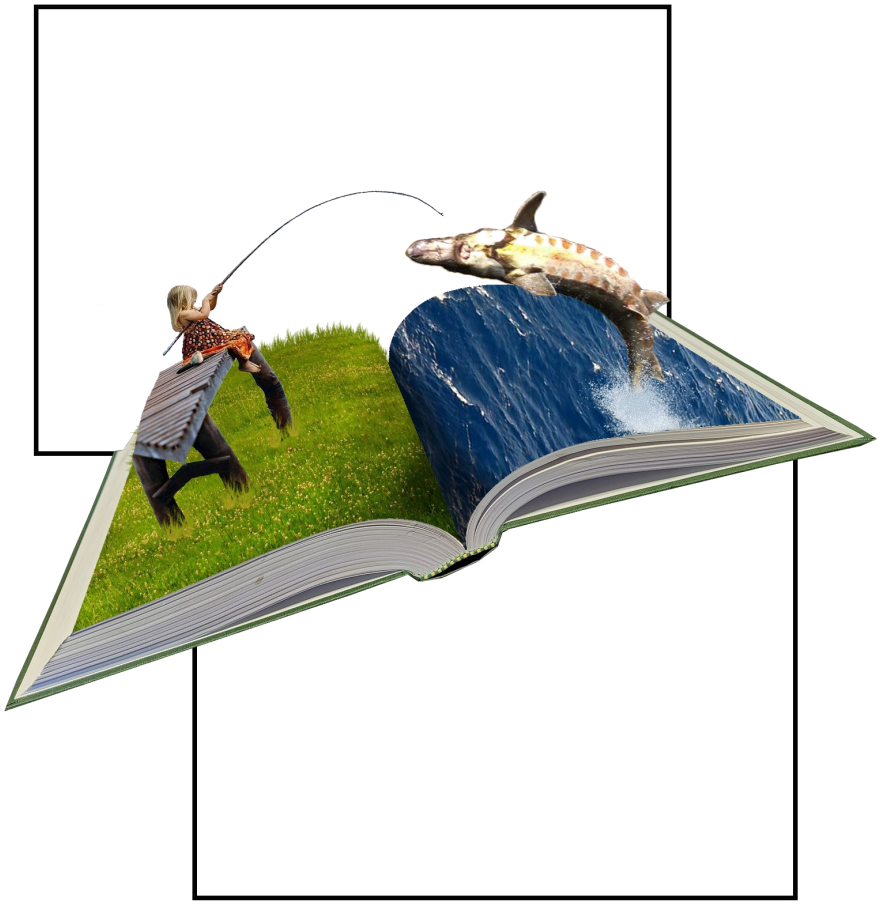
Colorado/Wyoming Chapter
American Fisheries Society



Science and Storytelling

2021 Annual Meeting

Virtual
February 22 - 25, 2021

PROGRAM

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Schedule at a Glance

Time	Event
Monday, February 22	
8:00 AM - 5:00 PM	Continuing Education - "Plain, Simple, and Concise Writing" Dr. Steve McMullin
Tuesday, February 23	
1:00 - 2:10 PM	Introduction and Plenary
2:10 - 2:30 PM	Break
2:30 - 3:30 PM	Contributed Papers
3:30 - 4:00 PM	Break
4:00 - 5:00 PM	Contributed Papers
5:00 - 8:00 PM	Fish in Film Festival
Wednesday, February 24	
1:00 - 2:30 PM	Business Meeting and Awards
2:30 - 2:50 PM	Break
2:50 - 4:00 PM	Contributed Papers
4:00 - 4:20 PM	Break
4:20 - 5:00 PM	Poster session
5:00 - 8:00 PM	Open zoom meeting for discussion and social interaction
Thursday, February 25	
9:00 AM - 5:00 PM	Continuing Education - "Bayesian Concepts for Aquatic Scientists" Dr. Mevin Hooten

Check your email for all Zoom links

AGENDA

Tuesday, February 23

Plenary: Story Telling

See page 9 for biographies of plenary speakers

Moderator: Jim White

1:00 - 1:10	**Jim White** Welcome, presidential message and introduction to the plenary
1;10 - 1:30	**Kurt Fausch** The power of stories for reaching public audiences
1:30 - 1:50	**Jeremy Monroe** Sharing freshwater beauty: using imagery and stories to invite more people into our world
1:50 - 2:10	**Todd Pearsons** Stories of starting
2:10 - 2:30	BREAK

	Session 1A: Inverts and Restoration ***Moderator: Steve Gale***	***Session 1B: Water Quality*** ***Moderator: Jason Burkhardt***
2:30 - 2:40	**Braxton Newkirk (professional)** A survey of current distributions for Wyoming crayfishes	**Ben Vaage (student)** Does acclimation to reduced dissolved oxygen increase hypoxia tolerance in juvenile Burbot?
2:40 - 2:50	**Dan Kowalski (professional)** Quantifying the habitat preferences of the stonefly *Pteronarcys californica* in Colorado	**Ashleigh Pilkerton (student)** Modeling surrogate metrics for fine sediment deposition impacts in suitable salmonid spawning habitat, Willwood Dam, WY
2:50 - 3:00	**Matt Kondratieff (professional)** Response of trout populations and pool depths to the addition of large wood through the installation of toewood treatments within lateral scour pools	**Carli Baum (student)** Laboratory evaluation of reproductive success in Johnny Darter *Etheostoma nigrum* relative to winter water temperature and duration
3:00 - 3:10	**Matt Kondratieff (professional)** Response of trout populations to the conversion of a sin-gle-stage, highly-confined, channelized, riprapped stream reach to a three-stage, moderately-confined stream with a functional floodplain	
3:10 - 3:30	**Eric Richer (professional)** From gold mining to gold medal fishery: evaluating the fishery response to stream restoration on the upper Arkansas River, Colorado	**Catherine Adams (professional)** Field examination of altered stream temperatures on reproductive development of Johnny Darter *Etheostoma nigrum* in the Front Range
3:30 - 4:00	BREAK	

Tuesday, February 23 - Continued

	Session 2A: Salmonids ***Moderator: Yoichiro Kanno***	***Session 2B: Fish Passage*** ***Moderator: Liz Krone***
4:00 - 4:10	**Lucia Combrink (student)** The tempo of ecological and evolutionary change: response to predator introduction in alpine lakes of the Wind River Range	**Erin Leonetti (professional)** Wyoming fish screen inventory
4:10 - 4:30	**Jeff Baldock (student)** Spawning behavior mediates reproductive success and population productivity of Snake River Cutthroat Trout	**Rachel Jones (student)** Efficacy of recently installed fish passage designs along the northern Colorado Front Range
4:30 - 4:50	**Audrey Harris (student)** Gene flow and spatial population structure of Brook Trout in a large headwater stream network in Colorado	**Cole Brittain (student)** How does rock-ramp fishway surface texture affect the passage success of small-bodied Great Plains fIshes?
4:50 - 5:00	**John Fennell (student)** Exploring mechanisms underlying the persistence of Yellowstone Cutthroat Trout despite hybridization in the North Fork Shoshone River drainage	**Brian Hodge (professional)** Recolonization by Colorado River Cutthroat Trout following barrier removal
5:00 - 8:00	Fish in Film Festival	

Wednesday, February 24

Business Meeting and Awards
Moderator: Jim White

1:00 - 2:30	Business meeting and awards
2:30 - 2:50	BREAK

	Session 3A: Native upper CO fishes ***Moderator: Bobby Compton***	***Session 3B: Invasives and sportsfish*** ***Moderator: Wes Gordon***
2:50 - 3:00	**Alissa Tiemann (student)** Evaluating movement patterns of Roundtail Chub and Flannelmouth Sucker in the Blacks Fork Subbasin	**Jake Ruthven (student)** Looking at the big picture: evaluating the landscape-level distributional drivers of Brook Stickleback in the North Platte River Drainage, Wyoming.
3:00 - 3:20	**Reese Samuelson (student)** Passive monitoring of the native 'Three-Species' in the Dolores River Basin and land management implications	**Benjamin Felt (professional)** Overview of recent illicit Northern Pike *Esox lucius* introductions in western Colorado and strategies Colorado Parks and Wildlife has implemented to address
3:20 - 3:40	**Jenn Logan (professional)** Post stocking survival and movement of captive reared Bluehead Sucker *Catostomus discobolus* in a Yampa River tributary	**Aaron Black (student)** Evaluation of natural and hatchery-produced Kokanee in Flaming Gorge Reservoir
3:40 - 4:00	**Mike Gross (professional)** A U.S. Fish and Wildlife Service recirculation endangered fish hatchery in a Western Colorado High School. Partnerships that create a feeling of conservation and ownership for native fishes within the Upper Colorado River Basin.	**Colter Brown (student)** Reproductive ecology of Mountain Whitefish in dissimilar populations
4:00 - 4:20	BREAK	
4:20 - 5:00	**Poster sessions** see next page for posters	
5:00 - 8:00	Open zoom meeting for discussion and social interaction	

Wednesday, February 24 - Continued

POSTERS

https://units.fisheries.org/cowyafs/2021-poster-session/

Room A, moderator: Chance Kirkeeng

4:20- 4:30 Katrina Cook (student) "Habitat selection and quality of an isolated wood frog *Lithobates sylvaticus* population"

4:30- 4:40 Derek Houston (professional) "Biodiversity, biogeography, and conservation of North American desert fishes"

4:40- 4:50 Nick Scribner (professional) "Bear Creek diversion: lessons learned"

4:50- 5:00 Lusha Tronstad (professional) "Using eDNA to estimate the distribution of California Floater *Anodonta californiensis/nuttalliana* clade and Western Pearlshell *Margaritifera falcata* mussels in the Bear River Basin of Wyoming"

Room B, moderator: Eric Fetherman

4:20- 4:30 Chance Roberts (student) "Sulfur stable isotopes reveal ontogenetic shifts in Lake Trout reliance on profundal energy pathway"

4:30- 4:40 Kaitlyn McKnight (student) "Time-scale specific (a)synchrony between Walleye and Yellow Perch dynamics across the Great Lakes"

4:40- 4:50 Tawni Riepe (student) "Non-lethal detection of *Renibacterium salmoninarum* (causing bacterial kidney disease) in Brook Trout *Salvelinus fontinalis*"

4:50- 5:00 Tomas Swickley (student) "Changes in relative weights between coolwater and warmwater species in a large river ecosystem"

PRE-RECORDED TALKS

https://units.fisheries.org/cowyafs/2021-pre-recorded-talks/

Kevin Bestgen (professional) "Abundance estimation following increased removal verifies declining trends of Northern Pike in the Yampa River, Colorado" link: https://youtu.be/XmIk_VRPiro

Ryan Fitzpatrick (professional) "Plains fish identification training improves staff performance and data quality" link: https://youtu.be/s6pulFnq04I

Sarah Gump (professional) "Merwin Trap: definitions, design and southwest success" link: https://youtu.be/HxWu29wVGvs

Koreen Zelasko (professional) "Incorporating passive antenna detections with physical recaptures improves survival rate estimates for Razorback Suckers" link: https://youtu.be/GgmmgjXDrHo

Plenary speakers

Science and Storytelling

Dr. Kurt Fausch, Colorado State University

Professor Emeritus, Department of Fish, Wildlife, and Conservation Biology, and Graduate Degree Program in Ecology, Colorado State University

Dr. Kurt Fausch is a stream ecologist and Professor Emeritus at Colorado State University in the Department of Fish, Wildlife, and Conservation Biology where he taught and conducted research for 35 years. He was also a charter member and Acting Director of the Graduate Degree Program in Ecology and active in the Water Center. He currently serves on the Independent Scientific Review Panel which evaluates projects to restore native salmon and trout in the Columbia River basin for the Northwest Power and Conservation Council, and speaks about why rivers are essential for fish and people.

Jeremy Monroe, Freshwaters Illustrated

Founder and Executive Director, Freshwaters Illustrated

Jeremy founded Freshwaters Illustrated to help create more immersive imagery and stories that carry the beauty, biodiversity, and value of freshwater ecosystems. Jeremy sees his job as helping to reconnect people to the intricacy, wonder, and needs of rivers, lakes, and wetlands. Jeremy is a Colorado State University graduate and has degrees in Aquatic Ecology and Fisheries Biology. Jeremy uses this knowledge to access stories that celebrate the vibrance and value of freshwater life and feels fortunate to have a talented group of visual artists and communicators to make these stories as immersive as possible!

Dr. Todd Pearsons, WDAFS

President, Western Division of American Fisheries Society

Dr. Todd Pearsons will talk about the importance of starting his profession, how that translated into his passion for photography, and evolved into his current service role with the Western Division of the American Fisheries Society. Dr. Pearson will end by challenging the students and members to "start a new story" by getting involved in AFS. Todd received both his M.S. and Ph.D. degrees from Oregon State University where he showed that the chub from the Umpqua River deserved recognition as a separate species. His Ph.D. research examined the differences between physical factors vs. interactions that affected habitat selection of fishes in the John Day basin. Todd has worked as the leader of the Yakima Basin Species Interaction Research Program for the Washington Department of Fish and Wildlife. Dr. Pearsons has won many awards for leading his research teams and now works as the Chief Fisheries Scientist for Grant County Public Utilities District. Dr. Pearsons loves natural history and fish and has taken to capturing their images in snapshots and on film. Many of Dr. Pearsons' videos and photographs at posted at Todd-Pearsons-Gallery .

Mentoring Program Update!

The principal goal of the Colorado/Wyoming AFS Mentoring Program is to assist college students and young fisheries professionals in expanding their fisheries expertise and skills and continuing their personal and professional growth. The mentoring committee paired up four mentees with mentors for the 2020 mentoring program, which means a total of 28 successful pairings have occurred since the program started in 2014. Past mentors have offered a wide range of great opportunities for prospective mentee applicants including the following: 1) travel to diverse locations; 2) interaction with personnel from multiple agencies and NGOs; 3) field experience with chemical treatments, hydroacoustics surveys, and amphibian and reptile surveys; 4) experience working with GIS, program R, and other data entry and analyses programs; 5) professional guidance with applications, cover letters, and résumés; and 6) exposure to grant writing and federal permitting. We are now accepting applications for mentors and mentees for the 2021 mentoring program!

Mentor applications will require a description of the proposed mentoring focus or general area of opportunity and of the location of opportunity. Mentors are allowed and encouraged to co-mentor with other fisheries professionals in the same or another host organization, in order to give students a broad view of the many dimensions of fisheries science. We welcome mentor applicants from municipal, state, federal, provincial, tribal, university, private, and non-governmental organizations within Colorado or Wyoming. The mentor application period will be open until March 15, 2021 to allow posting of the opportunity prior to the end of the mentee application period.

The mentee application period will be open until March 31, 2021. All applicants will be notified by the beginning of April regarding their acceptance status. Mentee application packages must include a contact and general information page, a student statement of interest, and one recommendation from a college/university professor or fisheries or wildlife professional. Application to the program is open to students enrolled in biology or ecology related programs at any Colorado or Wyoming university or college or to individuals who have obtained a degree in biological or ecological sciences and are currently residing in the states of Colorado or Wyoming. Successful applicants should expect to receive a positive mentoring experience that supplements previous school or work experiences in the fisheries field. Once a mentor is paired with a mentee, the two will agree upon the areas of emphasis they wish to work on.

Mentor and Mentee Applications can be found at https://units.fisheries.org/cowyafs/mentoring-program/!

AFS Meetings Code of Conduct

AFS is committed to providing a safe, productive, and welcoming environment for all meeting participants

Purpose:

American Fisheries Society (AFS) meetings are among the most respected scientific meetings of fisheries professionals in the natural resource scientific community. AFS values the diversity of views, expertise, opinions, backgrounds, and experiences reflected among all attendees, and is committed to providing a safe, productive, and welcoming environment for all meeting participants and AFS staff. All participants, including, but not limited to, attendees, speakers, volunteers, exhibitors, staff, service providers, and others, are expected to abide by this Meetings Code of Conduct. This Code of Conduct applies to all AFS meeting-related events, including those sponsored by organizations other than AFS but held in conjunction with AFS events, in public or private facilities.

Expected Behaviors:

- Treat all participants, attendees, AFS staff, and vendors with respect and consideration, valuing a diversity of views and opinions, and critiquing ideas rather than individuals.
- Refrain from demeaning, discriminatory, or harassing behavior and speech directed toward other attendees, participants, AFS staff, and suppliers/vendors.
- Be mindful of your surroundings and of your fellow participants. Alert AFS staff or venue event staff if you notice a dangerous situation or someone in distress.
- Respect the rules and policies of the meeting venue, hotels, AFS-contracted facility, or any other venue.
- To foster a welcoming environment, assist AFS members with impaired physical or cognitive abilities, if necessary.

Unacceptable Behaviors:

- Harassment, intimidation, or discrimination in any form is unacceptable. Harassment includes speech or behavior that is not welcome or is personally offensive. Behavior that is acceptable to one person may not be acceptable to another, so use discretion to be sure respect is communicated. Harassment intended in a joking manner still constitutes unacceptable behavior. Regardless of your intent, if you are advised directly or by another party that some aspect of your speech or behavior at an AFS meeting is harassment, you are expected to stop engaging in such speech or behavior.
- Do not physically or verbally abuse any attendee, speaker, volunteer, exhibitor, AFS staff member, service provider, or other meeting guest.
- Examples of unacceptable behavior include, but are not limited to, unwelcome or offensive verbal comments related to age, appearance, or body size, employment or military status, ethnicity, gender identity and expression, individual lifestyle, marital status, national origin, physical or cognitive ability, political affiliation, sexual orientation, race, or religion. Harassment can also include the use of sexual and/or discriminatory images in public spaces or in presentations; deliberate intimidation; stalking; following; harassing photography or recording; sustained disruption of talks or other events; bullying behavior; inappropriate physical contact; and unwanted sexual attention.
- Appropriate and responsible personal use of photographs or posts to social media of another individual's oral presentation, poster, or likeness is acceptable unless permission is specifically denied by the individual.
- Do not disrupt talks at oral or poster session or activities in the exhibit hall or at other events organized by AFS at the meeting venue, hotels, or other AFS-contracted facilities.
- Any retaliation against participants for reporting unacceptable behavior is unacceptable. Like harassment or discrimination, retaliation against reporting poor behavior will be subject to consequences.

Reporting Unacceptable Behavior:

- Anyone experiencing or witnessing behavior that constitutes an immediate or serious threat to public safety at any time should contact local law enforcement (by calling 911) and immediately notifying facility security without delay.
- If you are not in immediate danger but feel that you are the subject of unacceptable behavior, you are encouraged to file a formal complaint to the AFS Ethics and Professional Conduct Committee and/or an AFS officer or the AFS Executive Director which will then be forwarded to the Ethics and Professional Conduct Committee for assessment.

2021 CO/WY AFS Contributed Papers – Abstracts

By order of presentation, followed by prerecorded papers and posters

A survey of current distributions for Wyoming crayfishes

Braxton Newkirk, Wyoming Cooperative Fish and Wildlife Research Unit, Department of Zoology and Physiology, University of Wyoming, Laramie, WY 82071, lakepowell01@yahoo.com

Annika Walters, US Geological Survey, Wyoming Cooperative Fish and Wildlife Research Unit, Department of Zoology and Physiology, University of Wyoming, Laramie, WY 82071, annika.walters@uwyo.edu

Eric Larson, Department of Natural Resources and Environmental Sciences, University of Illinois at Urbana-Champaign, Urbana, IL 61801, erlarson@illinois.edu

Abstract: Crayfish are important members of freshwater ecosystems worldwide, affecting food web structure and occasionally acting as ecosystem engineers. Further, some crayfish species are threatened with extinction, whereas others have negatively affected ecosystems and economies as invasive species. Here, we combined past crayfish surveys (1987, 2010) with modern surveys (2020) to determine trends and distribution of native and non-native species across Wyoming. Surveys included timed searches and baited trapping for crayfish by Wyoming Game and Fish biologists and University of Wyoming researchers. We found that *Faxonius virilis* has become more prevalent in Wyoming over time, including watersheds where they are non-native. *F. virilis* appears to be displacing some native crayfish species, such as *F. immunis* and *Pacifasticus gambelii*, from parts of their historic native ranges. We also found that *F. neglectus* is expanding their range, perhaps due to introductions by humans. Our surveys also found a new population of *F. rusticus*. We found that Wyoming's rare native species still exist in their native range. *P. gambelii* are found within the Snake River and Bear River drainages, although it appears that their distribution in these drainages has decreased through time. Our results document changes in crayfish communities across Wyoming which may have management implications for native species conservation, aquatic community structure, and ecosystem functioning.

Quantifying the habitat preferences of the stonefly *Pteronarcys californica* in Colorado

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Eric Richer, Colorado Parks and Wildlife, Aquatic Research Section, 317 West Prospect Road, Fort Collins, CO 80526, Eric.Richer@state.co.us

Abstract: The salmonfly *Pteronarcys californica* is a large stonefly species that is ecologically important and recreationally significant to anglers in coldwater river systems throughout the western United States. Salmonflies are sensitive to disturbance and pollution and are considered an indicator of quality coldwater stream habitat. They are declining in range and abundance in some river systems and their extirpation from several western rivers has led to restoration attempts including habitat improvement projects and direct reintroductions. These efforts could be improved with a clear understanding of the causes of these declines, a quantitative description of the species' preferred habitat, and practical management recommendations for the restoration of habitat where it has been lost. The objective of this study was to measure variables that describe the physical habitat of sites supporting varying densities of salmonflies in Colorado. Width to depth ratio, bed slope, D50 sediment size, percent fine sediment, and embeddedness were measured at 18 riffle sites and compared to an index of salmonfly density estimated over three years. Correlation analysis and multiple linear regression with model selection were used to identify important

variables. Salmonfly density was highest at sites with low amounts of fine sediment, low cobble embeddedness, and large cobble size. Fine sediment (particles < 2 mm) was the single best predictor of salmonfly density and ranged from 0-6% at sites with high salmonfly densities. As habitat characteristics influence the range and density of salmonflies in Colorado and elsewhere, results from this study can inform land use practices, flow management, and river restoration activities to benefit this important indicator species.

Response of trout populations and pool depths to the addition of large wood through the installation of toewood treatments within lateral scour pools

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Eric Richer, Colorado Parks and Wildlife, 317 West Prospect Road, Fort Collins, CO 80526, eric.richer@state.co.us

Abstract: Overwinter habitat was identified as a limiting factor for populations of Brown Trout *Salmo trutta* in the Middle Fork of the South Platte River near Hartsel, Colorado. To address this limitation, a 2.1-mile habitat restoration project was initiated within a portion of the degraded watershed with the purpose of converting shallow, over-widened pools into deeper, larger-volume pools to improve overwinter habitat. The hypothesis was that the creation of deeper, larger pools would attract and hold adult fish year-round, and that they would reside in the project reach instead of migrating to overwinter in a downstream reservoir. Pools were constructed in one of three ways: 1) excavation of a deep pool and construction of a point bar (no wood); 2) excavation of a deep pool, construction of a point bar, and introduction of large wood placed at the bank toe of the outside bend in a haphazard manner (Type 1); and, 3) excavation of a deep pool, construction of a point bar, and introduction of large wood intentionally placed at the bank toe of the outside bend to function as an undercut bank (Type 2). Monitoring of pool habitat characteristics and fish populations occurred 8 years post-construction. Fish populations were surveyed using multi-pass depletion electrofishing techniques with block nets to satisfy the assumption of closure. Project effectiveness monitoring was based on data for Brown Trout as it is a wild population (not stocked), a popular game species, and less sensitive to confounding variables such as whirling disease and impaired water quality. Fish population monitoring consisted of estimating Brown Trout abundance (number/100 ft of pool), quality Brown Trout abundance (>14” TL/ 100 ft of pool), and Brown Trout biomass (lbs/100 ft of pool), as well as White Sucker *Catostomus commersonii* abundance and biomass. Pool habitat characteristic measurements included pool type (Type 1, Type 2, or no wood), pool length, and maximum pool depth. Analyses were conducted to determine which treatment types were most effective at maintaining deep pools, the response of trout and sucker populations to the introduction of large wood, and which treatment type conferred the greatest benefit to trout populations.

Response of trout populations to the conversion of a single-stage, highly-confined, channelized, riprapped stream reach to a three-stage, moderately-confined stream with a functional floodplain

Matt C. Kondratieff, Colorado Parks and Wildlife, 317 West Prospect Road, Fort Collins, CO 80526, matt.kondratieff@state.co.us

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Paul Winkle, Colorado Parks and Wildlife, 6060 Broadway Avenue, Denver, CO 80216, paul.winkle@state.co.us

Abstract: Many Colorado streams have been channelized to convey floods, accommodate infrastructure, and maximize crop production over the past two centuries. We report on a study evaluating the effects of converting a single-stage, channelized, riprapped, highly-confined Rosgen F-stream (entrenchment ratio = 1.2; channel slope < 2%) to a three-stage, moderately-confined Rosgen Bc-stream (entrenchment ratio = 2.0; channel slope = 0.9%) on trout populations. Primary treatments within the high-intensity segment consisted of removal of riprap and excess bank material to create a new floodplain and shape a new active channel that aligned with the current hydrologic regime, including bankfull discharge. Response of trout population abundance from the high-intensity segment were compared to low-intensity and control stream segments. Channel cross-sectional geometry was not altered in the low-intensity segment (pre- and post-construction average entrenchment = 1.2). The low-intensity segment remained highly-confined, riprapped, and constrained between two roadways. Pre-construction baseline data were collected at the high-intensity (two years), low-intensity (three years), and control (one year) segments. Post-construction fish population monitoring continued for a total of five years, evaluating fish population composition, density (number/mile), and biomass (lbs/acre) for populations within the three segments. Project effectiveness monitoring was based on data for Brown Trout *Salmo trutta* only as they are a wild and self-sustaining population (not stocked), a popular game species, and less sensitive to confounding variables such as whirling disease and impaired water quality. Post-project monitoring of Brown Trout populations suggest that habitat treatments have resulted in an increase in Brown Trout density and biomass in both high- and low-intensity treatment segments. Within the control reach, Brown Trout density and biomass did not change significantly over the monitoring period. The magnitude of change for Brown Trout density within the high-intensity segment (+182%) was higher as compared to the low-intensity segment (+104%). Brown Trout biomass increased even more within the high-intensity segment (+422%) as compared to the low-intensity segment (+76%). This evaluation suggests that the conversion of highly-confined, channelized and riprapped, single-stage streams to a reference-like historic condition can result in large increases in trout population abundance and biomass.

From gold mining to gold medal fishery: Evaluating the fishery response to stream restoration on the upper Arkansas River, Colorado

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Matt Robinson, Colorado Parks and Wildlife, 317 West Prospect Road, Fort Collins, CO 80526, matthew.d.robinson@state.co.us

Greg Policky, Policky Aquatics, 711 Poncha Boulevard, Salida, CO 81201, greg.policky@gmail.com

Abstract: Metals, pollution, and channel disturbance associated with historic mining, land use, and water development degraded aquatic and riparian habitat along the upper Arkansas River near Leadville, Colorado. Following water quality remediation, habitat restoration was conducted for an eleven-mile reach characterized as an over-wide channel that lacked velocity refuge and deep pools for over-winter habitat. The primary goals of restoration were to improve Brown Trout *Salmo trutta* populations and individual fish health, with a target to improve fish metrics by 10% within five years after restoration. To achieve these goals, the project design focused on channel narrowing to improve sediment transport, stabilizing stream banks to reduce erosion and downstream sedimentation, developing diverse stream

morphology to enhance aquatic habitat, and creating overhead cover for trout. Fish metrics included Brown Trout density, biomass, quality, and relative weight. Changes in all fish metrics were evaluated with a before-after-control-impact study design that utilized five control sites and five impact sites. Brown Trout density, biomass, and relative weight all increased significantly following restoration, but only biomass exhibited a significant interaction between site type and period. Changes at individual sites were less evident, with only one impact site showing significant improvements in biomass and quality trout. Results from the study will be used to inform adaptive management and the design of future restoration projects and monitoring programs.

Does acclimation to reduced dissolved oxygen increase hypoxia tolerance in juvenile Burbot?

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Christopher Myrick, Colorado State University, Fort Collins, CO 80523, chris.myrick@colostate.edu

Abstract: Burbot *Lota lota* are a candidate species for commercial aquaculture because of their palatability and optimal growth at temperatures similar to those used in trout aquaculture. However, data on Burbot environmental tolerances and requirements are sparse, especially with reference to water quality relevant to aquaculture, such as dissolved oxygen (DO). Following a 63-day growth study, where juvenile Burbot were exposed to sub-lethal levels of DO (60, 70, 80, 90, and 100% saturation), we conducted a static respirometry experiment to test for differences in loss of equilibrium concentration (LOEcritical) by acclimation level. A total of 100 Burbot (20 fish/acclimation level; mean wet weight = 45.4 ± 12.7 g) were tested at 15°C (optimal growth temperature). The combined group mean LOEcritical was 1.64 ± 0.34 mg/L and only the control (100% saturation) fish LOEcritical was significantly higher than the other levels (LOEcritical = 1.85 ± 0.33 mg/L; p-value = 0.003). No clear trend was observed in tolerance by acclimation level. Although chronic exposure to reduced DO (60% saturation) did not result in significantly higher hypoxia tolerance, these LOEcritical measurements will provide future Burbot farmers with information on the hypoxia sensitivity of Burbot reared at optimal growth temperatures.

Modeling surrogate metrics for fine sediment deposition impacts in suitable salmonid spawning habitat, Willwood Dam, WY

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Annika Walters, US Geological Survey, Wyoming Cooperative Fish and Wildlife Research Unit, Department of Zoology and Physiology, University of Wyoming, Laramie, WY 82071, annika.walters@uwyo.edu

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Abstract: Managing sediment accumulation behind dams is a critical challenge in Wyoming. Accumulation of sediment behind dams can prevent their effective operation to meet water user needs, compromise structural integrity, and increase maintenance costs, but sediment releases can harm downstream fisheries and aquatic life. In Wyoming, this challenge in managing sediment is exemplified by Willwood Dam, a 70-foot-tall concrete diversion dam located on the Shoshone River. Historically, sediment was released on an annual basis via the sluice gates, but concerns about the effects to the

downstream fishery led to operating criteria restricting releases. The accumulated sediment has made it difficult for the Willwood Irrigation District to operate the dam or conduct maintenance without unintentionally releasing large amounts of sediment. Our work aims to better quantify the impacts of varying sediment releases on downstream fisheries and aquatic life.

We conducted field studies during the Fall 2019 and Fall 2020 pool drawdown events at Willwood Dam to evaluate the relationships between approaches that measure sediment releases from dams and their relevance to fisheries. We compared water column approaches (e.g., suspended sediment, turbidity) with river substrate approaches (e.g. sediment deposition in sensitive habitats, hyporheic dissolved oxygen) below Willwood Dam for a series of sediment release targets during the fall pool drawdown period. Using multiple regression models, we have developed a preliminary set of models capable of predicting hyporheic dissolved oxygen levels and fine sediment deposition rates. Built using Fall 2019 data, these models will be validated with Fall 2020 data and refined to longitudinally predict the downstream effects.

This research will enhance our understanding of effective metrics for monitoring sediment releases from dams and mitigating downstream impacts on fisheries, biological systems, and fluvial processes. Further, it will equip managers and stakeholders with site specific knowledge to best protect and maintain downstream fisheries and other aquatic life in the Shoshone River, while also allowing the Willwood Irrigation District to deliver water to its users.

Laboratory evaluation of reproductive success in Johnny Darter *Etheostoma nigrum* relative to winter water temperature and duration

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Abstract: Changes in water temperature and its seasonal timing may influence the physiological processes of many aquatic ectotherms. Rapid urbanization and development of wastewater treatment plants (WWTP) along the Front Range of Colorado have likely contributed to warmer and more consistent water temperatures throughout the year, particularly in winter months. Reduced variation in seasonal temperatures may have adverse effects on fishes that rely on temperature fluctuations or sustained periods of specific over-winter temperatures for proper reproductive development. Assessing thermal requirements for reproduction is a necessary step towards the conservation of native warm water fishes residing in WWTP effluent-impacted streams. Johnny Darter *Etheostoma nigrum* are being used as a sentinel species for winter water temperature regulations in Colorado because they are a thermally sensitive native species. We evaluated the effects of winter stream temperature and winter duration on reproductive success in wild Johnny Darter. Winter duration and temperature treatments were designed to simulate warmed effluent-impacted streams as well as minimally impacted streams with a natural thermal regime. Analyses are ongoing and preliminary. However, data indicate changes in the timing of reproduction based on temperature and duration. Reproductive output appears similar among treatments but needs to be evaluated in the context of seasonal timing. The evaluation of reproductive success in each winter treatment will inform criteria development of acceptable WWTP winter water temperature standards to help protect a thermally sensitive species, with the hopes of also protecting a broad range of fishes in the South Platte River Basin.

Field examination of altered stream temperatures on reproductive development of Johnny Darter *Etheostoma nigrum* in the Front Range

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Abstract: Increases in water consumption from expanding human populations coupled with decreases in stream flow attributed to climate change in the inner-mountain and south-western USA have resulted in the domination of many streams along the Front Range of Colorado by wastewater treatment plant effluent (WWTPE). Winter effluent temperatures can be as high as 15ºC warmer than instream temperatures and this may adversely impact fish reproductive timing. We are currently studying how effluent temperatures may influence Johnny Darter *Etheostoma nigrum* (JD) reproduction because JDs are used as a sentinel species for current temperature standards. Greater than 300 total JDs sampled from 14 sites upstream and downstream of WWTPE at four South Platte tributaries between 02 March 2020 and 14 October 2020 were evaluated histologically, and gonads were scored by the Organization for Economic Co-operation and Development (OECD) gonad staging criteria (0-4) to estimate reproductive developmental timing. Water temperature was measured at each collection site year-round. We hypothesized that advanced gonadal stages would occur earlier at sites with water warmed by WWTPE. Sampling in 2020 showed reproductive development beginning in early April with spawning activity continuing through mid-July. Water temperatures downstream of WWTPE sites were 5-12ºC warmer than upstream sites in winter but were not appreciably different during the rest of the year. Fish collected from one tributary in late April above and below a WWTPE were in different gonadal stages (mean stage 1 and stage 3, respectively) representing early and late maturation and supporting our hypothesis. Ovaries of fish below the WWTPE also had post-ovulatory follicles present, evidence of recent spawning, not seen in fish upstream. Current challenges include sample size and sampling frequency. Sampling in 2021 will target the spawning season, with weekly sampling efforts from April through mid-May to gather more data and determine any differences in reproductive development above and below WWTPE.

The tempo of ecological and evolutionary change: Response to predator introduction in alpine lakes of the Wind River Range

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Abstract: Introduced apex predators are key drivers of ecological and evolutionary change within ecosystems. However, few studies have examined how predator-induced shifts in resource abundance may in turn spur the adaptation of the predators themselves. We seek to examine this potential for rapid evolutionary change in several populations of introduced trout in the naturally fishless, oligotrophic alpine lakes of the Wind River Range, Wyoming. Previous research in this system has demonstrated a decrease in average zooplankton body size following the introduction of invasive trout. We hypothesize that this shift in planktonic prey size may in turn lead to the selection of trout adaptations that facilitate predation

on smaller zooplankton such as an increase in number of gill rakers, decrease in space between gill rakers, or both. These findings will contribute to our knowledge of the tempo of evolutionary and ecological change in wild populations and the eco-evolutionary feedbacks that may occur after the introduction of a novel invasive predator.

Spawning behavior mediates reproductive success and population productivity of Snake River Cutthroat Trout

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Abstract: Understanding whether and how populations are regulated is a central challenge for ecologists. Competition for high quality breeding habitat can regulate populations by determining reproductive success of individuals. This is especially true for salmonids, as females compete for redd (i.e., nest) sites based on the environmental conditions that maximize embryo survival. When spawning densities are high, competition is mediated through redd superimposition, where later-spawning females construct redds overlapping existing ones, destroying already present embryos. The role of superimposition in regulating salmonid populations is not well understood. We ask to what extent redd superimposition mediates reproductive success and population productivity of Snake River Cutthroat Trout *Oncorhynchus clarkii behnkei* spawning in spring-fed tributaries of the Snake River, Wyoming. We captured larval fish as they emerged from redds of known levels of superimposition as determined from detailed spawning ground surveys. We then used genomic tools to reconstruct parent-offspring relationships and test whether superimposition affects maternal reproductive success. We then leveraged historical spawner abundance and redd mapping datasets to ask whether spawner density drives patterns of superimposition. Finally, we employed a population model to determine the effect of superimposition on population productivity. We found that superimposition dramatically limits maternal reproductive success. Further, we did not find a relationship between spawner density and the extent of superimposition, indicating that this behavior may be independent of habitat availability. We note that these results are preliminary, and this project, especially population modelling, is ongoing. Our results suggest that while redd superimposition limits individual reproductive success, there may be minimal effects at the population level. As a result, conservation efforts aiming to reduce the prevalence of superimposition may not produce the desired results in terms of population growth.

Gene flow and spatial population structure of Brook Trout in a large headwater stream network in Colorado

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Abstract: We studied gene flow of non-native Brook Trout *Salvelinus fontinalis* in a 60-km section of continuous stream network in the upper Cache la Poudre River basin, where a large-scale reclamation effort to restore federally threatened Greenback Cutthroat Trout *Oncorhynchus clarkii stomias* (GBCT) is taking place. This effort—the Poudre Headwaters Project—represents the most important recovery effort of the state fish of Colorado and will result in a fivefold increase in total occupied GBCT habitat. However, the reclamation area is currently dominated by non-native Brook Trout. Key steps to ensure the success of the Poudre Headwaters Project include removing non-native Brook Trout and physically isolating the area from reinvasion. We examined existing spatial population structure in the reclamation area to provide scientific guidance for effective Brook Trout removal and subsequent GBCT reintroduction. During summer and fall of 2018 and 2019, tissue samples were collected from 23 sites in the Long Draw region. We genotyped a subsample of 792 Brook Trout using 12 microsatellite loci to examine spatial population structure within the reclamation area. Our results show that fine-scale spatial population structure is present (FST = 0.038; D = 0.067) and overall genetic diversity is comparable to previously published estimates throughout the native range of Brook Trout (HO = 0.610; HS = 0.618). Preliminary analysis of genetic differentiation among sites suggests that populations in the reclamation area may function as a metapopulation, with fine-scale genetic structure present among tributaries that are loosely connected by gene flow. In the future, we plan to use a riverscape genetics framework to identify potential barriers and environmental factors that drive movement and gene flow. Understanding how the landscape influences connectivity and population persistence will provide key scientific guidance for Brook Trout removal efforts and allow managers to release GBCT in stretches of critical habitat that ensure the highest probability of reintroduction success.

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

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Abstract: Interactions with introduced species constitute a significant threat to the long-term persistence of ecologically and economically important native fishes. Within the North Fork Shoshone River drainage, genetically pure Yellowstone Cutthroat Trout *Oncorhynchus clarkii bouvieri* persist despite extensive hybridization with non-native Rainbow Trout *O. mykiss*. Our research aims to identify the mechanisms underlying the maintenance of Yellowstone Cutthroat Trout populations in the North Fork Shoshone River. Specifically, we ask whether temporal segregation exists in spawn timing between Yellowstone Cutthroat Trout, Rainbow Trout, and their hybrids. Fish traps were used to sample migrating adult trout as they entered two tributaries to the North Fork Shoshone River, Middle Creek and Trout Creek. Catch data from Middle Creek showed that Yellowstone Cutthroat Trout enter the spawning

tributary on average three to four weeks later than Rainbow Trout and hybrids. Catch data from our second study tributary, Trout Creek, showed no significant difference in timing between when Yellowstone Cutthroat Trout, Rainbow Trout, and hybrid individuals entered the spawning tributary. These results suggest that while temporal segregation may act as a mechanism of reproductive isolation between Yellowstone Cutthroat Trout and Rainbow Trout, reproductive characteristics of different genotypes might vary across tributaries in the drainage. We are currently analyzing environmental data to determine if Yellowstone Cutthroat Trout and Rainbow Trout respond differently to changing abiotic cues (water temperature, water discharge) during their spawning migrations. Our results have implications for fisheries management in this drainage and will add to the body of literature investigating the persistence potential of native fishes despite the introduction of non-natives.

Wyoming Fish Screen Inventory

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Abstract: Fish screens are becoming more widely used across Wyoming to prevent fish entrainment into irrigation canals. Screen types range from vertical, horizontal, and drum, and are mostly located on smaller canals (less than 10 cfs). These projects are an important and expensive investment for our fisheries, so many organizations and landowners work together to make them happen. In 2017, Trout Unlimited out of Utah began the development of a fish screen database and inventory methodology. Trout Unlimited's inventory throughout the Great Basin and the Upper Snake River Basin includes about 80 different sites. The Wyoming Game and Fish Department has utilized the methodology and inventoried over thirty screens throughout Wyoming. These projects have reduced or eliminated fish entrainment into irrigation canals and reconnected hundreds of stream miles. Trout Unlimited's goal for this project is to facilitate information sharing and continue to improve fish screening efforts to conserve our fish populations.

Efficacy of recently installed fish passage designs along the Northern Colorado Front Range

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Abstract: Fish species in the Great Plains ecoregion of the United States face mounting challenges to survive in fragmented river segments as man-made structures continue to proliferate. While low-head diversion dams are a frequent culprit, other structures such as whitewater parks or culverts further exacerbate the problem. In an attempt to restore connectivity where possible, fish passage structures of various types have been installed across the Northern Colorado Front Range in recent years, often intended to restore passage specifically for small-bodied native fish species. Little or no post-installation monitoring of these structures has been performed, however, providing little clarity in their comparative success. The goal of this project is to assess the passage success of fish communities at three existing Front Range fish passage structures to better understand how structure design and type affect efforts to restore connectivity. We conducted long-term monitoring of stationary Passive Integrated Transponder (PIT) tag antenna arrays detecting a free-ranging assemblage of PIT-tagged fishes. We also ran a series of short-term enclosure studies to allow controlled assessment of success for selected regional fish species.

The chosen structures focused on rock-ramp, wingwall bypass, and pool-and-weir style fishways in reaches of the Cache La Poudre and St. Vrain rivers with similar species compositions. We tagged 826 fish (representing 16 species) on the lower Cache la Poudre; 14 of those species were detected at the fishway and 13 successfully moved upstream over the fishway. At the lower St. Vrain River site, 794 fish (20 species) were tagged; 14 species were detected at the fishway and 13 successfully ascended the structure. The long-term monitoring data revealed movement patterns that seemingly corresponded with different seasonal periods or changes in flow, and, in the case of the wingwall bypass, showed the fishway's use as habitat in addition to facilitating upstream movement. The results of this study, focusing on the effects of design features (e.g., slope), will help refine the design and selection process of future Colorado Front Range fish passages.

How does rock-ramp fishway surface texture affect the passage success of small-bodied Great Plains fishes?

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Abstract: The waterways of the North American Great Plains have experienced extensive longitudinal fragmentation from instream structures and intermittency caused by excessive dewatering. The modifications to these waterways include numerous barriers that prevent the upstream movement of fish. Regional resource management agencies have turned to fish passage structures (e.g., rock ramp fishways) to restore connectivity. However, the passage efficiency of current structures may be limited for native small-bodied fish species because of a lack of information on how fish swimming behavior and performance interact with key fishway design parameters of slope, length, and texture. Recent research has provided more information on fishway slope and length, and identified texture of the surface between the larger roughness elements as an area needing more investigation. We evaluated the effects of four surface textures (smooth, 1-2 mm diameter coarse sand, 6-10 mm diameter pea gravel, and 19-31 mm diameter small cobble on the passage success of three native small-bodied fish species, Arkansas Darter *Etheostoma cragini*, Flathead Chub *Platygobio gracilis*, and Stonecat *Noturus flavus*, using an experimental rock-ramp fishway set at a 6% slope. Our results demonstrated that passage success for the Arkansas Darter increased from 0% on the smooth substrate to 32.2% for the small cobble substrate. A similar pattern was observed for the Stonecats, with an increase in passage success from 31.1% on the smooth substrate to 86.7% on the small cobble substrate. Flathead Chub passage success appeared independent of substrate treatment, as it exceeded 90% in all cases. Our study suggests that the use of more highly textured substrates is a viable option for increasing the passage success of small-bodied fishes on rock-ramp fishways.

Recolonization by Colorado River Cutthroat Trout following barrier removal

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Abstract: When biologists sampled the headwaters of Poose Creek in 2012-2013, native Colorado River Cutthroat Trout (CRCT) were almost completely absent from the reach above the one road-stream crossing but relatively abundant in the reach below the crossing. In 2014, agency and NGO partners retrofitted the box culvert with a vertical slot fishway. Although the fishway was designed only to pass adult trout, our ultimate goal was to facilitate repatriation by CRCT. The fishway project was thus rooted

in at least two testable hypotheses: 1) that removal or mitigation of the passage obstacle would result in fish passage, and 2) that the incursion of adult spawners into vacant habitats would result in recolonization by the species. A 2015-2016 PIT tag study answered the first question and satisfied the proximate goal of restoring passage. Nevertheless, questions still remained about the ultimate effect of restoring connectivity. In fall of 2020, approximately 1½ to 2 Cutthroat Trout generations after the fishway was installed, we tested the second hypothesis—that restoring fish passage would lead to recolonization of upstream habitats. Specifically, we used backpack electrofishing units to repeat an extensive one-pass electrofishing survey and multiple-pass removal method estimator above the culvert. Whereas CRCT density above the culvert was < 10 fish/mile in 2012, it was approximately 1,000 fish/mile in 2020 (350 fish/mile excluding the 2020 year-class). Further, while only adult CRCT were captured upstream of the culvert in 2012, all age classes were captured above the culvert in 2020. Our findings provide evidence that fish will naturally recolonize habitats following removal of long-standing migration obstacles.

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

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Abstract: Native fish populations have significantly declined in Wyoming. These declines are largely attributed to anthropogenic changes including irrigation diversions, altered flow regimes, habitat fragmentation and degradation, and the introduction of invasive species. Understanding the movement patterns of these native fish is critical to sustaining existing populations. Movement is a key component to the survival of a long-lived species and enables fish to respond and adapt to changing environmental conditions, thus increasing their chances of survival, growth, and reproductive success. Roundtail Chub *Gila robusta* and Flannelmouth Sucker *Catostomus latipinnis* are two fish species native to the Blacks Fork Subbasin that have been affected by habitat alteration and invasive species. While some life history data exists for these two species, limited spatial data has been collected. Research shows these fish are likely utilizing tributaries at some point in their life cycle, however, there is a limited understanding as to how and when these fish are using mainstem and tributary habitat. We conducted field surveys in the summers of 2019 and 2020 to identify seasonal movement patterns to understand mainstem and tributary habitat use by the Roundtail Chub and Flannelmouth Sucker. Preliminary results suggest tagging location and season affect movement patterns. Additionally, multiple regression models were applied to determine how the timing of seasonal movements were correlated with abiotic factors (i.e., temperature, flow). This research will provide a better understanding of Roundtail Chub and Flannelmouth Sucker movement behavior, and more effective management and conservation of remaining fish populations.

Passive monitoring of the native 'three-species' in the Dolores River basin and land management implications

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Abstract: Flannelmouth Sucker *Catostomus latipinnis*, Bluehead Sucker *C. discobolus*, and Roundtail Chub *Gila robusta*, collectively known as the three-species, are fishes native to the Colorado River basin that have experienced range-wide population declines. The Dolores River, a tributary to the Colorado River, has relatively robust populations of all three species, in part because there are comparatively fewer non-native fish species than elsewhere in their native ranges. Previous studies suggest that three species composition and biomass in the Dolores River basin are highly variable among different reaches and among years, and that individuals of these species may be highly transient. Herein, we 1) review a brief history of the land management and water use practices in the Dolores River basin, 2) present data on large-scale movement patterns of the three-species assemblage gathered using passive integrated technology, and 3) discuss potential management implications, particularly as they pertain to the proposed rebuilding of a river-wide diversion structure in the Dolores River. Our data show that all three species migrate over long distances, with a substantial proportion of PIT-tagged fish entering the Dolores River drainage from the Colorado River in the spring and exiting in the late summer and fall. Our findings underscore the need to pursue innovative ways to maintain connectivity for native fish, while simultaneously protecting the basin from nonnative invasion, to work toward the long-term conservation of one of the last remaining three-species strongholds in the world.

Post stocking survival and movement of captive reared Bluehead Sucker *Catostomus discobolus* in a Yampa River tributary

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Abstract: Once common in the Yampa River of northwestern Colorado, native Bluehead Sucker *Catostomus discobolus* are now encountered infrequently in the main-stem river and tributaries upstream of Lily Park, approximately 55 miles west of Craig, CO. Prolonged drought, hydrologic changes, predation and competition by non-native fish species, and hybridization with nonnative suckers have contributed to Bluehead Sucker population declines. The Three Species Range-Wide Conservation Agreement and Strategy (2006) established conservation actions that include expansion of populations through transplant activities or reintroductions into historic habitats. In 2010, Colorado Parks and Wildlife (CPW) acquired adult Bluehead Sucker broodstock from the Yampa River near Lily Park and transported these fish to CPW's Native Aquatic Species Restoration Facility (NASRF) where they spawned successfully for the first time in 2012. Additional adults collected in the Yampa River above Cross Mountain Canyon, expanded the captive breeding population at NASRF in 2014.

Milk Creek, a tributary of the Yampa River located 14 miles southwest of Craig, historically supported a population of Bluehead Sucker. While a small remnant population persists, efforts to augment this population began in 2015. Over 11,600 captive propagated Bluehead Suckers have been released into

Milk Creek from 2015 through 2019. Fish were reared to a minimum length of 7 inches and implanted with passive integrated transponder (PIT) tags prior to release. Due to elevated water conductivity, erratic stream discharge, and challenging physical habitat conditions, monitoring and capture of fish by traditional survey methods is difficult within Milk Creek. To increase our detection of stocked individuals and aid in assessment of survival and movement, submersible passive interrogation arrays (PIAs) were deployed. In addition, electrofishing crews working in the Yampa River assisted recapture efforts. Combining PIA detections of individuals within Milk Creek with basin wide recapture information illustrates survival and movement of stocked fish, and highlights the feasibility of augmenting wild populations of Bluehead Suckers with captive reared individuals

A U.S. Fish and Wildlife Service recirculation endangered fish hatchery in a Western Colorado high school. Partnerships that create a feeling of conservation and ownership for native fishes within the Upper Colorado River basin.

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Abstract: Since 2015, when planning began, the Upper Colorado River Endangered Fish Recovery Program has partnered with Palisade High School in the Grand Valley of Western Colorado to create the Palisade High School Fish Hatchery. This collaboration is unique in that it is one of a small handful of endangered fish hatcheries in the United States operated by high school students, and potentially the only non-salmonid endangered fish partnership of its kind. Full-time operation of this facility began during summer of 2020 with the introduction of nearly 200 Razorback Sucker. Students will learn a wide array of aquaculture and fisheries science techniques and topics revolving around the conservation of upper Colorado River fishes including recirculating aquaculture, conservation of native fishes, Colorado River politics, ichthyology, fish biology, water chemistry, and, much more. The hatchery also presents many other cross-curriculum opportunities for School District 51 students and faculty to utilize such as webpage design, art, math/statistics, and more. Long term conservation success for native fishes of the Upper Colorado River depends on local level acceptance and support. This partnership creates a real world sense of ownership for the native fishes living in the Upper Colorado River among the Grand Valley community.

Looking at the big picture: evaluating the landscape-level distributional drivers of Brook Stickleback in the North Platte River Drainage, Wyoming.

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Abstract: Understanding the distributional drivers of a species on the landscape is a cornerstone of developing and implementing effective management strategies. Despite invasive species becoming increasingly prevalent, however, our knowledge of the environmental variables facilitating their presence in novel environments is still lacking. Invasive species can be a threat to native fishes through predation, competition, and disease transmission. As such, understanding their habitat preferences is of critical importance for fishery managers seeking to protect and enhance at-risk native fish populations. Brook Stickleback *Culaea inconstans*, an invasive species in Wyoming, may pose a risk to native, non-game

fishes in the North Platte River Drainage. We utilized historic and current data within a Random Forest modeling framework to determine the strongest landscape-level predictors of occurrence for Brook Stickleback in the North Platte River Drainage, Wyoming. Our results provide a better understanding of the drivers of Brook Stickleback distribution to inform future management strategies of both Brook Stickleback and native non-game fishes in the state.

Overview of recent illicit Northern Pike *Esox lucius* introductions in Western Colorado and strategies Colorado Parks and Wildlife has implemented to address

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Abstract: One of the greatest threats facing fisheries on the western slope of Colorado is the illicit introduction of non-native, non-salmonid fish species. These illicit introductions adversely affect native fish conservation and recovery efforts, as well as hinder the management of sport fisheries, through predation, hybridization, and/or competition with desirable fish species. Northern Pike *Esox lucius* in particular have a significant history in multiple waters of western Colorado. In response to recent illicit introductions, Colorado Parks and Wildlife (CPW) is actively managing against this species in more than a dozen lentic systems, in addition to more well-known Northern Pike removal efforts associated with main-stem rivers. Control methods implemented include mechanical removal (e.g., electrofishing, gill netting, and fyke netting), angler harvest incentives, regulation changes, manipulation of physical habitat to reduce spawning success, and chemical reclamation. This presentation will provide an overview of recent Northern Pike introductions in western Colorado and the various control methods implemented by CPW.

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

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Abstract: Kokanee *Oncorhynchus nerka* were first stocked in Flaming Gorge Reservoir (FGR), Wyoming-Utah, in 1963. In a system that uses supplemental stocking to enhance a popular sport fishery,

an understanding of the contributions from natural and hatchery-produced fish is critically important so that hatchery resources can be appropriately allocated. Identifying contributions to FGR was accomplished using otolith microchemistry. Otoliths were analyzed for the strontium isotope ratio (i.e., 87Sr/86Sr) using laser ablation and a multi-collector inductively coupled plasma mass spectrometer. Flaming Gorge Reservoir has a unique strontium signature compared to the hatcheries that produce kokanee for FGR. Kokanee were sampled from June-July throughout the reservoir using suspended gill nets and creel surveys. Kokanee from spawning aggregates were collected from September-October in the reservoir using sinking gill nets and in spawning tributaries using weirs. We collected and analyzed 1,655 otoliths from 2018-2020. Line scans of 87Sr/86Sr were visually inspected to identify kokanee origin. Hatchery-produced kokanee were identified by a shift in the Sr signature from the primordium to the edge. Naturally produced kokanee had no shift in their Sr signature across the otolith. In our preliminary results we were able to identify origin of 1,385 kokanee: 592 as hatchery origin and 793 as natural origin. Fish that were identified as hatchery origin were 41% of the sample in 2018, 62% in 2019, and 23% in 2020. Natural origin fish were 59% of the sample in 2018, 38% in 2019, and 77% in 2020. Water samples collected from FGR, spawning tributaries, and hatcheries will be analyzed for their unique Sr signature. Water samples will be used to assign kokanee to a specific hatchery or FGR and help with classifying the remaining unknown fish that could not be classified during the visual examination.

Reproductive ecology of Mountain Whitefish in dissimilar populations

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Abstract: Mountain Whitefish *Prosopium williamsoni* have experienced declines in population abundance in rivers within their native range. Problems with recruitment are suspected, but often the specific mechanisms resulting in population declines are unknown. Our approach to better understanding the mechanisms that influence Mountain Whitefish population dynamics was to compare the reproductive ecology of Mountain Whitefish between two populations in the Intermountain West — upper Green River, Wyoming and the Madison River, Montana (previous study). The Green and Madison rivers were selected because the Mountain Whitefish populations differ in abundance and the rivers vary regarding anthropogenic modifications such as number of dams and regulated discharge. Here, we specifically address the question do reproductive traits and movement during the spawning period differ between the populations? We also asked the question does the relationship between spawning timing and water temperature differ between rivers. To address these questions, we collected otoliths and gonad tissue from Mountain Whitefish in the upper Green River. We also tracked 59 Mountain Whitefish during the spawning period. We used methods identical to the those for studying Mountain Whitefish in the Madison River. Fecundity, spawning periodicity, and age-at-maturity were similar between populations. For example, 50% of the females were sexually mature by 2.5 years in the Green River and 2.6 years in the Madison River. Spawning movement differed between populations. Mean distance moved during the

spawning period in the Green River was 5.2 km whereas it was 25.5 km in the Madison River. Mountain Whitefish in the Green River did not exhibit a directed migration downstream, which was observed in the Madison River. Water temperature during the spawning period and early embryo development differed between rivers. The maximum lethal water temperature for embryo development was never exceed in the Green River but was in the Madison River. Our results suggest the variation between populations may be a result of abiotic conditions influencing embryo survival rather than differences in reproductive traits.

2021 CO/WY AFS Prerecorded Contributed Papers – Abstracts

Merwin Trap: definitions, design and southwest success

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Abstract: Merwin traps are used in Colorado to capture kokanee *Oncorhynchus nerka* for egg take operations in the fall. I will present the history, design and use of these traps in southwest Colorado. Findings indicate that the Merwin trap is an effective and efficient method of fish capture compared to other capture methods.

Previous capture methods involved setting weirs in streams, blocking the migration but requiring a substantial effort to capture and maintain the weir.

Just three biologists spawned 1357 female kokanee in four hours (approximately two fish per minute per biologist). No capture time is required and only a crew of 3-5 people are needed to spawn on a typical day.

Incorporating passive antenna detections with physical recaptures improves survival rate estimates for Razorback Suckers

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Abstract: Survival rate is an informative metric to evaluate stocking success of hatchery-reared animals such as endangered Razorback Suckers *Xyrauchen texanus*. Past efforts to estimate stocked Razorback Sucker survival in the upper Colorado River basin (UCRB) used mark-recapture sampling data from 1995–2006. Survival was influenced by time since stocking, stocking season, and fish total length. Since 2008, antennas have greatly increased the distribution and number of passive detections of tagged Razorback Suckers throughout the UCRB and San Juan River basin (SJRB), including in Lake Powell. We used the Barker model in Program MARK to incorporate detections with mark-recapture records to estimate population parameters for Razorback Suckers encountered in the UCRB and SJRB, 2003–2017. Of the 321,233 Razorback Suckers stocked, 93% were never seen again and 7% were later encountered. Of those encountered, 62% were physically captured over 15 years, while 30% were antenna-detected and nearly all in the last five years. The remaining 8% were physically captured and detected. The top estimating model included effects of time since stocking, season of stocking, and total length at stocking. Survival rates were low in a fish's first year and lowest for smaller fish stocked in summer, supporting earlier analyses. Mean survival of Razorback Sucker after the first year was 0.80, higher than in the 1995–2006 period. Mean first-year survival rates for 350-mm-TL Razorback Suckers were 0.57, 0.18, and 0.46 for spring-, summer-, and autumn-stocked fish, respectively, with relatively low mean coefficients of variation of 6, 9, and 5%. These estimates were substantially higher and more precise than those obtained using data only from 1995–2006. Capture probabilities were low overall, but higher during first sampling

occasions (mean: 0.06, range: 0.01–0.18) than any subsequent occasions (mean: 0.04, range: 0.02–0.07). Detection probabilities were higher in the Green River subbasin (mean: 0.03, range: <0.01–0.16) than in the Colorado River subbasin (mean: 0.01, range <0.01–0.04). Incorporating relatively cost-effective antenna detections alongside physical captures yielded the most robust survival rate estimates available for hatchery-reared Razorback Suckers, which will aid evaluation of stocking practices and progress toward recovery.

Abundance estimation following increased removal verifies declining trends of Northern Pike in the Yampa River, Colorado

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Abstract: Widespread removal of Northern Pike *Esox lucius* in the Yampa River, northwestern Colorado, has been conducted since 2004 to reduce the predatory threat of this invasive species and enhance recovery of native and endangered fishes including Colorado Pikeminnow *Ptychocheilus lucius*. Removals through 2010 indicated substantial annual reduction of Northern Pike, but populations replenished each year via local recruitment and immigration. Increased focus on source populations, especially prior to spawning, was recommended. Beginning in 2014, gill nets were set in early spring in nearshore backwaters where Northern Pike spawning occurred to increase removal, in addition to boat electrofishing in the main channel. Declining capture rates of Northern Pike through 2018 suggested the addition of gill-net removals was effective, but verification of that trend with a more robust capture-tag-recapture technique was needed. To accomplish this, boat electrofishing crews captured, tagged, and released 84 Northern Pike in the Hayden-Craig river reach before backwater netting began in April 2019. We chose this reach because it formerly supported the largest population of Northern Pike in the Yampa River and was the focal area of backwater netting efforts. Subsequent electrofishing and gill netting captured and removed 251 Northern Pike, of which 23 had tags. An estimated 917 (95% profile likelihood interval, 681-1304) Northern Pike occurred in the reach prior to sampling in 2019, a large reduction compared to estimates from 2004-2010, when as many as 4,000 pike were present. The 2019 abundance estimate was consistent with a low capture rate of Northern Pike in the reach and indicated declining abundance trends postulated after 2014 were legitimate. Northern Pike management upstream of our study area may also contribute to downstream declines. These results support continued use of both boat electrofishing and backwater netting as Northern Pike removal techniques. Effects of reduced Northern Pike removal in 2020, due to COVID-19, need to be tracked going forward to better understand pike abundance dynamics and efficacy of efforts to reduce their abundance. We recommend expanded removal effort in other Northern Pike production areas to further reduce populations and facilitate recovery of native and endangered fishes.

Plains fish identification training improves staff performance and data quality

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Abstract: Species misidentifications during field surveys of aquatic organisms results in mis-estimated distributions, biased occupancy analyses, and possibly, inappropriate conservation actions. Morphologically similar organisms, including some native fishes of Great Plains streams, demand rigorous attention during identifications. However, fish identification for technicians is sometimes conducted informally by staff whose training may have occurred years prior, or who may not have been properly trained themselves, which can result in perpetuation of incorrect characteristics being used and species misidentifications. In addition, a common practice is training workers only to identify species they are likely to encounter, which results in confusion if a nearby species invades, but is misidentified as a more common native taxa in the study area. We used a timed-testing approach implemented before and after a 2-day identification short course to quantify potential Great Plains fish misidentification rates and to demonstrate the utility of formal training to reduce these errors. Post-workshop results showed participants with 0 and up to 8 years of plains stream fish experience improved species identification scores. As expected, improvement was greatest in participants who had the least amount of experience; post-workshop scores increased up to ten-fold compared to pre-workshop. Consistent improvement of even experienced participants demonstrates the value of ongoing training. An unexpected result was reduced use of the answer “don’t know” in the post-workshop exam. This behavior occurred even with appropriate cautions against guessing if participant identification was uncertain, knowing false-positive identifications are particularly problematic in analyses. Repeated supervisor checks on identification proficiency during the field season may reduce overconfidence. A formalized training program will improve identification proficiency during field surveys of plains stream fishes, which should aid conservation decision-making.

2021 CO/WY AFS Contributed Posters – Abstracts

Biodiversity, biogeography, and conservation of North American desert fishes

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Abstract: North America hosts 336 lineages of fishes restricted to the desert region. These "desert endemics" have diverse distributions from large river basins to small springs. A major biogeographic boundary subdivides the region into: 1) Northern Great Basin-Colorado Plateau, and 2) Southern Desert-Eastern Steppes. These subdivisions are themselves divisible into 13 and 17 areas of endemism, respectively; each with a unique assemblage of endemics. Although a few widespread lineages endemic to the desert region occupy multiple areas of endemism due to a history of interconnection, 82% are restricted to single areas and no lineage occupies more than five areas. Estimates of diversification times indicate asynchronous evolution, with endemics arising at various times across the region throughout the last ~23 My. A conceptual model of faunal assembly illustrates how areas of endemism become "centers of survival", with many also becoming "centers of origin" and "centers of accumulation" for desert fish diversity. Hence, collective conservation necessitates efforts to preserve and restore essential habitats in all areas of endemism.

Non-lethal detection of *Renibacterium salmoninarum* (causing bacterial kidney disease) in Brook Trout *Salvelinus fontinalis*

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Abstract: Studies of bacterial kidney disease (BKD), caused by *Renibacterium salmoninarum* (Rsal), are important because of BKD's role in salmonid declines in both aquaculture facilities and wild populations. Detections of Rsal in Colorado have been infrequent since the 1960s, but the pathogen has recently been detected in hatcheries with greater frequency in Colorado and nationally. Typically, detection of the pathogen has required sacrificing fish; however, many hatcheries have valuable and sometimes irreplaceable brood stocks, and lethal sampling is undesirable. Therefore, the development of non-lethal detection methods is a high priority. The goal of our study was to compare non-lethal sampling methods with the standardized lethal kidney tissue sampling method that is used to detect Rsal infections in Brook Trout *Salvelinus fontinalis*. In 2017, we collected mucus, buccal, and anal swabs (non-lethal) and kidney tissue samples (lethal) from 72 adult Brook Trout reared at the Colorado Parks and Wildlife Pitkin Brood

Unit and used single-round polymerase chain reaction (PCR), quantitative PCR (qPCR), and direct fluorescent antibody tests (DFAT) to assess bacterial infections from each sampling method.

All tests combined indicated that 62 of 72 fish were positive for Rsal. Of the 62 positive fish, detection varied between sampling methods. Kidney PCR's only detected 21 of the 62 fish, while Kidney DFATs detected 47 of the 62 positive fish, making it the most sensitive test for detecting Rsal. Buccal and anal swabs with qPCR performed poorly only detecting 11 and 9 of the 62 fish positive fish, respectively. Mucus swabs analyzed using qPCR detected 39 of the 62 positive fish. The likelihood of detecting Rsal did not differ between mucus swabs (qPCR) and kidney tissues (DFAT), highlighting the utility of non-lethal methods and suggesting that the use of non-lethal methods for detecting R. salmoninarum in inland trout populations is worth further consideration.

Habitat selection and quality of an isolated wood frog *Lithobates sylvaticus* population

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Abstract: Isolated populations are geographically separated from the species' more contiguous range due to distance or barriers, and may be particularly susceptible to threats such as habitat degradation or disease. Amphibians have experienced population declines and extirpations worldwide from habitat change and pathogens such as the chytrid fungus. Understanding the habitat requirements and prevalence of disease in understudied populations is therefore essential for effective management and species' persistence. Moreover, the extent to which individual amphibians may be able to selectively lessen the negative effects of disease via microhabitat choices remains unknown. The wood frog *Lithobates sylvaticus* is a glacial relict species in Wyoming, found only within the Medicine Bow and Bighorn National forests. The wood frog is listed as a Species of Greatest Conservation Need in the State Wildlife Action Plan due to a lack of information about key habitat requirements and response to disease (chytridiomycosis). We are addressing knowledge gaps by identifying habitat characteristics selected by adult wood frogs across multiple life stages (breeding, foraging, overwintering), spatial scales (microsite and breeding pond), and with variation in disease status. Also, we are investigating the efficacy of aquatic benthic invertebrates as a proxy for the quality of wood frog breeding ponds. We radio tracked over 80 wood frogs in the Medicine Bow National Forest in 2020 between May and October. For each frog's relocation we collected a chytrid sample and microhabitat attributes. Habitat characteristics were also measured at three random locations within twenty meters of each frog's location. Aquatic macroinvertebrates were sampled across a range of potential and known breeding ponds and will be compared to observed numbers of wood frog egg masses. Our study will provide managers with key information about habitat characteristics selected by wood frogs, and identify additional microhabitats used for clearing themselves of infection. We will assess whether aquatic invertebrates can be a practical tool for researchers and managers to use for identifying quality amphibian breeding habitat. More broadly, our study will increase understanding of the ecology of isolated populations and interactions between animal behavior, habitat, and disease susceptibility.

Using eDNA to estimate the distribution of California Floater *Anodonta californiensis/nuttalliana* clade and Western Pearlshell *Margaritifera falcata* mussels in the Bear River basin of Wyoming

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Abstract: Mussels are cryptic animals that are often difficult to study due to their biology and characteristics of the aquatic ecosystem. Environmental DNA (eDNA) can be a useful tool to direct field surveys by identifying areas with DNA fragments from the mussel species of interest. Mussels are ideal animals for eDNA surveys because they slough cells while filtering large volumes of water during feeding. We collected water samples for eDNA throughout the Bear River basin in Wyoming and analyzed samples for DNA from California Floater *Anodonta californiensis/nuttalliana* clade and Western Pearlshell *Margaritifera falcata* mussels. California Floater was present in Wyoming from north of Evanston to where the Bear River flows out of the state north of Cokeville, and the highest concentrations of DNA were in the northern portion of the basin. Western Pearlshell were present throughout the basin in Wyoming from the southern border of Wyoming to where the Bear River flows out of the state north of Cokeville, and concentrations were highest in the southern portion of the basin. Locations identified by eDNA provided potentially new locations for both mussel species and will direct future field efforts.

Bear Creek Diversion: lessons learned

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Abstract: Bear Creek Diversion is located in Northwest Wyoming on Bear Creek approximately 10 miles northeast of Dubois, Wyoming. Bear Creek is part of the East Fork Wind River drainage, which supports one of the largest genetically pure populations of Yellowstone Cutthroat Trout *Oncorhynchus clarkii bouvieri* in Wyoming. Other native species that reside in Bear Creek and the larger East Fork drainage include Mountain Sucker *Catostomus platyrhynchus*, Mountain Whitefish *Prosopium williamsoni*, and Longnose Dace *Rhinichthys cataractae*. Bear Creek provides important spawning and juvenile rearing habitat and the lower part of the drainage lies within Wyoming Game and Fish (WGFD) managed lands before entering the East Fork Wind River. Lower Bear Creek has four irrigation diversions operated by WGFD that irrigate several hundred acres of meadows providing crucial winter forage for several big game species. Water management is key to balancing needs of wildlife and the fishery in Bear Creek, and in typical years irrigation water starts turning off when 20 cfs is measured below all four diversions. The largest of those four diversions is Bear Creek Diversion that provides water to roughly 250 acres. In 2009, work began to improve the diversion for fish passage, eliminate entrainment, and to reduce annual maintenance. Installation of those plans were completed in 2011 that included two grouted rock ramps, an over-shot rotary drum screen, sediment sluice, trash rack, and fish return pipe. Since construction completion the fish screen has been modified three times, the sediment sluice plugged frequently, and 800 feet of significant channel work was needed immediately downstream of the diversion to maintain fish

passage and stream stability. Many lessons have been learned at this site that has provided valuable insight to fish passage and fish screening work across Wyoming.

Sulfur stable isotopes reveal ontogenetic shifts in Lake Trout reliance on profundal energy pathway

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Abstract: Stable isotopes have emerged a powerful tool to quantify foraging patterns and food web dynamics in aquatic systems. Conventional dual stable isotope approaches generally use 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. Here, we employ a tri-isotope approach, including sulfur stable isotopes (δ34S), to quantify ontogenetic shifts 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 the traditional dual isotope and the tri-isotope approach. Both dual and tri-isotope mixing models indicate that Lake Trout consume a wide variety of prey items, but the tri-isotope approach provided greater resolution to differentiate pelagic and profundal energy pathways. Preliminary results suggest a high reliance on profundal energy pathways during juvenile life stages, especially during periods of stratification. Future analyses will compare the proportion of kokanee *Oncorhynchus nerka* in Lake Trout diets estimated with a dual and tri-isotope approach. Results have important implications for understanding how energy flows through reservoir food webs and developing management strategies to promote and maintain multi-species fisheries in the West.

Changes in relative weights between coolwater and warmwater species in a large river ecosystem

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Abstract: The Upper Mississippi River has populations of warmwater and coolwater fishes. In recent decades, water temperatures in the Upper Mississippi River have increased rapidly (>1 °C in 25 years). We used data from a standardized, long-term monitoring program to assess changes in the body condition and catch per unit effort of Largemouth Bass *Micropterus salmoides*, Bluegill *Lepomis macrochirus*, and Walleye *Sander vitreus* across three pools in the Upper Mississippi River. Warmwater species tended to display more positive trends in both abundance and relative weight, while Walleye populations tended to

show declines in both relative weight and abundance. These trends suggest rising temperatures may be causing substantial changes in the fish assemblages of large rivers.

Time-scale specific (a)synchrony between Walleye and Yellow Perch dynamics across the Great Lakes

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Abstract: Synchronous and compensatory dynamics between species are important factors driving resilience of fisheries productivity to environmental change. Across the Great Lakes, Walleye *Sander vitreus* and Yellow Perch *Perca flavescens* support important fisheries; however, differentiating the influence of biotic interactions and environmental conditions on population dynamics remains challenging. Here, we calculate time-scale specific variance ratios for populations from multiple locations to quantify the time scale at which population dynamics between these species are synchronous and compensatory. Preliminary results support our a priori hypothesis that populations exhibit long-term synchrony, while at the short-term, interactions between these two species tend to be compensatory. However, results are not consistent across populations, highlighting (a)synchrony between populations is likely context-dependent. We discuss the importance of management actions and other ecosystem changes to explain patterns across populations.