolerance vs susceptibility to Bd fungus in two boreal toad populations.

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**Abstract:** Boreal toads (Anaxyrus boreas boreas) of the Southern Rocky Mountain population have experienced declines due to the introduction of Batrachochytrium dendrobatidis (Bd), an emerging

fungal pathogen that threatens many amphibian species worldwide. Boreal toads in Colorado are generally susceptible to Bd infection, but some Bd-tolerant populations persist in parts of the Southern Rocky Mountain and broader Eastern boreal toad populations. We conducted a Bd challenge with lab-reared sibling toads from Bd-susceptible Colorado and purportedly Bd-tolerant Utah populations, reporting on transcriptomic responses to Bd at late infection in skin tissue. Overall, we observed upregulation of innate and adaptive immune gene expression in both populations. However, Colorado toads had fewer immune genes involved in the response to Bd which were upregulated at much greater magnitudes than Utah toads indicating a dysregulated immune response. Colorado toads also had significant enrichment for downregulated metabolic functions suggesting physiological stress. Signatures of Bd-tolerance in Utah toads included moderate upregulation in gene expression and a significantly enriched suite of gene functions including key functions of the innate, adaptive, and signaling immune response. Our results indicate that Utah toads are tolerant to Bd, rather than resistant, because they carried Bd loads similar to Colorado, had significant gene expression response, and presented minimal clinical signs of chytridiomycosis. We conclude that closely related populations have divergent transcriptomic responses to Bd, with Bd-susceptibility at the population level linked to immune response dysfunction. We summarized key differences in a candidate gene panel for future exploration of functional genetic diversity and specific immune gene mutations that may collectively indicate tolerance to Bd in boreal toads. Understanding the immunogenetic mechanisms of Bd-susceptibility can be incorporated into management planning that supports population functional genetic diversity as part of a natural selection process for disease tolerance in this species.

## Using probiotics as a tool to mitigate chytridiomycosis in wild boreal toad populations

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**Abstract:** Amphibian populations around the world are experiencing declines due to the recently emerged fungal skin pathogen Batrachochytrium dendrobatidis (Bd). In Colorado, Boreal toad (Anaxyrus boreas) populations are undergoing Bd epidemics, however we have a very limited capacity to stem mortality rates caused by Bd in wild populations. Previous work has shown that amphibians harbor diverse microbial communities on their skin, and that some symbiotic bacteria produce anti-fungal metabolites that provide protection from Bd. Prior experiments in our lab have shown that the addition of a probiotic, anti-fungal bacteria increased survival in boreal toads exposed to Bd. This study represents our efforts to translate success observed in the lab to wild populations in the field. During

summer 2018, we conducted a field probiotic experiment on a population of boreal toads in the South Cottonwood drainage in Chaffee County, Colorado. The experiment involved housing individuals in field mesocosms assigned to either a control (sham treated, n=107) group or a probiotic group (n=110). We targeted late stage tadpoles near metamorphosis because previous work has indicated this is a time of skin microbial turnover. We used a strain of Janthinobacterium lividum (Jliv) that was isolated from a toad at the same site. Toads completed metamorphosis successfully in the tubs with very limited mortality. Swab samples were collected at multiple timepoints in the mesocosms to evaluate the microbial communities on the toads in the treatment and control groups. Mucosome soak samples were also collected to allow us to determine how inhibitory the skin microenvironment was to Bd, using assays in the lab. Toads were tagged and released, and resurveys were conducted and will continue. Analysis of marker gene sequencing (16S rRNA) demonstrated that the proportion of Jliv on the skin increases significantly on probiotic treated toads relative to controls, and persists at elevated levels after the treatment is removed. We also found that the specific stage of larval development is another key predictor related to whether the Jliv established in the skin community of metamorphic toads. This work represents a promising new development in translating amphibian probiotics to the field.

## A continuum of risk tolerance: Reintroductions of toads in the Rockies

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**Abstract:** Success in reintroducing amphibians may be more context- than detail-dependent such that a slavish adherence to protocol may not foster success better than a more intuitive approach. We provide two reintroduction case studies for boreal toads Anaxyrus boreas boreas where approaches were different, but where both efforts resulted in gains in understanding, including first estimates of survival for boreal toads from a reintroduced population. Comparing these efforts also highlights the need for restructuring reintroduction guidelines. Disease, or the potential for disease in amphibian populations, is the new status quo for many amphibian systems. Maintaining populations on the landscape through reintroduction provides an opportunity for the development of disease resistance and may facilitate species persistence into the future. Thus, reintroduction is likely to remain an important tool in a conservation toolbox despite disease. However, to be effective, reintroduction guidelines will benefit from a better articulation of the importance of context, risk, and limitations.

# 2019 CO/WY AFS Contributed Posters – Abstracts

## Evaluating colonization of fish in the Wyoming Range

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**Abstract:** Wyoming native fish are affected by multiple stressors including energy development, invasive species, altered flow regimes, droughts, barriers, and livestock grazing. Fish with greater colonization rates are more likely to persist in these stressed ecosystems. Our aim is to compare colonization ability of two native species, mottled sculpin (Cottus bairdii, MSC) and mountain sucker (Catostomus platyrhynchus, MTS), and explore factors that can affect colonization such as abundance and habitat characteristics. We carried out a removal experiment and saw no difference in the number of MSC and MTS colonizers. We are currently modeling potential effects of various factors on colonization. A better understanding of colonization abilities and the factors controlling colonization will provide insight into persistence of native fish species in disturbed habitats.

## Exploring mechanisms underlying the persistence of Yellowstone Cutthroat Trout despite hybridization in the North Fork Shoshone River drainage

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**Abstract:** The Yellowstone Cutthroat Trout is a species of greatest conservation need in Wyoming. Angler harvest, habitat degradation and interactions with non-native species have all led to declines in Yellowstone Cutthroat Trout populations throughout their native range. Currently, the greatest threat facing these populations is hybridization with introduced non-native Rainbow Trout. Within the North Fork Shoshone River drainage, Yellowstone Cutthroat Trout and Rainbow Trout exist in sympatry and readily hybridize. Previous research in this system has shown Rainbow Trout exist throughout the drainage, often in greater densities than Yellowstone Cutthroat Trout. Despite this potential to hybridize, genetically pure Yellowstone Cutthroat Trout still persist in the drainage. Our work will aim to evaluate the mechanisms of reproductive isolation that maintain genetically pure Yellowstone Cutthroat Trout in the North Fork Shoshone River drainage. Potential mechanisms include temporal segregation in

spawning time between Yellowstone Cutthroat Trout, Rainbow Trout and hybrids, and selection against hybrids or parental species. Two tributaries to the North Fork Shoshone River, Trout Creek and Middle Creek, have been selected as study sites as they appear to be utilized by a higher proportion of spawning Yellowstone Cutthroat Trout compared to other tributaries. Genetic sequencing methods will be used to assign genetic ancestry to adult and juvenile fish. We will use traps to capture incoming spawning fish and weekly backpack electrofishing to collect outmigrating juvenile fish. This will provide detailed information on how spawning migration timing relates to genetic identity and how offspring ancestry relates to parental ancestry. This information will help inform management decisions in systems where Yellowstone Cutthroat Trout and Rainbow Trout exist sympatric to one another.

## Evaluating the use of redd counts in monitoring Snake River Cutthroat Trout in spring-fed tributaries of the upper Snake River watershed

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**Abstract:** Assessing population status and trends for species of recreational, commercial, or ecological value is often a primary goal of natural resource management agencies and conservation organizations. Redd counts are a commonly applied tool in fisheries science and management to estimate effective population size for salmonids and allow for greater spatial and temporal coverage in monitoring efforts than can be attained through tradition approaches. However, the validity of redd counts as an index of effective population size may be poor due to substantial sampling error, which may obscure our ability to detect important trends, especially over limited time-frames. Populations of Snake River Cutthroat Trout Oncorhynchus clarkii spp. spawning in groundwater-fed tributaries of the upper Snake River watershed have been monitored via redd counts since the 1960s. However, extremely high rates of redd superimposition (upwards of 90% of redds are superimposed in certain streams) introduce uncertainty into population estimates inferred from redd counts alone. We aim to evaluate the effect of redd superimposition on the validity of redd counts in monitoring population status and trends of Snake River Cutthroat Trout. Our focal questions are (1) how does observer bias and redd superimposition obscure our ability to accurately estimate spawning population size and (2) how can redd counts be used to understand long-term trends and synchrony-stability relationships? By examining redd superimposition, this project will provide insight into the mechanisms underlying the relationship between redd counts and actual redd numbers and population status. The accuracy and precision of any monitoring strategy must be critically evaluated in order to guide best management practices that maintain populations of conservation concern. The sampling error associated with redd superimposition constitutes a considerable gap in our understanding that must be addressed if we are to continue to use redd counts to evaluate population status and trends.

## Effects of Lake Trout Suppression Methods on Nutrient Cycling and Lower Trophic Levels in Yellowstone Lake

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**Abstract:** Lake Trout (Salvelinus namaycush) have been introduced widely across the western United States altering the ecosystems in which they were introduced. In Yellowstone Lake, Yellowstone National Park, the introduction of Lake Trout has caused a 90% decline in the native Yellowstone Cutthroat Trout (Oncorhynchus clarkii bouvieri) population. Following the discovery of Lake Trout in Yellowstone Lake the National Park Service began gillnetting to suppress the invasive fish. In recent years the National Park Service has begun investigating alternative suppression methods to target the embryos of Lake Trout. One of these alternative methods is the use of Lake Trout carcass deposition on Lake Trout spawning sites. Carcasses cause embryo mortality due to a drop in dissolved oxygen, but the effects of this method on nutrient cycling and lower trophic levels in the lake are unknown. This study focuses on the nutrient cycling before and after Lake Trout carcasses were deposited into the littoral zone, as well as tracing the nutrients from carcasses through the lower trophic levels of the food web. Water samples were collected and analyzed for ammonium, nitrate, phosphate, and chlorophyll a throughout the open water season (May-October) to investigate the degree to which carcasses caused an increase in nutrient concentrations. Phytoplankton, zooplankton, benthic algae, and fish were collected and are being analyzed for 15N to trace the nutrients from carcasses and the degree to which those nutrients are being taken up by organisms at lower trophic level. Nutrient data has been analyzed and no significant difference has been observed with the amount of carcass material deposited during the 2018 field season. Samples for isotope analysis have been submitted and we are awaiting results. Adding carcasses may stimulate the littoral food web through bottom-up effects by fertilizing primary producers; however, we are investigating to what degree this may occur depending on carcass loading.

## Wyoming Game & Fish Department, Truck Fish Stocking Program

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**Abstract:** The Wyoming Game and Fish Department transported and released over 12 million fish in 2018. Over 400 different waterways were stocked with a total of 17 species. Completing this task in a safe, efficient, and cost effective manner is quite the challenge. Through the constant evolution of our equipment and methods we have successfully taken on this challenge. Successes include: reduced

mortality, minimizing stress on fish and personnel during transport, increased equipment longevity, and a decrease in equipment maintenance. Our experience utilizing current fish transport technology will provide some useful insight for those looking to improve their stocking program.

## Spatiotemporal patterns of hybridization of Walleye and Sauger in the Bighorn and Wind River Sauger Populations

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**Abstract:** Sauger Sander canadensis are a species of greatest conservation need in Wyoming due to habitat fragmentation, competition with non-native fish, and the potential loss of genetic integrity through co-occurrence and hybridization with Walleye Sander vitreus. Sauger and Walleye are known to hybridize in river systems where they are sympatric and experimental crosses have confirmed the viability of hybrid offspring. Additionally, previous genetic analyses found that detecting hybrids may be challenging without known genotypes as some individuals appeared phenotypically to be one species, but were genetically hybrids. In turn, understanding the underlying mechanisms of hybridization between these species is pertinent for the conservation of native Sauger populations.

In Wyoming's Bighorn and Wind River drainages, Sauger and Walleye live in sympatry, but previous studies have failed to detect hybrids, with the exception of one confirmed Sauger/Walleye hybrid in the Bighorn River in 2014. However, it is possible that hybridization is more prevalent in this system, but that the temporal sampling scheme, coupled with difficulty identifying hybrids phenotypically, may have limited our ability to detect hybridization in previous studies.

In this study, we will be using genomic data (> 10,000 SNPs) to identify the presence and pervasiveness of hybridization between Sauger and Walleye in the Bighorn and Wind River drainages. Importantly, fish were sampled at multiple locations and in multiple time periods, reflecting differences in life history that are known to exist. The target sample size was 50 individuals per sample strata, independent of any phenotype bias. Planned genomic analyses will include identification of hybrids, a quantification of the divergence between life history strategies, and the relationship between these recently isolated populations. Understanding the spatial and temporal dynamics of hybridization and life histories of the Bighorn and Wind River Sauger populations will facilitate effective management decisions and provide a broader context for population genetic structure of Sauger in Wyoming.

## DO LARGER AND MORE DAPHNIA REDUCE THE PRESENCE OF CHYTRID FUNGUS?

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**Abstract:** The zooplankton, Daphnia, is a group of filtering crustaceans which have been documented consuming the infectious size of chytrid fungus in lab studies. However there have been few field studies comparing whether the presence of larger and more Daphnia species help to reduce the presence of chytrid zoospores where amphibians occur. Zooplankton samples were collected during the summer of 2018 at sites in the Bighorn Mountains where amphibians were swabbed for chytridiomycosis. Some results include site filtering rate (1/hr) being effected by both tadpole number estimate and chlorophyll a (algae biomass). We predict sites where there are larger and more Daphnia will result in smaller numbers of zoospores on collected chytrid swabs.

## Effects of hybridization on fitness in Oncorhynchus of the North Fork Shoshone River drainage

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**Abstract:** Hybridization between Rainbow Trout and Cutthroat Trout is a substantial and widespread threat to the maintenance of Cutthroat Trout genetic identity and population persistence. The Yellowstone Cutthroat Trout population of the North Fork Shoshone River drainage has been hybridizing with Rainbow Trout for decades but have managed to maintain non-introgressed Yellowstone Cutthroat Trout individuals. Temporal of spatial differences in spawning between the species may partially explain the persistence of Yellowstone Cutthroat Trout, but differential fitness between hybrid and non-hybrid fish may also substantially contribute. To address this, we will sample adult and juvenile Oncorhynchus from two tributaries, Middle Creek and Trout Creek, which have shown to have a higher proportion of Yellowstone Cutthroat Trout ancestry than others in the area. In the spring, adult fish will be captured by traps as they migrate up the tributaries to spawn, and juvenile fish will be sampled by weekly backpack electrofishing in the late spring and early fall as they out migrate to the river's main stem. Genetic samples will be collected from each fish and sequenced using a restriction digest protocol to obtain information at thousands of sites across the genome. With these data, we can identify parent-offspring relationships and hybrid status which will allow us to assess reproductive output as a function of parental ancestry. Importantly, we will be able to directly estimate fitness in a natural population, a crucial but difficult undertaking for studies of hybridization. This data can also be used to identify regions of the genome that may impact early-life mortality and understand how the difference in chromosome numbers between the parental species impacts the sharing of genetic information in hybrids. More broadly, this work can provide managers with more information on how the outcome of Rainbow Trout and Cutthroat Trout hybridization may change depending on the genetic background of the populations in question.

## An invertebrate multimetric index for Wyoming's wetlands: using invertebrates to assess ecosystem quality

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**Abstract:** Aquatic invertebrates are widely used as indicators of stream quality; however, they have infrequently been used to assess wetland quality. Invertebrates are excellent monitors of aquatic

ecosystems because they are relatively long lived, sedentary, abundant, diverse, easy to collect and have differing responses to poor water quality or other degradation. We estimated the ecological condition and sampled aquatic invertebrates associated with wetlands in the Great Divide Basin and Little Snake River basins of Wyoming in 2016 and 2017. We collected aquatic invertebrates using a D-frame dip net. We identified 170 invertebrate taxa from 57 sites. We are currently analyzing the data to assess which metrics have the largest range between reference and degraded sites and which metrics are most responsiveness to alterations. After the best metrics are chosen, we will check for correlations and finalize the multimetric index for Wyoming wetlands. We will be investigating to what degree invertebrate assemblages vary among wetland type and if a single index can be used to rank all wetlands. The multimetric index for Wyoming wetlands may be a handy tool to assess wetland conditions using aquatic invertebrates.

## Status of the opossum shrimp (Mysis diluviana) in Colorado and Wyoming: Introduction success and invasions

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**Abstract:** The opossum shrimp (Mysis diluviana) is a coldwater planktivorous crustacean native to the Upper Midwest and Canada. Mysis were first introduced to our region at Lower Twin Lakes, Colorado in 1957, with individuals transplanted from Clearwater Lake, Minnesota. During the 1960s and 1970s Mysis from Twin Lakes were subsequently transplanted into over 50 lakes and reservoirs throughout Colorado and Wyoming with the intention of increasing food availability for sport fish. Stocking was done from hatchery trucks at lower elevation, more accessible waters and from horseback, and aircraft in more remote, high elevation waters. Most lakes were stocked once, but others were stocked up to 10 times. A few other waters were known to have been invaded from stocked waters upstream. The overall outcome of this massive stocking program has never been studied in a systematic way. Beginning in 2013, we began a comprehensive sampling survey of over 100 waters in Colorado and Wyoming that were stocked or that could have been invaded. To date, we have sampled 59 waters, 24 of which were found to contain Mysis, and we documented four invasions of unstocked waters. The spatial distribution of stocked waters and waters vulnerable to invasion, as well as status of Mysis in each, will be presented.

## Application of Bismarck Brown Y dye as a short-term biological marker

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**Abstract:** To effectively make sound management decisions, population estimates are critical for fisheries managers. However, they can be difficult to obtain for small fish species. We conducted a laboratory experiment to determine which concentrations of Bismarck Brown Y solution (1:15,000/ 1:30,000/ 1:60,000) and fish exposure time (one and two hours) provided the most effective mark retention over a five-day experiment. Iowa Darter (Etheostoma exile) exposed to a dye solution for two hours displayed the most noticeable dye coloration after 96.75 elapsed hours indicating exposure time is more critical than dye concentration. A field experiment was conducted to evaluate the feasibility of this short-term biological marker in mark-recapture population estimates. Captured darters were dyed in a Bismarck Brown Y solution [1:15,000] for two-hours and then recaptured approximately 57 hours later. This field experiment displayed the benefit of Bismarck Brown Y to be safe to use on small fish species while allowing users to have a wide margin of error of dye solution concentration when mixing it in the field. Recommended use of Bismarck Brown Y as a marking method would include when managers need a short-term mass marking of sensitive species, accessibility to new equipment is restricted, and financial resources are limited. Use of Bismarck Brown Y would not be recommended to use if trying to track fish over time or when information about a specific fish is needed.

## Otolith microstructure analysis informs timing of nonnative Northern Pike removal in the Yampa River, Colorado.

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**Abstract:** Invasive Northern Pike negatively affect the native fish community in the Yampa River. Current management to reduce effects includes physical removal during spawning when pike congregate in riverine, channel-margin backwaters and are most susceptible to capture. To better understand and enhance management effectiveness, we investigated timing and duration of Northern Pike spawning in the Yampa River. To accomplish this, we collected young-of-year Northern Pike in 2011, 2016, 2017, and 2018 (71–198-mm total length), aged them by counting daily increments, and estimated hatching dates by subtracting age from the collection date. Temperature-dependent incubation periods were derived from local water temperatures and relationships in the literature to estimate spawn dates and better understand initiation and duration of spawning. We found that spawning began as early as 31 March in 2017, a year with early ice-off and as late as 1 May in 2011, a high-water year with late ice-off. Spawning duration ranged from 28 to 46 days. During spawning periods, mean daily flows were 2,907 cfs in 2017 to 9,185 cfs in 2011. Mean daily water temperature was 7°C at the start and averaged 8°C for the entire spawning period each year. Comparison of spawning seasons from our analyses with dates of adult removal from backwaters indicated removal sampling started about one to three weeks prior to estimated start of spawning and ended one to four

weeks before the end of spawning. We recommend extending the duration of adult removal one or more weeks to maximize the number of individuals removed later in the spawning season and to increase the period of spawning disruption.