Colorado/Wyoming American Fisheries Society Annual Meeting - Fostering Aquatic Resiliency

Event Schedule

Mon, Feb 28, 2022

8:00am

Continuing Education: Drones in Fishery Science

8:00am - 11:30am, Feb 28

The use of unmanned aircraft systems (UASs), commonly referred to as drones, has rapidly expanded across many scientific disciplines. Like other fields, fisheries research would benefit significantly from broader use of this emerging technology but has lagged behind other disciplines. The goal of the class is to provide information on how drones are being used for fisheries and other aquatic applications. The seminar will cover case-study examples and provide information on equipment considerations, software, operations, regulations, licensing and permitting, and putting together workflows for quantitative data and image analysis.

Speakers

J. Mason Harris Environmental Consultant , Axiom Environmental

James Nelson Ph.D. Assistant Professor , University of Louisiana at Lafayette

Dr. Whitney Broussard III Senior Scientist , JESCO, Inc.

Tue, Mar 01, 2022

8:00am

2022 Photo Contest

8:00am - 9:00am, Mar 1

View the 2022 Photo Contest Slideshow!

9:00am

Continuing Education - Giving a presentation vs. standing in front of people and saying words--tips and tricks to create and deliver an engaging presentation

9:00am - 10:30am, Mar 1

If you've been to a professional meeting, odds are you've seen some great talks...and at least a few presentations that missed the mark. Content matters, of course, but the best presentations have both style and substance. In this course, you will learn tips for presenting data effectively and accurately, formatting fixes to level up your PowerPoint game, and a bit about the psychology of crafting memorable messages.

Speaker

Dr. Jesse Trushenski Chief Science Officer , Riverence

1:00pm

Opening Remarks and Plenary: Fostering Aquatic Resiliency

1:00pm - 3:05pm, Mar 1
Zoom webinar

Speakers

Shawn Conner Restoration Ecologist, Bio-Logic

Ben Goldfarb Independent environmental journalist, Self-Employed

Dr. Emily Fairfax Assistant Professor of Environmental Science and Resource Management, California State University Channel Islands

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4 Subsessions

- Opening Remarks and Whova Rundown from Chapter President
  1:00pm - 1:20pm, Mar 1
- Reading the landscape to inform restoration site potential
  1:20pm - 1:55pm, Mar 1
- Dam it: working with beavers to achieve restoration goals
  1:55pm - 2:30pm, Mar 1
- Ribbons of refugia: beavers create durable fire-resistant patches of riparian habitat throughout the Rocky Mountain region
  2:30pm - 3:05pm, Mar 1

3:15pm

Speed Networking

3:15pm - 3:45pm, Mar 1

Come join us for a social mixer and meet other meeting participants! You'll be assigned to a table of 4 people that will get shuffled every 5 minutes. Be prepared with questions such as where are you from and where to you work. It should be a blast!

4:00pm

Disappearance to Recovery
4:00pm - 5:00pm, Mar 1

Moderator

Estevan Vigil

3 Subsessions

- "Sweet" ride to recovery
  4:00pm - 4:20pm, Mar 1
- Debris flows following the Cameron Peak Fire cause catastrophic loss in the Brown Trout Salmo trutta fishery of the Cache la Poudre River, Colorado.
  4:20pm - 4:40pm, Mar 1
- Fishways mitigate effects of diversion fragmentation on fish assemblage structure and movement in a Front Range river
  4:40pm - 5:00pm, Mar 1

Reservoir Ecology
4:00pm - 5:00pm, Mar 1

Moderator

Kevin Rogers Aquatic Researcher, Colorado Parks and Wildlife

3 Subsessions

- Integrating traditional and novel stable isotope analyses to understand foraging dynamics in New Fork Lakes, WY.
  4:00pm - 4:20pm, Mar 1
- Stable isotopes reveal ontogenetic shifts in foraging ecology of Lake Trout within Flaming Gorge Reservoir, Wyoming-Utah
  4:20pm - 4:40pm, Mar 1
- Evaluation of natural and hatchery-produced Kokanee in Flaming Gorge Reservoir
  4:40pm - 5:00pm, Mar 1

6:30pm

Film - The Beaver Believers with Q&A
6:30pm - 8:30pm, Mar 1

Sometimes the best solutions to the biggest problems can be found in the most unexpected places. Meet the beaver believers: five scientists and a sassy, spicy hairdresser, tackling climate change, one stick at a time.

The Beaver Believers is the urgent yet whimsical story of an unlikely cadre of activists who share a common

vision: restoring the North American Beaver, that most industrious, ingenious, bucktoothed engineer, to the watersheds of the arid West. The Beaver Believers encourage us to embrace a new paradigm for managing our western lands, one that seeks to partner with the natural world rather than overpower it. As a keystone species, beaver enrich their ecosytems, creating the complexity and resiliency our watersheds need to absorb the impacts of climate change. Beavers can show us the way and even do much of the work for us, if only we can find the humility to trust in the restorative power of nature and our own ability to play a positive role within it. Shot in 8 western US states, Mexico, and Canada, through desert drought, raging wild fires, spring floods, and wetland tranquility, this film will change the way you think about climate change and inspire you to step up to confront the challenges we face.

Speakers

Sarah Koenigsberg

Dr. Emily Fairfax Assistant Professor of Environmental Science and Resource Management, California State University Channel Islands

Wed, Mar 02, 2022

8:00am

Continuing Education - Low Tech Processed Based Restoration of Riverscapes

8:00am - 12:00pm, Mar 2

This half-day virtual-based workshop will be presented as part of the American Fisheries Society Continuing Education Program at the Colorado/Wyoming annual meeting. The workshop is intended to introduce resource managers, land-owners, and conservation groups to 'low-tech' process-based (LTPBR) approaches for restoring streams and their associated riparian areas (riverscapes) to benefit fish and wildlife. People that have some knowledge of LTPBR can also benefit as the instructors will be providing lessons learned from assessing, planning and implementing dozens of LTPBR projects across a wide variety of geographic settings in multiple states. Participants will learn principles guiding low-tech process-based restoration, become familiar with basic beaver ecology, and different types of low-tech structures, including Beaver Dam Analogues (BDAs) and Post-Assisted Log Structures (PALS). The focus of the workshop will be on the guiding principles, the construction of different low-tech structures, and the impairments the structures can treat. Specific examples related to fish population responses will be presented. A workshop website is provided which will include more in-depth information including links to digital copies of a low-tech process-based restoration manual and pocket guide, and an online lecture series which can be viewed either as videos or pdf documents. We encourage workshop participants to review Module 1 lecture material before the workshop (see link below). Hard copy manuals and pocket guides will also be available at the workshop free of charge.

Speakers

Stephen Bennett Fish and Wildlife Biologist, Principal of Anabranch Solutions and Utah State University Adjunct

Scott Shahverdian Geomorphologist, Associate of Anabranch Solutions and Utah State University Researcher

Brian Murphy P.E., Water Resources Engineer , Associate of Anabranch Solutions

1:00pm

Business Meeting

1:00pm - 2:15pm, Mar 2

Please join us for the annual Chapter business meeting. We will share Chapter updates from committees and plans for the 2023 annual meeting. A representative from Western Division will also provide an update. We plan to discuss updating our Chapter logo and announcing travel grant award recipients.

2:30pm

What's Your Move? - I

2:30pm - 3:30pm, Mar 2

3 Subsessions

- Population genetics reveals bidirectional fish movement across the Continental Divide via an interbasin water transfer
  2:30pm - 2:50pm, Mar 2
- A small seasonally warm tributary provides prespawning resources for endangered Colorado Pikeminnow in a dam-regulated river system
  2:50pm - 3:10pm, Mar 2
- Evaluating movement patterns of Roundtail Chub and Flannelmouth Sucker in the Blacks Fork Subbasin
  3:10pm - 3:30pm, Mar 2

Small is Mighty - I

2:30pm - 3:30pm, Mar 2

Moderator

John Alves Senior Aquatic Biologist, Colorado Parks & Wildlife

4 Subsessions

- Relative inference with paired data
  2:30pm - 2:50pm, Mar 2
- Does temperature limit the upstream distribution of fishes in the Rocky Mountain region?
  2:50pm - 3:10pm, Mar 2
- Experimental test of condition-specific competition between native Plains Topminnow and non-native Western Mosquitofish
  3:10pm - 3:20pm, Mar 2
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Hydrologic controls on growth and production of age-0 Snake River Cutthroat Trout
3:20pm - 3:30pm, Mar 2

3:45pm

What's Your Move? - II
3:45pm - 4:45pm, Mar 2

Speaker, Moderator

Liz Krone Aquatic Research Data Specialist, NE Native Aquatics Technician, Colorado Parks and Wildlife

3 Subsessions

- Culvert baffles – a low-cost fish passage solution
  3:45pm - 4:05pm, Mar 2
- Understanding the biological impacts of sediment flushing flows on spawning habitat: A case study of Willwood Dam, WY
  4:05pm - 4:25pm, Mar 2
- Grand challenges of the 21st century
  4:25pm - 4:45pm, Mar 2

Small is Mighty - II
3:45pm - 4:45pm, Mar 2

Speaker, Moderator

Elise Huysman Wyoming Game and Fish Department

4 Subsessions

- Monitoring plankton to assess the success of controlling invasive lake trout
  3:45pm - 4:05pm, Mar 2
- How a rare aquatic beetle makes a living in salty, ephemeral streams in central Wyoming
  4:05pm - 4:25pm, Mar 2
- A rusty crayfish story in Wyoming
  4:25pm - 4:35pm, Mar 2
- Fly Links an unique ecosystem sport
  4:35pm - 4:45pm, Mar 2

6:00pm

Student-Hosted Quiz Bowl and Social

6:00pm - 8:00pm, Mar 2

Join the student sub-units in a good old fish quiz! Test your knowledge. Following the quiz bowl there will be zoom social.

Thu, Mar 03, 2022

8:00am

Pre-recorded Talks
8:00am - 11:00am, Mar 3

7 Subsessions

- **Vulnerability of warm-, cool-, & coldwater fishes to stream warming in Wyoming & Montana**
  8:00am - 11:00am, Mar 3
- **Pond attributes associated with breeding presence of an isolated population of the wood frog (Lithobates sylvaticus)**
  8:00am - 11:00am, Mar 3
- **Reintroduction of an extirpated mussel to southeastern Wyoming**
  8:00am - 11:00am, Mar 3
- **Getting a pulse on invasive Brook Stickleback in Wyoming: distribution, habitat drivers, and overlap with native fishes in the North Platte River drainage.**
  8:00am - 11:00am, Mar 3
- **Evaluation of Longrie-Fectau fish passage structure for Great Plains fishes.**
  8:00am - 11:00am, Mar 3
- **Tracking co-occurrence of invasive carp with native predators over twenty years: high biomass, low availability**
  8:00am - 11:00am, Mar 3
- **Variable reproductive success across Oncorhynchus spp. in the North Fork of the Shoshone River**
  8:00am - 11:00am, Mar 3

1:00pm

Scientific Production
1:00pm - 2:30pm, Mar 3

Walleye Sander vitreus are a highly sought-after sportfish in North America but they are not native to Colorado waters. Dispersal of Walleye across the landscape, whether by legal, illegal, or natural means, are of concern to native species recovery efforts, as predation by and competition with invasive Walleye are known to have negative impacts on native species. Because triploid fish are typically sterile, the stocking of triploid Walleye is an alternative management approach to limit the risk of establishing new populations in areas with sensitive native species. There are few studies that have examined the trophic dynamics of triploid fish relative to diploid conspecifics, and under natural conditions. Lab studies with other species suggest that triploid fish may be less aggressive predators than diploid fish. Managers wishing to stock triploid walleye would have a better idea of what they might consume and how they would fare in their waters if more was known about prey selection of wild triploid walleye relative to diploid walleye. In this talk, we will present preliminary results of diet composition and prey size selection of a diploid and triploid Walleye population in Narraguinnep Reservoir, Colorado.

Moderator

A

Andrew Treble

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5 Subsessions

- Intensive fish culture of Walleye at Wyoming Game and Fish Department's Dan Speas Fish Hatchery
  1:00pm - 1:20pm, Mar 3
- Triploid Walleye: some considerations for managers
  1:20pm - 1:40pm, Mar 3
- Prey selection of diploid and triploid Walleye in a prey-limited system
  1:40pm - 2:00pm, Mar 3
- Population dynamics of MYY Brook Trout in Northern New Mexico
  2:00pm - 2:20pm, Mar 3
- Kokanee Salmon broodstock recap Tillett Rearing Station
  2:20pm - 2:30pm, Mar 3

Boreal Toads!

1:00pm - 3:00pm, Mar 3

Moderator

H

Harry Crockett Native Aquatic Species Coordinator, Colorado Parks & Wildlife

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6 Subsessions

- Wildfire influences individual growth and dispersal, but not survival and recruitment in a montane amphibian
  1:00pm - 1:20pm, Mar 3
- PIT-tagging versus photography: Trade-offs in intial and long-term handling efficiency
  1:20pm - 1:40pm, Mar 3
- No evidence for compensatory recruitment in montane amphibian populations challenged with chytrid fungus
  1:40pm - 2:00pm, Mar 3
- Environmental application of an Anti-Bd probiotic bacteria at a boreal toad breeding site
  2:00pm - 2:20pm, Mar 3
- Boreal toad population differences in transcriptome-level response to Bd fungus indicate dysregulated immune respone in susceptible populations
  2:20pm - 2:40pm, Mar 3
- Conservation and landscape genomics of an endangered montane amphibian reveals high historical gene flow, low genetic diversity, and selection pressure from disease

2:40pm - 3:00pm, Mar 3

2:45pm

Poster Session

2:45pm - 3:15pm, Mar 3

Speaker

Jim White

3 Subsessions

- Density-dependence outweighs habitat influences on Brook Trout condition in the southeastern US
  2:45pm - 2:55pm, Mar 3
- Body condition explains exploratory movement of Creek Chubs in experimental streams
  2:55pm - 3:05pm, Mar 3
- Gill lice distribution, prevalence, and infestation intensity in the Upper Snake River Watershed
  3:05pm - 3:15pm, Mar 3

3:30pm

Awards Presentation and Raffle

3:30pm - 5:00pm, Mar 3

The Awards Committee will present Chapter awards including the Award of Excellence, Max Award of Merit, Outstanding Mentor Award and the Leaky Boot Award. Best Paper/Poster Awards will also be presented. Following the awards presentation, the Raffle Committee will draw tickets to determine the winners of our fabulous raffle items.

2022 CO/WY AFS Contributed Papers – Abstracts

By order of presentation followed by posters and prerecorded

"Sweet" ride to recovery

Steve Gale, Wyoming Game and Fish Department, 1212 South Adams, Laramie, WY 82070, Steve.Gale@wyo.gov

Paul Gerrity, Wyoming Game and Fish Department, 260 Buena Vista Drive, Lander, WY 82520, paul.gerrity@wyo.gov

Abstract: This is a western native fish success story. A story that ranges across management and hydrological boundaries. Hornyhead Chub *Nocomis biguttatus* is one of the rarest fishes in Wyoming and a Species of Greatest Conservation Need. Wyoming's population is geographically isolated from other Hornyhead Chub populations in the United States, making it a glacial relict. Wyoming's small population size, fragmented distributions and limited dispersal make its population especially susceptible to common stressors such as wildfires, predation by non-native fish species, and increased sedimentation in rivers and streams. The species was historically documented in Box and Rawhide creeks and the Sweetwater, Laramie, and North Laramie rivers within Wyoming. However, by the beginning of 2020, it was limited to two isolated populations within the Laramie and North Laramie rivers. The North Laramie River population was extirpated by the 2012 Arapaho Fire, but has been re-established through numerous translocations from the Laramie River population. The temporary loss of the North Laramie River population to a catastrophic environmental disturbance demonstrated the precariousness of the species' continued existence in Wyoming, and emphasized the need to expand the range of the species before a possible statewide extirpation. An extensive evaluation of North Platte River drainage streams in 2016 and 2017 by the Wyoming Cooperative Fish and Wildlife Research Unit found that the Sweetwater River likely provides the best conditions for translocated Hornyhead Chub survival based on similarities in habitat and fish assemblage to the Hornyhead Chub-occupied Laramie River. Based on this research and the species' former presence in this river, re-introduction of Hornyhead Chub to the Sweetwater River successfully occurred in 2020 and 2021. Future work includes monitoring with eDNA and electrofishing, and possibly more rides to recovery.

Debris flows following the Cameron Peak Fire cause catastrophic loss in the Brown Trout *Salmo trutta* fishery of the Cache la Poudre River, Colorado

Elizabeth Krone, Colorado Parks and Wildlife, 317 W. Prospect Rd., Fort Collins, CO 80526, elizabeth.krone@state.co.us

Kyle Battige, Colorado Parks and Wildlife, 317 W. Prospect Rd., Fort Collins, CO 80526, kyle.battige@state.co.us

Abstract: While ecosystems in the western United States have evolved with fire, and in some cases are even dependent upon fire to support renewal and growth, the intensity of current day wildland fires supersedes that of historical fire regimes. Increasing fire severity will continue to impact streams and it will be increasingly important for fisheries managers to understand short- and long-term impacts on recreational fisheries. The Cameron Peak Fire in 2020 and associated Black Hollow Flood in the Cache la Poudre River in 2021 provide an opportunity to study the aftermath of a catastrophic fire and subsequent monsoonal precipitation event on a recreational fishery. To better understand the immediate ramifications to the Brown Trout *Salmo trutta* population post-fire and flood, we analyzed data for 13 sampling locations along the mainstem from three time periods: prior to 2019 (pre-fire/flood); post-fire/pre-flood (2020); and post-fire and flood (2021). Standardized sampling in 2021 revealed a complete loss of fish populations for approximately 16 miles downstream from the confluence of Black Hollow Creek and the main stem. Although there was a gradient to impacts, observed reductions in the Brown Trout population continued for over 40 miles downstream into Fort Collins. We discuss these findings in more depth, compare and contrast repercussions and projected outcomes to those of previous events, and potential management strategies to assist the fishery during recovery.

Fishways mitigate effects of diversion fragmentation on fish assemblage structure and movement in a Front Range river

Matt Haworth, Larval Fish Laboratory, Department of Fish, Wildlife, and Conservation Biology, Colorado State University, 1474 Campus Delivery, Fort Collins, CO 80523, matt.haworth@colostate.edu

Kevin Bestgen, Larval Fish Laboratory, Department of Fish, Wildlife, and Conservation Biology, Colorado State University, 1474 Campus Delivery, Fort Collins, CO 80523, kevin.bestgen@colostate.edu

Abstract: The Cache la Poudre (Poudre) River originates in the mountains of northern Colorado, has a snowmelt driven hydrograph, and transitions from a high-gradient, coldwater river in upstream canyon-bound reaches to a low-gradient, warmwater river in downstream plains reaches. The transition zone of the river is in and near the City of Fort Collins (City), where extensive modification for over 150 years has resulted in altered flows, temperatures, and habitat, and fragmentation by numerous water diversions structures, all of which may contribute to declines in the local fish assemblage. With significant investments into retrofitting numerous structures on the Poudre River and around the state with fish passage (fishways), our collaborators, the City and the Colorado Water Conservation Board, sought to better understand

effectiveness of these infrastructure additions to reduce effects of fragmentation. To accomplish this goal, they funded our three-year research program with objectives to: 1) investigate fine-scale fish community composition in the Poudre River transition zone; and 2) measure passage rates of fish over existing diversion dams with fishways, and compare those to dams without fishways. We found that species richness was similar in reaches separated by a diversion with a fishway, but decreased in reaches upstream of diversions without a fishway. Multiple years of tracking fish movement with physical recaptures and a variety of tag detection approaches confirmed tagged fish passed over diversions both with and without fishways in upstream and downstream directions, but multistate mark-recapture analysis showed they did so at a substantially greater rate when a fishway was available. Upstream movements were especially higher during increased flows associated with runoff, and downstream movements were more prevalent in lower flow. Facilitating higher rates of upstream and downstream passage indicated fishways are a valuable tool to mitigate habitat fragmentation in the Poudre River and other Front Range streams. Continued study of these structures under shifting environmental and biological conditions – such as extended drought or the widespread 2021 fish kill from flash flooding associated with the Cameron Peak fire – will provide insight into their utility in facilitating recolonization and their long-term effectiveness to mitigate habitat fragmentation.

Integrating traditional and novel stable isotope analyses to understand foraging dynamics in New Fork Lakes, WY

Caroline Rosinski, University of Wyoming, 1000 E. University Ave., Laramie, WY 82071, crosins1@uwyo.edu

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Samuel Wicks, University of Wyoming, swicks3@uwyo.edu

Abstract: Non-native species pose a range of management challenges throughout Colorado and Wyoming. Notably, the introduction of Lake Trout *Salvelinus namaycush* to lakes and reservoirs throughout the west has led to challenges in managing other desired fish species, due to the voracious and adaptable appetites of Lake Trout. Lake Trout interactions with kokanee *Oncorhynchus nerka* have received attention in many systems, as both species are desirable for recreational fisheries, but Lake Trout predation can negatively impact kokanee populations. In New Fork Lakes, WY, the kokanee population is used as a source of broodstock for the state's hatchery system, but this population is in decline, possibly as a result of Lake Trout predation. Here, we investigate trophic interactions in New Fork Lakes using traditional and novel approaches. Stomach content analysis and muscle tissue stable isotope analysis have been used

extensively in fish diet studies and give us information about foraging on recent timescales (days to months). Here, we add a third analysis, eye lens stable isotope analysis, to further our understanding of Lake Trout foraging histories. Stable isotope analyses of eye lenses can be used to recreate an individual's foraging history throughout their lifetime to understand variability in life histories both within and among individuals. Understanding the level of specialization present within the Lake Trout population can help us discover how ubiquitous foraging on kokanee may be, a key step towards understanding the extent to which Lake Trout may be inhibiting the kokanee population in New Fork Lakes.

Stable isotopes reveal ontogenetic shifts in foraging ecology of Lake Trout within Flaming Gorge Reservoir, Wyoming-Utah

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Sarah Collins, Department of Zoology and Physiology, University of Wyoming, 1000 E. University Ave., Laramie, WY 82071, sarah.collins@uwyo.edu

Travis Neebling, Aquatic Assessment Crew, Wyoming Game and Fish Department, 3030 Energy Lane, Casper, WY 82604, travis.neebling@wyo.gov

Ryan Mosley, Flaming Gorge Project Leader, Utah Division of Wildlife Resources, P.O. Box 145, Dutch John, UT 84023, ryanmosley@utah.gov

John Walrath, Green River Regional Fisheries Crew, Wyoming Game and Fish Department, 351 Astle Ave., Green River, WY 82935, john.walrath@wyo.gov

Abstract: Stable isotopes have emerged as a powerful tool to quantify foraging patterns and food web dynamics in aquatic systems. Conventional stable isotope approaches generally utilize carbon (δ13C) and nitrogen (δ15N) stable isotopes to estimate trophic position and reliance on pelagic and benthic energy pathways. However, quantifying detrital energy pathways remains challenging, including profundal energy pathways in deep lakes and reservoirs. Theory predicts the importance of different energy pathway likely varies along environmental gradients, influencing food web dynamics. Here, we employ a tri-isotope approach, using carbon (δ13C), nitrogen (δ15N), and sulfur (δ34S) stable isotopes, to quantify spatial and temporal variation in Lake Trout *Salvelinus namaycush* foraging on pelagic, benthic, and profundal energy pathways in Flaming Gorge Reservoir, Wyoming and Utah. Lake Trout diet proportions were estimated with Bayesian mixing models (SIMMR) using a tri-isotope approach. Mixing models indicate that juvenile Lake Trout rely heavily on profundal energy pathways, but their dietary niche expands to include a wide variety of prey items during adulthood. However, patterns of ontogenetic niche shifts differ along longitudinal reservoir zones. These results have important implications for understanding energy flow through food webs in large, western reservoirs and

can inform development of management strategies to promote and maintain multi-species fisheries.

Evaluation of natural and hatchery-produced kokanee in Flaming Gorge Reservoir

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Mark Smith, Wyoming Game and Fish Department, 5400 Bishop Blvd., Cheyenne, WY 82009, mark.smith2@wyo.gov

John Walrath, Wyoming Game and Fish Department, 351 Astle Ave., Green River, WY 82935, john.walrath@wyo.gov

Abstract: In a system that uses supplemental stocking to enhance a fishery that serves a dual purpose, an understanding of the contributions from natural and hatchery-produced fish is critically important so that hatchery resources can be appropriately allocated. Kokanee *Oncorhynchus nerka* were first stocked in Flaming Gorge Reservoir (FGR), Wyoming-Utah, in 1963 and serve a dual purpose as a prey resource and sport fish. Although natural recruitment occurs in the reservoir a supplemental stocking program was initiated in 1991. The goal of this research was to identify the natal origin (i.e., natural, hatchery) of kokanee in FGR using otolith microchemistry. Return to the creel, composition of spawning aggregates, and growth of kokanee in Flaming Gorge Reservoir were evaluated with a focus on differences associated with natal origin. Kokanee otoliths collected from hatcheries (n = 60) and FGR (n = 1,003) were analyzed for the strontium isotope ratio, 87Sr/86Sr, using laser ablation and a multi-collector inductively coupled plasma mass spectrometer. Kruskal-Wallis tests were conducted to compare the Sr isotope ratios from the otolith edge of kokanee sampled from hatcheries and FGR. We found that strontium isotope ratios differed for eleven out of twelve hatcheries ($P < 0.01$), however, the Wigwam Hatchery was not significantly different from FGR ($P = 0.84$). Model-based discriminant function analysis was used to assign natal origins for kokanee caught in FGR. Hatchery contribution to the population at large varied from 21% to 50% among year classes from 2014 to 2018. The percentage of hatchery origin kokanee in the creel (18-50%) was similar to what was observed in the population. Hatchery-produced kokanee contributed a higher proportion to tributary-spawning aggregates (40-90%) than shoreline-spawning aggregates (19-58%) by sample year. Growth of natural and hatchery kokanee was similar, suggesting similar performance in the system. Results from this study identify that hatchery supplementation contributes to the population and recreational harvest of kokanee in FGR. This

research also provides insight on the ecology of kokanee that is useful for better understanding kokanee population dynamics in reservoir systems.

Population genetics reveals bidirectional fish movement across the Continental Divide via an interbasin water transfer

Audrey Harris, Idaho Department of Fish and Game, Eagle Fish Genetics Lab, Pacific States Marine Fisheries Commission, 1800 Trout Rd., Eagle, ID 83616, audrey.harris@idfg.idaho.gov

Sara Oyler-McCance, Fort Collins Science Center, U.S. Geological Survey

Jennifer Fike, Fort Collins Science Center, U.S. Geological Survey

Matt Fairchild, Arapaho-Roosevelt National Forests & Pawnee National Grassland, U.S. Forest Service

Chris Kennedy, Colorado Fish and Wildlife Conservation Office, U.S. Fish and Wildlife Service

Abstract: Interbasin water transfers are becoming an increasingly common tool to satisfy municipal and agricultural water demand, but their impacts on movement and gene flow of aquatic organisms are poorly understood. The Grand Ditch is an interbasin water transfer that diverts water from tributaries of the upper Colorado River on the west side of the Continental Divide to the upper Cache la Poudre River on the east side of the Continental Divide. We used single nucleotide polymorphisms to characterize population genetic structure in Cutthroat Trout *Oncorhynchus clarkii* and determine if fish utilize the Grand Ditch as a movement corridor. Samples were collected from two sites on the west side and three sites on the east side of the Continental Divide. We identified two genetic clusters, but they did not align with the west and east sides of the Continental Divide. Spatial distributions of admixed individuals indicated that the Grand Ditch facilitated bidirectional fish movement across the Continental Divide, a major biogeographic barrier. Many others have demonstrated the ecological impacts of interbasin water transfers, but our study is one of the first to utilize genetics to understand how interbasin water transfers affect connectivity between previously isolated watersheds. We also discuss implications on native trout management and the need for balancing water demand and biodiversity conservation.

A small seasonally warm tributary provides prespawning resources for endangered Colorado Pikeminnow in a dam-regulated river system

Edward Kluender, Larval Fish Laboratory, Department of Fish, Wildlife, and Conservation Biology, Colorado State University, 1474 Campus Delivery, Fort Collins, CO 80523, kluender@rams.colostate.edu

Kevin Bestgen, Larval Fish Laboratory, Department of Fish, Wildlife, and Conservation Biology, Colorado State University, 1474 Campus Delivery, Fort Collins, CO 80523, kevin.bestgen@colostate.edu

Abstract: Riverine habitat mosaics, including connected tributaries, are an important reason the Green River subbasin supports the largest remaining population of endangered Colorado Pikeminnow *Ptychocheilus lucius* in the Colorado River Basin. Upstream Colorado Pikeminnow distribution is limited by Flaming Gorge Dam, and few typically occurred in the reach most affected by thermally and hydrologically altered dam releases. However, sampling from 2011-2021 revealed seasonal congregations of up to 75 Colorado Pikeminnow each year in the mouth of Vermillion Creek, a small tributary in the regulated reach. A total of 93 Colorado Pikeminnow – 11% of the entire 2017-2018 Green River basin population – were encountered in Vermillion Creek over the 11-year study. Vermillion Creek was used primarily when Green River spring flows from Flaming Gorge Dam were high and cold in late May through mid-June, and when the confluence was a large, deep backwater up to 10°C warmer than the main channel that also supported potential forage fishes. Intra-annual PIT tag detections revealed seasonal residence times for individual Colorado Pikeminnow of up to 91 days, and multiple inter-annual encounters indicated site fidelity. Frequent detections of Colorado Pikeminnow in the Yampa River spawning habitat soon after detections of the same individuals in Vermillion Creek indicate this small tributary is an important resource for adult fish during their reproductive season. Understanding and protecting seasonal use patterns of riverine habitat mosaics may assist with recovery of Colorado Pikeminnow.

Evaluating movement patterns of Roundtail Chub and Flannelmouth Sucker in the Blacks Fork Subbasin

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Abstract: Movement is among the most important of animal behaviors. It enables an animal to complete its life history by responding and adapting to changing environmental conditions for increased growth, survival and reproductive success. Linking movement behavior to life history characteristics is especially important for native fish as scale and pattern of fish movement varies widely in organisms at the individual, population and species level. In Wyoming, many native fish populations have declined due to altered flow regimes, habitat fragmentation and degradation, and the introduction of invasive species. Roundtail Chub *Gila robusta* and

Flannelmouth Sucker *Catostomus latipinnis* populations have a reduced distribution relative to their historic range and many populations have become isolated. There is a limited understanding as to how these fish are persisting in these isolated habitats. Our goals were to identify seasonal movement patterns, to understand mainstem and tributary habitat use, and determine how abiotic factors are influencing movement. We PIT-tagged fish and used a variety of PIT-tag antennas systems during the summers of 2019 through 2021 in the Blacks Fork Subbasin to evaluate Roundtail Chub and Flannelmouth Sucker movement. Preliminary results suggest tagging location, life stage and season affect movement patterns. Annual movements include spring adult pre and post-spawn movements and juvenile overwintering movements. Additionally, access to both mainstem and tributary habitat are critical to the completion of Roundtail Chub and Flannelmouth Sucker life histories. This research will provide a better understanding of critical habitat needed for the completion of Roundtail Chub and Flannelmouth Sucker life histories and will contribute to more effective management and conservation of remaining populations.

Relative inference with paired data

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Abstract: The classical paired t tool works on incremental change (i.e., change measured by subtraction within the pairs). If one is interested in relative change (i.e., change measured as a ratio), one approach would be to calculate appropriate ratios within pairs, and conduct a suitable one-sample analysis on the mean of them (Mean of Ratios). In this talk, I will introduce an alternative (Ratio of Means) that is more appropriate when inference at the population level (commonly so for fisheries studies) is of interest. Importantly, the two methods do not always yield the same answer, and so choosing between them should be done thoughtfully. I will share some illustrative examples, and introduce a bootstrapping app (coded in Excel) for creating confidence intervals.

Does temperature limit the upstream distribution of fishes in the Rocky Mountain region?

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Abstract: As climate change increases stream temperatures in freshwater ecosystems, it is widely considered that species will track shifting isotherms to higher elevations. This assumes that historic upper elevation distribution limits are determined by thermal factors. However, observed distributions do not always correspond to thermally suitable limits suggesting that other factors are limiting the ability of fish to fill their fundamental thermal niche. Using stream fish presence/absence data from 858 surveys across a mountain-plains gradient (Colorado and Wyoming, 1990-2021), we investigated the relative influence of thermal and non-thermal factors on the distribution of 21 fish species. Using generalized additive mixed models, we quantified species response to five ecological predictors (stream temperature, stream gradient, stream flow, Brown Trout *Salmo trutta* and Smallmouth Bass *Micropterus dolomieu* presence/absence) and utilized hierarchical partitioning to indicate which factors have the greatest influence on the upper distribution limit of each species. Results indicate that stream gradient and stream size have a greater influence on species distribution than stream temperature for many species. As climate warming increases, the conservation of native fishes in the Rocky Mountain region will require knowing if they can move upstream to remain within thermally suitable conditions. Species whose current upstream distribution is limited by factors other than temperature will be especially vulnerable to climate change since they will not be able to move upstream to compensate for thermally unsuitable conditions downstream. Information regarding species climate tracking ability will be important to consider as climate change persist, and biologists face important decisions regarding the conservation of freshwater biodiversity in the central Rocky Mountain region.

Experimental test of condition-specific competition between native Plains Topminnow and non-native Western Mosquitofish

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Abstract: The Western Mosquitofish *Gambusia affinis*, considered one of the 100 worst invasive species in the world, has been implied in declines of native fish populations including the Plains Topminnow *Fundulus sciadicus*. However, little is known about why their invasions are so successful in some cases but not elsewhere. We performed experiments to identify how

competition between Plains Topminnow and Western Mosquitofish is mediated at three temperatures of 16°C, 22°C, and 28°C and at varying densities of 40, 60, 80, 100, and 120 individuals and recorded fish habitat preference between high and low velocity tanks, where fish could move via a corridor. We found that both fish species preferred the low velocity habitat that represented plains streams and wetlands more closely. However, in sympatry, temperature and density played a key role in mediating competition among Western Mosquitofish and Plains Topminnow. Western Mosquitofish were most successful at occupying their preferred habitats at cold temperatures (16°C) and low densities. At high temperatures (28°C), the two species appeared competitively similar as proportions of individuals occupying the preferred habitats were similar between the two species. In addition, intraspecific agonistic behaviors of Plains Topminnow were the most frequent and significantly outnumbered agnostic behaviors initiated by Western Mosquitofish. More importantly interspecific competition is unlikely to be a major factor for Western Mosquitofish's successful invasion, and other factors such as life history traits and environmental tolerances warrant additional research.

Hydrologic controls on growth and production of age-0 Snake River Cutthroat Trout

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Abstract: Rivers and streams of the western United States are characterized by conditions that limit the growth and production of fishes such as Cutthroat Trout *Oncorhynchus clarkii* (e.g., flooding, drought, ice formation, and high summer water temperatures). However, groundwater input buffers spring-fed streams against seasonal variability in water temperature and discharge such that suitable habitat may persist year-round. While spring-fed streams have long been considered critical habitat for Cutthroat Trout and other salmonids, the benefits to key population parameters such as juvenile growth and production have not been considered. We aim to quantify the effect of groundwater input to tributary streams on the timing and magnitude of growth and production for age-0 Snake River Cutthroat Trout *Oncorhynchus clarkii behnkei* in the upper Snake River watershed, Wyoming. In 12 focal streams, we will use sine-wave regression of paired air-water temperature data to estimate the proportion of streamflow derived from groundwater sources. We will then calculate seasonal rates of growth and production by comparing changes in age-0 size and density through time for each stream. Finally, we will use a Bayesian statistical framework to quantify the effect of groundwater input to tributaries on the timing and magnitude of growth and production; models will include other stream habitat variables known to affect fish growth and density. Note that data collection and analyses are

ongoing; only preliminary results will be presented. Growth and production during the first year of life has strong effects on the dynamics of later life stages for many salmonid species. Our anticipated results will provide a mechanistic understanding of disproportionate contributions of spring-fed streams to the mainstem Snake River metapopulation of Cutthroat Trout. Further, our results will elucidate the role of spring-fed streams in sustaining viable trout populations, especially as climate change renders other tributaries unsuitable.

Culvert baffles – A low-cost fish passage solution

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Abstract: Road crossings of streams are ubiquitous across Wyoming and the entire U.S. A recent effort to build a fish passage prioritization tool led by U.S. Fish and Wildlife Service for the intermountain west has identified over 40,000 road crossings to date and a majority of that data is from the U.S. Forest Service. The total number of road crossings is considerably higher. Road crossings can have substantial impact on aquatic organism movement and fragmentation of habitat depending on the structure design and layout. Undersized and improperly placed structures are the common characteristics of these problematic crossings that also affects sediment transport and debris passage besides fish movements. Complete replacement is the ideal remedy for such situations to improve stream function and connectivity, but there are financial and labor constraints to replacing structures. Identifying low-cost solutions to improving passage could increase the number of crossings that can be improved in high priority areas and be more cost effective at low priority crossings.

In 2020, 22 road crossings in the Laramie Range of Southeast Wyoming were inventoried to document their impact on fish passage, structural condition, and sites to test the use of rubber baffles. Such baffles are used extensively in New Zealand and other countries, but have not seen much use in the U.S. They are a hard rubber material, 6 in high and 2-4 ft long, conform to various culvert sizes and shapes, and installed with hand tools and fasteners. In October 2021, these baffles were installed in eight culverts with diameters ranging from 3-7 ft and both concrete and metal material. Velocity and water depths were recorded in the larger culverts (n = 4) before and after baffle installation. Velocities decreased an average of 81.3% from 3.3 ft/s to 0.7 ft/s and depths increased 2 to 3 fold. Anecdotal evidence of improved passage was also documented at three sites where fish were observed resting in the culverts during and after installation.

Understanding the biological impacts of sediment flushing flows on spawning habitat: A case study of Willwood Dam, WY

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Abstract: Dams have notable effects on fluvial transport and downstream river morphology, with sediment trapping behind dams, and the consequential reduction of sediment loads downstream of dams, being the most pervasive effects. Due to the important role of sediment in the physical, chemical, and biological integrity of aquatic ecosystems, the disruption in sediment transport presents a monumental challenge for managers. Traditionally, sediment is released during flushing operations with aims to evacuate the greatest volume of sediment with little consideration for downstream aquatic life. Managers are concerned how to best tackle reservoir sedimentation whilst protecting downstream aquatic ecosystem.

Our research demonstrates the potential to protect sensitive spawning habitat and aquatic life while meeting dam operational needs and provides a suite of metrics and models to predict impacts of controlled sediment flushing operations. Through intensive in-situ sampling paired with long-term monitoring data, we developed models capable of predicting the rates of fine sediment deposition on spawning substrate and hyporheic dissolved oxygen at biologically relevant depths. In addition to sharing suggested methods for real-time monitoring of controlled sediment flushing operations, we provide a cost-benefit analysis for managers to balance financial investment with model accuracy.

This research enhances our understanding of effective metrics for monitoring sediment releases from dams and mitigating downstream impacts on fisheries, biological systems and fluvial processes. It equips managers and stakeholders with site-specific knowledge to best protect and maintain downstream fisheries and other aquatic life in the Shoshone River, with broad applications to dam sediment management worldwide.

Grand challenges of the 21 century

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Abstract: This talk will discuss the grand challenges to the profession in general and primarily to those in the Western U.S., particularly the state of Colorado.

1. The conundrum of managing inland fisheries in an age of uncertainty.
2. Instream flow the state of the art-Top Ten Models.
3. The need for statewide guidance on stream improvement projects and instream flow studies. Guidance could be a white paper with standards, or rules and regulations.
4. The need for statewide data sets for the profession and especially wild trout populations that are not significantly affected/supplemented by stocked fish. These data sets could be used to study both the effects of climate change and fluctuating flow (discharge or Q) of stream fishes.
5. The National Science Foundation-NSF has standardized long term data sets: Long Term Ecological Research-LTER has one site Niwot Ridge in Colorado and National Ecological Observatory Network-NEON has seven sites in Colorado.
6. The state of California has implemented a state-wide set of protocols used for instream flow studies. We should do the same after it is modified for the state of Colorado needs.
7. The triumphant NSF research proposal for research and management in the West and most importantly to inform stakeholders, policy decision makers and managers at all levels of government in the city and county, state and Federal agencies in Colorado.
8. The importance of role models in the profession.
9. Career advice for college students.

Monitoring plankton to assess the success of controlling invasive Lake Trout

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Abstract: Invasive fish are increasingly occupying and altering ecosystems, resulting in the reduction or loss of native species including fish, invertebrates and flora. Several methods are

used to control for or eradicate invasive fish; however, the success of these methods vary greatly among ecosystems and generally lack thorough evaluation. Plankton are excellent trophic levels to evaluate the effectiveness of control measures because they have short lifespans and are known to be sensitive measures of food web structure. We monitored plankton in Yellowstone Lake and compared phytoplankton and zooplankton assemblages to pre- and post-Lake Trout *Salvelinus namaycush* invasion data to assess how control measures altered the food web. Following the piscivorous lake trout invasion and concurrent decline of native, planktivorous Cutthroat Trout *Oncorhynchus clarkii bouvieri*, phytoplankton biomass decreased, and the biomass and individual size of large zooplankton increased. Phytoplankton biomass, measured as chlorophyll-a and Secchi disk depth, did not differ from the Lake Trout-dominated period; however, phytoplankton biovolume was intermediate between the pre- and post-invasion eras. The increase in phytoplankton biovolume may be due to depositing > 280,000 Lake Trout in the depths of Yellowstone Lake annually, as carcasses mineralize nutrients fertilizing phytoplankton. The zooplankton assemblage continued to be dominated by large species with longer individual body lengths during the period of high Lake Trout removal. The plankton assemblage indicated that Yellowstone Lake continues to be dominated by Lake Trout despite a large effort to control the adult stage of these fish with gill nets. Collecting plankton annually will also benefit monitoring for a recently discovered nonnative fish, Cisco *Coregonus artedi*, in Yellowstone Lake.

How a rare aquatic beetle makes a living in salty, ephemeral streams in central Wyoming

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Abstract: Rare insects are difficult to study, but basic life history information is necessary to manage populations. Beetles are the largest insect order and contain about 25% of animal species on Earth, containing both common and rare species. The narrow-foot Hygrotus diving beetle *Hygrotus diversipes* is a rare aquatic beetle only known from central Wyoming. We compiled existing data on the narrow-foot diving beetle and surveyed for the beetle annually to understand trends, habitat needs, and characteristics of the species. The beetle lives in streams that are a series of pools with higher concentrations of salts. This species was discovered in 1964 and became a Category II Candidate Species under the Endangered Species Act from 1984 to 1996 leading to several surveys and discovering the beetle in four additional streams. The Narrow-foot diving beetle was petitioned for listing three times between 2007 and 2013, and annual monitoring began in 2010. The beetle occupied different streams likely in response to varying habitat conditions. Four streams were occupied during ≥ 33% of years and were considered the core sites used by the narrow-foot diving beetle. Specific conductivity was the most important

variable explaining their distribution according to principal components analysis. Individual pool surveys revealed that most pools held water the entire summer, but a hot dry spell caused water levels to drop and specific conductivity to increase. Water levels in streams were subsurface except after rainstorms, which caused floods and flowing water before the streams dried to a series of pools. We collected the diving beetles in smaller pools with structure (i.e., wood, overhanging grass) and without fish. We also marked any narrow-foot diving beetles we collected in the field for recapture. Statewide surveys in 2021 not only found the diving beetles in new streams, but also in a new region of Wyoming. Much more is known about the narrow-foot Hygrotus diving beetle since it was described, but there is still much to learn about their ecology and life cycle.

A rusty crayfish story in Wyoming

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Abstract: Rusty crayfish *Orconectes rusticus* are a listed Aquatic Invasive Species in Wyoming and were recently detected in numerous waters in Southeast Wyoming. This problematic species can outcompete native crayfish, prey on fish and invertebrates, destroy aquatic plants, and increase water turbidity. They were first detected in Wyoming in 2006 as a result of illegal stockings in the Wagonhound Creek drainage near Douglas. Eradication efforts were conducted, but rusty crayfish were found again in 2012 and subsequent removal occurred in 2013. Monitoring to determine the success of that attempt is ongoing, and the Colorado company that introduced the crayfish paid large fines for their felony Lacey Act violation. In 2020, rusty crayfish were found in the Laramie River as part of a state-wide crayfish survey conducted by the University of Wyoming. Further sampling in 2020 and 2021 revealed that this ecosystem disrupter is established in the Laramie River and Bluegrass Creek east of Rock River, and in the North Fork Little Laramie River south of Centennial. They are also present in at least ten reservoirs on three private ranches. Investigations determined that a Department-approved private fish hatchery illegally stocked rusty crayfish in the late 1990's into these waters. A total of 98 waters in 15 basins were stocked by this hatchery from 1998-2011, but rusty crayfish have only been found in the waters mentioned above. Based on the stocking patterns at these locations, it seems likely that rusty crayfish were stocked as a part of a larger "forage package" that also included approved Fathead Minnows *Pimephales promelas* and scuds *Gammarus* sp., which were intended to boost the trout fisheries. Actions taken thus far include information and education efforts, landowner outreach, and signing of infested waters. Moving forward, we plan to suppress or eradicate rusty crayfish at certain waters and strengthen regulations that limit the introduction of Aquatic Invasive Species by private fish hatcheries in Wyoming.

Fly Links an unique ecosystem sport

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Abstract: Fly Links is a new experience and sport unlike anything else. Combining the characteristics that make fishing and golfing fun while connecting to your inner outdoorsman. An event that is goal oriented with a track and structure to follow but also allows you to wonder and be in awe of nature. A structure that puts "players" on a fishing "track". Fly Links layout keeps people and "play"/movement going forward using its fishing stations (strokes) on every hole. This allows players the experience of natural fishing adventure like trying to find the hole that holds unique sport and native fish without as much need to think/trial and error. With anywhere from 3-5 stations (strokes) per hole over nine holes there is no doubt in player/designers head that trophy fish can be landed, the odds are in anyone's favor.

Our team is excited to promote native historically non-game species as well as well established game species. The fishing experience will require innovative and new approaches to catch and release of species that have not previously been promoted in this way. We are excited about the opportunity to connect people to the wonderment and awe of restored and natural reference ecosystems through this new sport called Fly Links.

5SSR and RiverSHARED are currently working on developing master plans for four Fly Links courses in four difference states and unique ecosystems. The talk will simply be to introduce the concept for discussion.

Intensive fish culture of Walleye at Wyoming Game and Fish Department's Dan Speas Fish Hatchery

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Abstract: Beginning in 2020, the Wyoming Game & Fish Department's Dan Speas Fish Hatchery conducted intensive fish culture trials on Walleye *Sander vitreum*. These trials aimed to evaluate the feasibility of rearing walleye through intensive fish culture. The trials included the research of specialized equipment and methods necessary to intensively rear Walleye. Two years of trials resulted in above average survival rates of up to 75%. This presentation will provide an overview of the equipment, daily operations, as well as a summary of results over the two years of trials.

Triploid Walleye: some considerations for managers

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Abstract: Walleye *Sander vitreus* is a widely distributed and important recreational fish species throughout North America, but it is not native to the western United States. Outside of their native range, Walleyes can negatively impact native species via predation and competition. Stocking Walleye is prohibited in many parts of the West, yet legal, illegal, and natural introductions are common, and managers need a means to limit the invasiveness of Walleyes. As a result, some state agencies, including Colorado Parks and Wildlife, have begun stocking triploid Walleyes, which are effectively sterile. This alternative stocking approach should help limit the invasiveness of Walleye, while still providing high-quality sport fisheries anglers desire. However, very little is known about how triploid Walleyes perform in the wild. In this talk, we will present preliminary results comparing diploid and triploid Walleye, with a focus on aspects of interest to the fisheries manager.

Prey selection of diploid and triploid Walleye in a prey-limited system

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Abstract: Walleye *Sander vitreus* are a highly sought-after sportfish in North America but they are not native to Colorado waters. Dispersal of Walleye across the landscape, whether by legal, illegal, or natural means, are of concern to native species recovery efforts, as predation by and competition with invasive Walleye are known to have negative impacts on native species.

Because triploid fish are typically sterile, the stocking of triploid Walleye is an alternative management approach to limit the risk of establishing new populations in areas with sensitive native species. There are few studies that have examined the trophic dynamics of triploid fish relative to diploid conspecifics, and under natural conditions. Lab studies with other species suggest that triploid fish may be less aggressive predators than diploid fish. Managers wishing to stock triploid Walleye would have a better idea of what they might consume and how they would fare in their waters if more was known about prey selection of wild triploid Walleye relative to diploid Walleye. In this talk, we will present preliminary results of diet composition and prey size selection of a diploid and triploid Walleye population in Narraguinnep Reservoir, Colorado.

Population dynamics of MYY (YY-Male) Brook Trout in northern New Mexico

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Abstract: Nonnative fish often displace and outcompete native trout in western North America. Therefore, removal of nonnative fish is a primary focus of conservation efforts. Unfortunately, suppression of nonnative fish can vary in success and usually requires large operational costs. To mitigate the limitations of traditional suppression techniques, managers are implementing the YY-Male (MYY) approach to eradicate nonnative fish. However, there are uncertainties surrounding the effectiveness of the MYY approach due to limited information on the comparative performance of MYY fish and their wild counterparts. As part of an ongoing MYY project, we investigated the population dynamics of MYY Brook Trout *Salvelinus fontinalis* and wild Brook Trout in northern New Mexico. Fish were sampled in Rito de los Piños, Placer Creek, and Leandro Creek in July and September 2021. Following population abundance estimation, approximately 50% of the wild Brook Trout from each population were removed and replaced with age-0 MYY Brook Trout. Annual survival was estimated in each stream using a Cormack-Jolly-Seber model. Mean annual survival of MYY fish varied from 0.28-0.63; whereas,

wild Brook Trout survival was between 0.46-0.75. Based on comparable survival between MYY and wild fish, use of the TYC (Trojan Y-chromosome) approach could be used to efficiently extirpate nonnative Brook Trout. Results from this research will address knowledge gaps associated with the TYC approach and inform future suppression efforts of nonnative Brook Trout in western North America.

Kokanee salmon broodstock recap Tillett Rearing Station

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Abstract: In 2016, the Wyoming Game and Fish Department decided to explore the option of a kokanee *Oncorhynchus nerka* captive brood stock at the Tillett Springs Fish Rearing Station. Disease concerns with wild brood sources and the need for a consistent egg source year to year led this charge. Prior to starting, protocols and procedures were researched and identified from the only two known semi-successful captive brood kokanee programs ever developed.

The captive brood program started in December of 2016 with eyed eggs from a late run kokanee egg source provided by the state of Colorado sent from their Glenwood Springs Fish Hatchery. These fish were successfully spawned in the fall of 2019. Since its inception, the captive kokanee brood stock have spawned every fall. We experienced difficulties in our second year of spawning with only a portion spawning during the fall of 2020 and summer of 2021. Our third year of spawning in the fall of 2021 was very successful and the fourth year class on station looks well on its way to spawning this fall. To date we have collected over 6 million eggs from 15,790 fish.

Wildfire influences individual growth and dispersal, but not survival and recruitment in a montane amphibian

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Abstract: Global wildfire regimes are changing rapidly, with widespread increases in the size, frequency, duration, and severity of wildfires. Whereas the effects of wildfire on ecological state variables such as occupancy, abundance, and species diversity are relatively well-documented, changes in population vital rates (e.g., survival, recruitment) and individual responses (e.g., growth, movement) to wildfire are limited as comparisons necessitate detailed information on the same individuals both pre- and post-fire. We capitalized on the 2018 Roosevelt wildfire, which occurred during our six-year (2015–2020) capture-mark-recapture study of boreal toads *Anaxyrus boreas boreas* (n = 1415) in the Bridger-Teton National Forest, USA, to evaluate the responses of population vital rates and individual metrics to wildfire. We employed robust design capture-recapture models to compare the growth, dispersal, survival, and recruitment of adult boreal toads pre- and post-fire at burned versus unburned sites. Growth was reduced during the year directly following wildfire, but increased substantially two-years post-fire. Boreal toads emigrated from our study area more at burned sites than unburned sites and dispersal increased two years post-fire compared with the year directly following wildfire. Annual survival and recruitment did not differ between pre- and post-fire years nor among pre-fire years, the year following wildfire, and two years post-fire. We demonstrate that, in certain contexts, emigration can play a major role in changes to state variables (e.g., abundance) after wildfire, as opposed to other vital rates such as survival and recruitment. Our study therefore represents an important step towards understanding the biological processes that underlie observed patterns in state variables following wildfire, which ultimately will be critical for the effective management of species in landscapes experiencing shifts in fire activity.

PIT tagging versus photography: trade-offs in intial and long-term handling efficiency

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Abstract: Individual identification is required for investigations that examine population-level changes (i.e., demography, disease) and the mechanisms associated with those changes in wild animal populations. Such identification requires the application of a mark, or the documentation of characteristics unique to the individual animal. To minimize effects on captured individuals

and populations, marking strategies that minimize handling time (i.e., stress) are necessary. We examined the relative efficacy of passive integrated transponder (PIT) tagging and photo-identification techniques used to individually identify boreal toads *Anaxyrus boreas boreas* at four different sites in Colorado and Wyoming in field and environmentally controlled settings. We evaluated whether initial handling time was influenced by identification method (PIT tag or photo-identification) and environment (field or controlled). Initial handling time was higher for PIT tagging than photo identification and higher in the field than in a controlled environment. To evaluate handling time over the life-time of a toad, we combined our initial handling time estimates with annual toad survival estimates. While handling time was initially shorter for photo-identification compared to PIT tagging, cumulative handling time over the expected lifetime of an individual was >5 times longer for photo-identification, suggesting that the study design (planned surveys and duration) and the species' life expectancy should be considered when determining appropriate marking methods. We developed an application (Shiny app) to allow managers to enter these values to determine cumulative handling time and to inform the selection of marking methods.

No evidence for compensatory recruitment in montane amphibian populations challenged with chytrid fungus *Batrachochytrium dendrobatidis*

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Abstract: Emerging infectious diseases are often important drivers of host population dynamics as documented by recent outbreaks in human, domestic animal, and wildlife systems. While many diseases cause catastrophic harm to host populations, there often exists population-level variation in response to disease whereby some host populations are extirpated, some persist at lower densities or abundances, and others rebound to pre-disease levels. One such mechanism of population persistence that has gained support in the amphibian-chytridiomycosis host-pathogen system is compensatory recruitment. Some populations may persist by increasing recruitment to compensate for reduced survival due to infection, thus limiting the negative effects of the disease on population trajectories. We use 20 years of long-term capture-mark-recapture data on five populations of boreal toads *Anaxyrus boreas boreas* in Colorado including before and after pathogen exposure data to assess whether populations can persist with disease via compensatory recruitment. Prior to disease arrival, we found a life history trade-off between survival and recruitment across elevations, where high elevation toads have high survival but lower

recruitment and vice versa at lower elevations. Disease arrival had a strong negative effect on apparent annual survival and recruitment, and led to negative population growth rates and host abundances. We did not find support for compensatory recruitment in our system, highlighting the strength of disease in these populations and their vulnerability.

Environmental application of an Anti-Bd *Batrachochytrium dendrobatidis* probiotic bacteria at a boreal toad *Anaxyrus boreas boreas* breeding site

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Abstract: Amphibian populations around the world are declining due to the recently emerged fungal skin pathogen *Batrachochytrium dendrobatidis* (Bd). In Colorado, boreal toad *Anaxyrus boreas boreas* populations are declining due to Bd. 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. In the summer of 2021 we treated the sediment surrounding a Bd positive boreal toad breeding site with a known Bd-inhibitory bacteria immediately before the emergence of metamorphs. Here we present results from that study, including data from 16S marker gene sequencing and quantitative PCR with Bd specific primers from swabs of toad skin. This data allows us to evaluate the transfer of our probiotic on to toad skin and estimate its impact on Bd at the site.

Boreal toad *Anaxyrus boreas boreas* population differences in transcriptome-level response to Bd fungus *Batrachochytrium dendrobatidis* indicate dysregulated immune response in susceptible populations

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Abstract: Boreal toads *Anaxyrus boreas boreas* of the Southern Rocky Mountain population are declining due to the introduction of *Batrachochytrium dendrobatidis* (Bd). 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 population. We conducted a Bd challenge with lab-reared sibling toads from Bd susceptible Colorado and purportedly Bd-tolerant Utah populations and report on transcriptomic responses to Bd at late infection in skin tissue. Fewer immune genes were expressed in response to Bd in Colorado toads, but with greater upregulation compared to 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 more moderate upregulation in gene expression and significantly enriched suite of gene functions including key functions of the innate, adaptive, and signaling immune response. Our transcriptomic results support the notion that Utah toads are tolerant to Bd, rather than resistant, carrying Bd loads similar to Colorado yet having significant gene expression responses and presenting minimal clinical signs of chytridiomycosis. We conclude that closely related populations have divergent transcriptomic responses to Bd with a dysfunctional response in Bd-susceptible 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.

Conservation and landscape genomics of an endangered montane amphibian reveals high historical gene flow, low genetic diversity, and selection pressure from disease

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Abstract: Wildlife diseases are a major global threat to biodiversity. The boreal toad *Anaxyrus boreas boreas* is endangered in the southern Rocky Mountains (SRM) of Colorado due largely to lethal skin infections caused by the chytrid fungus *Batrachochytrium dendrobatidis* (Bd). We used conservation and landscape genomics tools, including the development of a new reference genome and reduced-representation sequencing across the range of boreal toads in the SRM, to investigate patterns of effective population sizes, genetic diversity, and habitat factors related to gene flow and local adaptation. Effective population sizes were small and genetic diversity was low across the range, likely due to Bd-related population crashes over the last three decades. However, gene flow was high across the range, likely due to historically greater numbers of larger and well-connected populations and long generation times of boreal toads in montane environments. Gene flow was highest in areas with lower annual precipitation, colder minimum temperatures in the coldest month, less tree canopy cover, lower heat load index, and lower percent impervious surface. Finally, we found 10x more putatively-adaptive loci related to Bd

intensity at breeding habitats than to all other habitat variables combined related to climate, forest cover, riparian habitats, topography, and human development. This suggests boreal toads that persist in habitats with Bd have experienced stronger selection pressure from disease than from varying environments across their range in the SRM. These findings are being used by conservation managers in Colorado and other nearby states to conserve and recover the species though genetic rescue of populations experiencing Bd-related crashes, reintroductions to historically-occupied habitats, and captive breeding programs.

2022 CO/WY AFS Contributed Posters - Abstracts

Density-dependence outweighs habitat influences on Brook Trout condition in the southeastern U.S.

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Abstract: Brook Trout *Salvelinus fontinalis* are a salmonid native to the eastern US. Threatened by streamflow and temperature changes associated with climate change, they occur in high elevation and high latitude habitats, and thrive where they can avoid competition with invasive salmonids. Brook Trout have also been found to show strong density-dependent patterns in vital rates such as growth and recruitment. Little research has compared the influences of habitat and density variables on Brook Trout condition, defined here as body weight at length. We investigated the importance of density-dependent vs. density-independent predictors on Brook Trout condition using quantile regression. We analyzed 589 sites from Georgia to Maryland in the southeastern U.S., where Brook Trout populations have declined most significantly. Our analysis reveals that the influence of density on predicted Brook Trout condition was stronger than that of latitude or elevation. Density of larger trout had the strongest negative influence on predicted weight at length, suggesting that density effects are the result of size-mediated competition for food resources. Where they exist in sympatry with nonnative Rainbow Trout *Oncorhynchus mykiss* and Brown Trout *Salmo trutta*, Brook Trout condition is more negatively affected by nonnative trout density than their own density, indicating the preeminence of interspecific competition over intraspecific competition. Our results add important substance to the debate over the relative importance of density-dependent vs. density-independent drivers of individual Brook Trout condition.

Body condition explains exploratory movement of Creek Chubs in experimental streams

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Abstract: We conducted laboratory experiments to evaluate whether metrics of body condition affected exploratory movement of Creek Chub *Semotilus atromaculatus* at 16 and 22°C. Each of two experimental streams was composed of two circular tanks (4 feet diameter) connected by a straight corridor (18 inches wide, 5 feet long), which was equipped with a pair of PIT tag antennas to monitor fish movement between the circular tanks. Creek Chub (74-97 mm TL) were collected from the Spring Creek, Fort Collins, in October 2021 and were transported to the experimental streams on the Colorado State University main campus (n=52 fish at 16°C and n=50 fish at 22°C). After a 24-hour acclimation period, we monitored inter-pool movement of fish tagged with 12-mm PIT tags for 72 hours with a photoperiod controlled at 9 hours of daytime and 15 hours of night. Results showed that, at both temperatures, larger fish or fish in better body conditions moved more frequently than smaller fish or those in poorer body conditions. Percent weight loss and dry matter content (ratio of wet versus dry weight) were better predictors of movement than weight-at-length, which is mostly typically used as a surrogate of body condition in the field movement research. The vast majority of movement occurred in the dark, and mobile individuals were consistently mobile across three nights. This study indicated that individual variation in movement could be linked to various metrics of body condition.

Gill lice distribution, prevalence, and infestation intensity in the Upper Snake River watershed

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Abstract: Pathogens are an emerging threat in aquatic ecosystems and are predicted to negatively affect fish populations with climate change. Potential changes include the abundance, distribution, and infestation intensity of pathogens such as gill lice, ectoparasitic copepods that parasitize fish. The synergistic and antagonistic effects of these parasites on fish population dynamics are poorly known. This study aims to quantify the geographic distribution and infestation intensity of gill lice in the Upper Snake River watershed and explore potential impacts of gill lice on fish populations, including iconic Snake River Cutthroat Trout *Oncorhynchus clarki behnkei*. During 2020 and 2021, we assessed 7,773 fish (4,613 and 3,160,

respectively) for gill lice in lakes and rivers across the Upper Snake River watershed. The prevalence of gill lice varied from 0 to 15.4% at sites in 2020 and from 0 to 63.2% in 2021. The mean infestation intensity was 1.90 parasites/infected fish in 2020 and 1.84 in 2021. Interestingly, 2021 was a low water year with higher-than-normal temperatures throughout much of the Upper Snake River. These preliminary data suggest gill lice prevalence and infestation intensity is low; however, differences across years suggest water levels, flow rates, and water temperature may influence gill lice prevalence and infestation intensity. Our research provides critical baseline data on pathogen-fish interactions in the Upper Snake River watershed. Future research will integrate environmental data with the presence/absence of infestations and infestation intensity to make informed predictions about how changes in water temperatures and flow rates may affect future outbreaks.

2022 CO/WY AFS Contributed Papers/Prerecorded Abstracts

Vulnerability of warm-, cool-, & coldwater fishes to stream warming in Wyoming & Montana

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Abstract: Significant declines in many coldwater species have been predicted due to stream warming from climate change. However, climate-induced temperature changes are less frequently considered with regards to cool- and especially warmwater species. We therefore examined the sensitivity and vulnerability of 62 native fish species to stream warming across Montana and Wyoming, a thermally-diverse area that spans conifer forest, rolling prairie, and high desert systems. By comparing species' realized thermal niches to current and projected stream temperatures, we predict that thermally suitable habitats for 7 cold-, 8 cool-, and 4 warmwater fishes are likely to decline in significant portions of their current range. Vulnerable coldwater fishes include Columbia Slimy Sculpin *Cottus cognatus*, Redband Trout *Oncorhynchus mykiss gairdneri*, Cutthroat Trout *Oncorhynchus clarkii*, and Bull Trout *Salvelinus confluentus*, and vulnerable coolwater fishes include Lake Chub *Couesius plumbeus*, Mountain Sucker *Catostomus platyrhynchus*, Mountain Whitefish *Prosopium williamsoni*, and Northern Redbelly Dace *Chrosomus eos*. The four vulnerable warmwater fishes are Iowa Darter *Etheostoma exile*, Plains Sucker *Pantosteus jordani*, Red Shiner *Cyprinella lutrensis*, and Plains Topminnow *Fundulus sciadicus*. While future declines in species abundance and distribution are likely to depend on dispersal abilities, availability of newly suitable upstream habitats, species interactions, and stream drying, this work demonstrates that vulnerability to stream warming is unlikely to be limited to coldwater fishes.

Pond attributes associated with breeding presence of an isolated population of the wood frog *Lithobates sylvaticus*

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Abstract: Isolated populations that are geographically separated from the species' more contiguous range due to distance or barriers can be particularly susceptible to threats such as habitat degradation. Amphibians have experienced population declines worldwide from habitat change. Given the limited resources for amphibian population monitoring, understanding which pond attribute(s) (biological, chemical, physical) are most effective at indicating the presence of breeding and the quality of breeding ponds is essential, particularly for understudied populations. The wood frog *Lithobates sylvaticus* is a glacial relict species in Wyoming, found only within the Snowy and Bighorn mountains, and is listed as a Species of Greatest Conservation Need in the State Wildlife Action Plan partly due to a lack of information about key habitat requirements. We are addressing these knowledge gaps by identifying biological, chemical, and/or physical attributes that best predict the presence and extent of breeding (via number of egg masses). In 2020 and 2021, we measured water chemistry, algal biomass, and physical characteristics of 18 ponds, which spanned variation in the number of egg masses present. Based on preliminary results, lower algal biomass and specific conductivity, as well as higher dissolved oxygen appear to be associated with the presence of wood frog breeding, but may not be able to differentiate the number of egg masses across breeding ponds. Our study will provide managers with key information about what habitat characteristics are best for identifying potential breeding ponds and measuring the quality of existing breeding ponds of wood frogs. More broadly, our study will increase understanding of the ecology of isolated populations and interactions between breeding presence and habitat quality of breeding sites.

Reintroduction of an extirpated mussel to southeastern Wyoming

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Abstract: Native freshwater mussels play an important ecological role in river systems. Plain pocketbook mussels *Lampsilis cardium* have a documented historical range in the Laramie and North Platte rivers in Wyoming but the last live specimen was found in 2008. The Wyoming Game and Fish Department completed thorough physical and environmental DNA surveys, and believe the plain pocketbook mussel to be extirpated from Wyoming. The Department created a reintroduction plan based on this historical range that would utilize mussels cultured by the Nebraska Game and Parks Commission. Sites above and below Grayrocks Reservoir were chosen for the reintroduction in an attempt to establish multiple populations. Habitat surveys were completed and release locations were selected based on depth and substrate. Multiple age classes of mussels were released in the Laramie River in 2020 and again in 2021. Three types of tags were used to allow for future monitoring of the species. Follow up surveys to date have found very few dead mussels, growth at all sites, and even evidence of sexual maturity in 2021. This project highlights one of the potential conservation actions available to help conserve native mussels in the western United States.

Getting a pulse on invasive Brook Stickleback in Wyoming: distribution, habitat drivers, and overlap with native fishes in the North Platte River drainage

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Abstract: As freshwater biodiversity continues to decline due to invasive species introductions, a central focus of fisheries management is eradicating invaders and protecting populations of imperiled fishes. However, vast landscapes and limited funding and personnel resources demand a prioritized approach to management, based on an understanding of an invasive species' distribution, habitat drivers, and overlap with native fishes. Brook Stickleback *Culaea inconstans* is an aquatic invasive species in Wyoming that may pose a risk to native nongame fishes in the North Platte River drainage. We used a spatially balanced sampling approach, in addition to revisiting both historically occupied sites and lentic sites, to update the current distribution of Brook Stickleback in our study area and evaluate for possible range expansion. Further, we used these data to construct a Random Forest distribution model to better understand the species'

landscape-level habitat drivers and subsequent occupancy potential for streams across the North Platte River drainage. Finally, we used nonmetric multidimensional scaling to examine Brook Stickleback's overlap with native nongame fishes across all sampling locations. Broadly, Brook Stickleback distributions do not seem to be expanding, and at the landscape scale, the species preferred low-gradient, slow-moving streams with moderate disturbance risk and high groundwater input. Brook Stickleback overlapped with 13 species in our sampling. Brassy Minnow *Hybognathus hankinsoni* and Iowa Darter *Etheostoma exile* showed fidelity to lentic sites without Brook Stickleback despite a similar preference in habitat. Our results provide valuable information to managers grappling with developing the most effective management plans for Brook Stickleback in Wyoming.

Evaluation of Longrie-Fectau fish passage structure for Great Plains fishes

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Abstract: Connectivity is critical for freshwater fish conservation, and the design of fish passage structures is a tradeoff between the space available for construction, slope, and costs associated with the structure. The Longrie-Fectau-style fish passage structure was designed to be modular, readily deployable, and site-generic. To accomplish this, it was designed as two prefabricated portions (straight and curved) that can be quickly installed and accommodate various barrier heights by adding or removing sections. Additionally, the length of straight sections can be altered to fit any site. The sinuous passage design allows a relatively low grade (2%) and passage over large structures with short apron space. The individual pre-cast costs were $9,000 for each of the straight sections, and $6,000 for each of the curved sections. The foundation required to support the pre-cast sections was approximately $4,000 per section. Other financial considerations that will vary depending on the site include the passage entrance and exit, the cap to limit sheet flow over the passage, diverting and dewatering the creek during construction, and additional foundation construction to support the pre-cast sections. We evaluated fish passage through this structure in Fountain Creek, Colorado via a PIT tag mark-recapture study. We documented four Great Plains native fish species successfully ascending the passage structure, with most passage occurring at night. We estimated a 3% probability of a released fish encountering the first array, indicating attraction flows are important consideration for passage

design. However, once in the structure, there was a high probability of complete passage (82%). Although this particular structure is large (123 m), passage was relatively fast once fish entered, with median time of successful ascent of 19 minutes and fastest successful passage of six minutes. While fish passage often requires site-specific engineering and design, the Longrie-Fectau-style fish passage design is an option that may reduce construction costs due to its modularity and simplicity.

Tracking co-occurrence of invasive carp with native predators over twenty years: high biomass, low availability

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Abstract: Aquatic invasive species can drastically alter the ecosystems they invade and cause substantial harm. Although the downsides of aquatic invasive species are well documented, they may also benefit certain native species, particularly if native predators are able to consume the invasive species. Silver Carp *Hypophthalmichthys molitrix* have invaded large river ecosystems in the Midwest, where they are efficient planktivores. We examined the potential of age-0 Silver Carp to benefit native predators. Using 20 years of data from the La Grange Reach of the Illinois River, Illinois, we measured the availability of small Silver Carp relative to three abundant native species (Bluegill *Lepomis macrochirus*, Emerald Shiner *Notropis atherinoides*, and Gizzard Shad *Dorosoma cepedianum*). We also calculated the co-occurrence of these four species with four native predators (Black Crappie *Pomoxis nigromaculatus*, Largemouth Bass *Micropterus salmoides*, Shortnose Gar *Lepisosteus platostomus*, and White Bass *Morone chrysops*). Even when there were abundant small Silver Carp, small native fishes tended to have higher occupancy rates across sites, and native predators co-occurred with native prey at a higher rate. Silver Carp appear to reduce the condition of native planktivores without presenting a reliable prey resource for native predators.

Variable reproductive success across *Oncorhynchus* spp. in the North Fork of the Shoshone River

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Abstract: Examining the action of natural selection in wild populations presents many challenges, but also sheds light on important ecological and evolutionary processes. Additionally, in hybridizing populations, natural selection may be an important determinant of the eventual outcome of hybridization. We characterized several components of relative fitness in hybridizing populations of Yellowstone Cutthroat Trout *Oncorhynchus clarki bouvieri* and Rainbow Trout *Oncorhynchus mykiss* in an effort to better understand the prolonged persistence of both parental species despite predictions of extirpation. Thousands of genomic loci enabled precise quantification of hybrid status in adult and subsequent juvenile generations; a subset of those data also identified parent-offspring relationships that we used to assess the effects of ancestry on reproductive output and mate choice decisions. We found a relatively low number of late-stage (F3+) hybrids and an excess of F2 juveniles relative to the adult generation, which suggests the presence of hybrid breakdown decreasing the fitness of F2+ hybrids later in life. Assessments of reproductive output showed that Yellowstone Cutthroat Trout females are more likely to successfully reproduce and produce slightly more offspring than their Rainbow Trout and hybrid counterparts. Mate choice was highly variable, though we did find statistical support for slight female preference for males of similar ancestry and higher Yellowstone Cutthroat Trout ancestry. Together, these results show that native Yellowstone Cutthroat Trout are able to outperform Rainbow Trout in terms of reproduction and suggests that management action to exclude Rainbow Trout from spawning locations may bolster the now rare Yellowstone Cutthroat Trout.