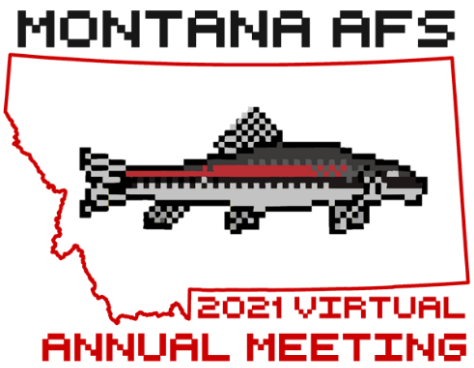
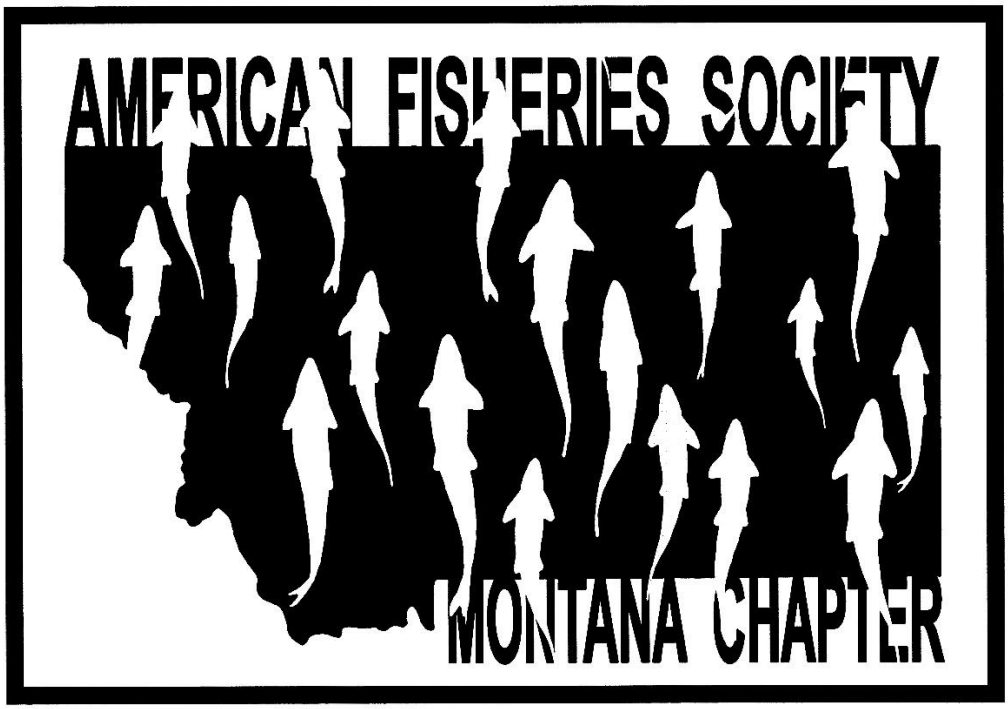


Montana Chapter of the American Fisheries Society 54th Annual Meeting

March 1-5th, 2021 (Virtual)



THANKS!

THANK YOU to the wonderful folks willing to give a talk in this new environment and those willing to attend this in this virtual world. Every day brings new challenges. It is always amazing to hear what wonderful things that MT professionals have achieved. I appreciate the membership's attendance and participation, especially when it would be so easy not to participate. I also want to thank the workshop leaders and plenary speakers who have agreed to present and broaden our perspectives and knowledge base.

Thanks to the MTAFS Executive Committee (and past officers) for their guidance, help, patience, and encouragement with this year's meeting. Thanks to Scott Opitz for his membership communication, Sam Bourret for putting together a wonderful newsletter, and Nathan Cook for continuing his effort with the MTAFS website. Traci Sytle has been a wonderful awards chair and Pat Bigelow has kept us on track with Wally McClure Scholarships, thanks to you both. Once again Niall Clancy has developed a creative and fun logo for our virtual meeting.

The UM and MSU Student subunits have been creative, collaborative, and positive this year with their meetings and work. I appreciate their flexibility and help with ensuring this meeting goes well.

Finally, thanks to the sponsors that have supported this meeting and our Chapter!

Daily Schedule of talks with full co-author list and title (* indicates student speaker).

Monday March 1, 2021		
8:30-12:00PM	Leaders: Michael Callahan, Elissa Chott, and Torrey Ritter and Moderator Lily Haines	Workshop: Beavers, Restoration, and Effective Conflict Resolution
2:00-3:00PM	Andrea Reid and Zachary Penney	Plenary: Meeting at the Confluence: Indigenous and Western Science Coexistence in Modern Fisheries
3:15-4:00PM		Panel Discussion

Tuesday March 2, 2021		
Symposium: Crossing Disciplines in Large River Restoration (Clark Fork River Restoration)		
10:00-10:15 AM	Joe Griffin	Silver Bow Creek: 100 years as a copper mine — Can it be restored?
10:15-10:30 AM	Nathan Cook	The highs and lows of upper Clark Fork River trout populations
10:30-10:45 AM	Rafael Feijo de Lima; Colman, B. ; Cross, W.; Gold-Quiros, T.; Ruiz-Sanchez, J. Shaw, J.; Valett, M.; White, D.; Witzowskey, C.	Disentangling the impacts of multiple stressors in the Upper Clark Fork food webs
10:45-11:00 AM	Erick Greene	Ospreys as environmental sentinels
11:00-11:10AM		**BREAK**
11:10-11:25AM	Will McDowell	Long Shot: the potential to restore fluvial native trout in a fragmented, contaminated basin
11:25-11:40AM	Michelle Terwilliger*; Floyd, T.M. ; Metcalf, E.C.; Mohr, J.J.	Collaboration on the Upper Clark Fork River: a case study from the Montana CREWS project
11:40-11:55AM	Alex Leone	Responding to public doubts: what about the habitat?
11:55-12:10PM	Arica Crootof	Restoring the Upper Clark Fork: integrating public perceptions of the Warm Springs ponds & conducting collaborative research for successful river restoration
12:10-12:30PM	*All available speakers*	*Didn't get your question answered? Want to chat with available speakers? Join the collaborative session*
12:30-1:30PM		**LUNCH**

Tuesday Contributed Sessions		
1:30-1:45PM	Taylor Preul*; Verhille, C.; Bourret, S.	Validation of the use of behavioral assessments in identifying wild origin westslope cutthroat trout vulnerable to artificial selection at Sekokini Springs Hatchery, MT
1:45-2:00PM	Mike Siemiantkowski*; Guy, C.; Cox, T.; Williams, J.; Eckelbecker, R.; Glassic, H.; Lewis, M.; Maskill, P.; McGarvey, L.	A paradoxical knowledge gap in science for critically endangered fishes, species of special concern, and game fishes during the sixth mass extinction.
2:00-2:15PM	Kristen Cook*; Zale, A.; Stagliano, D.; Anderson, M.; Guy, C.; Albertson, L.	Reproductive phenology and hermaphroditism of western pearlshell mussels in two watersheds in Montana
2:15-2:30PM	David Stagliano; Anderson, M.; Cook, K.	Evaluating western pearlshell mussell populations for viability, reproduction and host fish glochidia Infestations across five watersheds in western Montana.
2:30-2:45PM	**BREAK**	
2:45-3:00PM	Sam Bourret	Illegal fish introductions in Montana: how can we stop the spread?
3:00-3:15PM	Mark Schnee; Bourret, S.; Clancy, N.; Boyer, M.	Recovery of freshwater invertebrates in alpine lakes and streams following eradication of nonnative trout with rotenone
3:15-3:30PM	Shannon Blackburn; Ruggles, M.; Radonski, E.; Olszewski, B.	Status of Burbot in the Yellowstone River from the Bighorn River to Park City, Montana
3:30-3:45PM	Jacob Williams; Holmquist, L.; Rhoten, J.; Grisak, G.	Using large scale PIT arrays to monitor native species movements in a large prairie stream tributary to the Missouri River
3:45-4:00PM	**BREAK**	
Lightening Talks		
4:00-4:10PM	Jared Krebs; Dalbey, S.	Status and future assessment of Burbot (*Lota lota*) in the Missouri River Drainage.
4:10-4:20PM	Hayley Glassic*; Driscoll, S ; Guy, C; Koel, T	Presence of microplastics in the food web of the largest high-elevation lake in North America.
4:20-4:30PM	Kerrie Berger	Washoe Park Trout Hatchery- spawning overview 2020
4:30-4:40PM	Beth Gardner	Case study of six intentional migration barriers to protect cutthroat trout. Some lessons learned at what it takes to be successful
4:40-5:00PM	*All available speakers*	*Want to chat with available speakers? Join the collaborative session.*

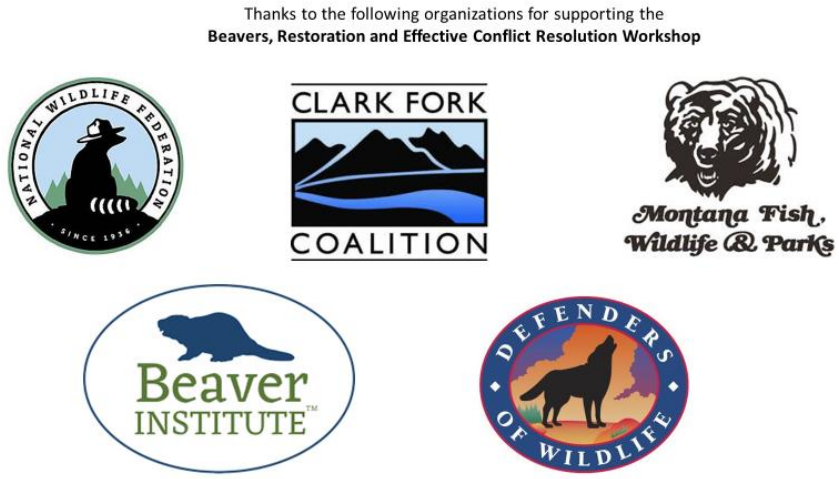
Wednesday March 3, 2021		
11:00AM-12:00	**Business Meeting**	
12:00-1:00PM	**LUNCH**	
	Contributed Sessions	
1:00-1:15PM	Madeline Lewis*; Guy, C.; Oldenburg, E.	Individual characteristics, population density, and environmental conditions explain temporal variation in out-migration dynamics of juvenile Bull Trout
1:15-1:30PM	Kadie Heinle*; Al-Chokhachy, R.; Sepulveda, A.; Bouwes, N.; Verhille C.	Investigating the effects of streamflow and non-native Brown Trout (*Salmo trutta*) on native Yellowstone Cutthroat Trout (*Oncorhynchus clarkii bouvieri*) in Duck Creek, MT, USA
1:30-1:45PM	Colter Brown*; Guy, C.; Webb, M.; Rhea, D.	Reproductive ecology of Mountain Whitefish in dissimilar populations
1:45-2:00PM	Robert Eckelbecker*; Guy, C.; Schmetterling, D.; Heili, N.	Relative-condition equations for Montana fishes
2:00-2:15PM	Andriana Puchany*; Zale, A.; Koel, T.; Shepard, B.	Status of Westslope Cutthroat Trout and Arctic Grayling following conservation translocations in Yellowstone National Park
2:15-2:30PM	**BREAK**	
2:30-2:45PM	Dan Isaak; Young, M.	Factors contributing to present and future occurrence of relict headwater bull trout populations in the northern Rocky Mountains
2:45-3:00PM	Adam Sepulveda; Al-Chokhachy, R.; Laramie, M.	It's complicated…Environmental DNA as a predictor of trout and char abundance in streams
3:00-3:15PM	Robert Al-Chokhachy; Letcher, B.; Muhlfeld, C.; Dunham, J.; Hitt, N.; Roberts, J.; Schmetterling, D.	Factors driving the body size of trout species: beyond climate refuges and refugees
3:15-3:30PM	Kate Gaut; Sylte, T.; DeArment, J; Thompson, M.	A Toolbox, Prybar, and Megaphone for your Fisheries Data: Don't Miss How We Built an User-friendly, Interactive, Cost-Efficient Reporting Platform Utilizing Data Visualizations, Dashboards, and Story Maps to Facilitate Analysis and Promote Sharing of Stream Temperature Data
3:30-3:45PM	**BREAK**	

3:45-4:00PM	Mike Anderson	Montana DNRC habitat conservation plan riparian timber harvest monitoring
4:00-4:15PM	Andrew Lahr*; Eby, L.	Quantifying the effects of beaver dam analogs on fish habitat and communities
4:15-4:30PM	Franz Ingelfinger	A developing approach for restoring cottonwood communities from seed
4:30-4:45PM	Niall Clancy; Wolf, M.; Rosenthal, L.	Bull Trout passage at beaver dams in the Bitterroot and Flathead basins
4:45-5:00PM	Mike LeMoine; Eby, L.; Clancy, C.; Nyce, L.; Jakober, M.; Isaak D.	Landscape resistance mediates native fish species distribution shifts and vulnerability to climate change in riverscapes
5:00-5:15 PM	**BREAK**	
Thursday March 4, 2021		
1:00-1:15PM	Donovan Bell*; Kovach, R.; Muhlfeld, C. ; Schmetterling, D. ; Whited, D.; Al-Chokhachy, R. ; Lukacs, P.; Whiteley, A.	Past and future projected shifts in the occupancy of trout in Montana
1:15-1:30PM	Ryan Kovach; Leary,R. ; Bell, D.; Painter, S.; Whiteley, A.	Genetic variation in westslope cutthroat trout reveals that widespread genetic rescue is warranted
1:30-1:45PM	Troy Smith*; Liermann, B.; Eby, L.	Natal stream characteristics associated with migratory Westslope Cutthroat Trout
1:45-2:00PM	Jeff Strait; Kovach, R.; Kardos, M.; Muhlfeld, C.; Amish, S. ; Eby, L.; Boyer, M. ; Lowe, W.; Luikart, G.	Genome-wide SNP analysis reveals loci linked to fitness-related traits in a Westslope Cutthroat x Rainbow Trout hybrid zone
2:00-2:15PM	**BREAK**	

2:15-2:30PM	Amber Steed; Boyer, M.	Diversifying conservation and management of Westslope Cutthroat Trout in the upper Flathead River System
2:30-2:45PM	Anthony Dangora*; Barfoot, C.; Whiteley, A.; Eby, L.	Evaluating the effects of selective passage of Westslope Cutthroat Trout on non-native admixture in the Jocko River, MT over 15 years
2:45-3:00PM	Matt Jaeger, Bateman, L.; Berry, J.; Breen, L.; Clancey, P.; Detjens, C.; Duncan, M.; Edgington, C.; Franklin, T.; Gander,T.; Gatlin, M.; Horton, T.; Hutchinson, P.; Koel, T.; Kovach, R.; Kreiner, R.; Kruse, C.; Larsen, N.; Leinonen, E.; Lodmell,A.; Lohrenz,T.; Luckenbill, P.; McCormack,M.; Olsen, J.; Painter, S.; Pipinich, C.; Spoon,R.; Stringer, A.; Thomas, N.; Whiteley, A.; Weinner, K.; Korb, N.	Westslope cutthroat trout conservation in the Missouri River headwaters
3:00-3:15PM	Brad Shepard; Delomas, T.; Campbell, M.; Kruse, C; Taper, M.; Zale, A.	Contributions, inbreeding, and outbreeding of wild- and hatchery-origin stocks of Westslope Cutthroat Trout released as eyed embryos into vacant habitat
3:15-3:30PM	Clint Muhlfeld; Kovach, R.; Strait J.; Leary, R; Allendorf, F.	What we've learned from 40 years of hybridization research in Montana
3:30-3:50PM	*All available speakers*	*Want to chat with available speakers? Join the collaborative session.*
4:00-5:00PM	**Awards Event (Student Scholarship, MTAFS Awards, and 50:50 Raffle Results)**	
Friday March 5, 2021		
8:30AM-12:00	Leader: Joe Wheaton; Moderator: Adam Sepulveda	Workshop: Introduction to Low Tech Restoration
1:00-3:00PM		ExComm Meeting

Workshop 1: Beaver, Restoration and Effective Conflict Resolution Workshop

The North American beaver is a native keystone species with the ability restore natural wetland ecosystems cheaper and more effectively than humans. By partnering with beavers we can have a larger restoration impact. However, beaver activities such as dam building and felling trees can sometimes conflict with human land uses. We will explore the reasons beaver restoration is important, as well as the best practices to resolve beaver-related flooding and other potential conflicts whenever they occur. This workshop will be led by Mike Callahan (Beaver Institute); Elissa Chott (Clark Fork Coalition); and Torrey Ritter (MT Fish Wildlife & Parks)



Workshop 2: Introduction to Low Tech Restoration Workshop

This ½ day workshop, you will be introduced to the principles of a healthy riverscape and low-tech process-based restoration. This workshop will be led by Dr. Joe Wheaton who is an ecogeomorphologist and fluvial scientist in the Watershed Sciences Department at Utah State University, and restoration practitioner (http://www.joewheaton.org/).

If you are interested in finding out more about this topic check out: http://lowtechpbr.restoration.usu.edu/resources/Topics/.

Abstracts (in alphabetical order by speaker)

Factors driving the body size of trout species: beyond climate refuges and refugees

Al-Chokhachy, Robert; Letcher, Ben; Muhlfeld, Clint; Dunham, Jason; Hitt, Nathaniel; Roberts, James; Schmetterling, David

Salmonids are a group of fishes with high social, economic, and ecological value. Understanding the importance of landscape and climatic attributes on the performance of salmonids is an important step in management and conservation of these fishes, particularly in the context of climate change. Here, we used data from over 10,000 sampling sites across the United States to better understand how trout size is related to attributes influenced by climate change (e.g., stream size, temperature), fragmentation, and intrinsic density and how these patterns vary across basins. Our dataset included over 3 million individual fish measurements collected across sites, including over 1 million within Montana alone. Our results illustrated that a large amount of the variation in body size is driven by watershed-specific characteristics, suggesting the importance of attributes such as stream productivity. Next, we found that access to larger streams (positive) and population density (negative) are the most consistent and largest factors affecting trout body size. However, the strength of these relationships differed across species. We also found that trout with access to lake and reservoir environments to be considerably larger than fish in similar fluvial environments. Within the context of climate change, our results suggest the importance of habitat complementation and providing access to larger, productive aquatic habitat may be increasingly important to enhance resilience.

Montana DNRC habitat conservation plan riparian timber harvest monitoring

Anderson, Mike

Montana Department of Natural Resources and Conservation implemented a Habitat Conservation Plan (HCP) on classified forest lands in cooperation with the USFWS beginning in 2011. Aquatic conservation strategies were developed to maintain suitable habitat for Bull, Westslope cutthroat, and Columbia redband trout. One of the primary conservation strategies focused on aquatics was the implementation of variable width riparian harvest buffers (RMZ) along perennial Class-1 streams in the HCP project area. Riparian timber harvest commitments focused on managing riparian stands to minimize potential harvest effects including reduction in stream shade, increased stream temperature, and changes in large wood loading rates. DNRC delineated riparian management zones (RMZ) on 15 projects per year, with harvest occurring on 7 projects per year with an average annual harvest of 55 acres. Riparian stands showed reduced trees per acre, increased mean tree diameter, and a reduction in basal area. Stream shade was reduced by an average of 5–8% between June and September, which was sufficient to maintain thermal regimes in the majority of monitoring sites. Post-harvest monitoring noted increased LWD in 70% of the sites ranging from 8.7–380% increase, while LWD loading decreased in 30% of the sites ranging from 5.2%–32.1%. Initial assessment of the RMZ harvest strategy has indicated that additional protections afforded under the HCP are sufficient in the majority of stream to maintain the existing thermal regime.

Past and future projected shifts in the occupancy of trout in Montana

Bell, Donovan; Kovach, Ryan; Muhlfeld, Clint; Schmetterling, David; Whited, Diane; Al-Chokhachy, Robert; Lukacs, Paul; Whiteley, Andrew

Climate change and invasive species will interact in complex ways to affect future patterns of biodiversity, but empirical studies examining their joint effects on native species at large spatial and temporal scales are scarce. We quantified the impacts of climate change on the spatiotemporal dynamics of interacting native and invasive trout species across the northern Rocky Mountains, USA. Using 20,630 fish surveys collected over 30 years, we show that climate-driven expansion of invasive species and reductions in suitable habitat have caused widespread declines of two native trout across the region. Predicted declines of bull trout (48% by 2080) were

driven by increasing water temperature and decreasing streamflow, while declines of native westslope cutthroat trout (22% by 2080) were primarily driven by climate-induced interactions with invasive species. Our projections demonstrate that joint effects of climate and invasive species will continue to differentially drive the extirpation of native trout without species-specific management action.

Washoe Park Trout Hatchery - spawning overview 2020

Berger, Kerrie

The mission of the Washoe Park Trout Hatchery (WPTH) is to maintain Montana's Westslope Cutthroat Trout conservation brood stock, known as the M012. The hatchery maintains the health and genetic integrity of the M012 brood stock and supplies eyed eggs to three other hatcheries in the state. The progeny of the M012 are used for multiple management objectives, including population management, urban fisheries, native species restoration and research. A second facet of the hatchery's mission is to provide public outreach and education. This mission is accomplished by various means including the maintenance of an exceptional interpretive center, classroom education, and hatchery tours. Please enjoy a short video we created during spawning season 2020 using the Splice Video app and an Apple iPhone 11.

Status of Burbot in the Yellowstone River from the Bighorn River to Park City, Montana

Blackburn, Shannon; Ruggles, Mike; Radonski, Earl; Olszewski, Brad

Burbot *Lota lota* have experienced population declines throughout their native distribution. In Montana, Burbot are native to the Columbia and Missouri river basins. Little is known about the population dynamics and status of Burbot in these lotic systems, especially in the mid-Yellowstone River in south-central Montana. Since 2010, Montana Fish, Wildlife & Parks has been monitoring Burbot to better understand their distribution, relative abundance, and population characteristics in the Yellowstone River from the Buffalo Mirage Fishing Access Site to the confluence of the Bighorn River. Burbot were targeted using baited 1.3 and 2.5-cm bar mesh hoop-nets during the early spring. Nets were set across seven standardized sampling reaches. From 2010–2020, hoop-nets were fished for 2,456 net nights and collected 1,858 Burbot. Sampled Burbot varied between 162–878 mm total length (mean total length = 468 mm) and weighed between 25–3,765 g (mean weight = 667 g). The size (i.e., length, weight) of Burbot did not vary significantly between the sampling reaches or by mesh size ($p \geq 0.05$). However, the hoop-nets with the 1.3-cm mesh had significantly higher catch rates ($p = 0.03$) than nets with the 2.5-cm mesh. Catch rates suggest that diversion dams may limit movement as Burbot appear to be more abundant below the Huntley Diversion Dam. Results will provide insight on effective sampling techniques and the ecology of Burbot to help guide management decisions in the Yellowstone River.

Illegal fish introductions in Montana: how can we stop the spread?

Bourret, Sam

The spread of non-native fish species is a common problem in lakes and streams worldwide. Species that establish viable populations in a new environment can deplete populations of native species and desired sportfishes. In some instances, extirpation of a native species has occurred. In North America, the most common avenue by which non-native species invade new waterbodies is illegal stocking by anglers, aquaculturists, and others. In Montana, Illegal fish introductions of nonnative game species are increasing in occurrence statewide. Thus, preventing further illegal fish introductions is of the utmost importance for native aquatic species and sport fish management. Using data collected by state agency personnel from 1953 to 2016, I examine the spread of illegal fish introductions around the state and examine factors that best explain which locations are vulnerable. I include case studies that highlight tools resource managers can implement to understand, investigate, and prevent illegal fish introductions. These ideas have broad implications that can be applied to many regions with illegal fish introductions. The goal is to prevent future spread of non-native fish species through prevention and outreach of the pervasive problem.

Reproductive ecology of Mountain Whitefish in dissimilar populations

Brown, Colter; Guy, Christopher; Webb, Molly; Rhea, Darren

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 two Mountain Whitefish populations — the upper Green River, Wyoming and the Madison River, Montana (previous study). The Green River and Madison River were selected because the Mountain Whitefish populations differ in abundance and the rivers vary regarding anthropogenic modifications. Here, we specifically address the question do reproductive traits and movement during the spawning period differ between the populations? We also asked, 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. Fecundity, spawning periodicity, and age-at-maturity were similar, but spawning movement differed between populations. In addition, water temperature during the spawning period was higher 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.

Bull Trout passage at beaver dams in the Bitterroot and Flathead basins

Clancy, Niall; Wolf, Marshall; Rosenthal, Leo

Beaver relocation and mimicry is a popular tool for restoring streams. Benefits include floodplain reconnection, multi-threaded channels, improved riparian condition, and increased late-season streamflow. Beaver activity can also be a nuisance in agricultural settings, increase invasive species abundance, and create in-stream barriers to fish. Previous studies indicate that spring-spawning salmonid species can pass beaver dams in high proportions while fall-spawning species may pass in much lower proportions. However, charr are also known to select beaver ponds over other habitats and may rely on ponds as overwintering habitat. Beaver restoration in streams containing threatened Bull Trout is therefore of concern to many biologists. We evaluated Bull Trout passage at beaver dams in two streams: Meadow Creek in 2020 (Bitterroot drainage) & Morrison Creek annually from 1980-2020 (Flathead drainage). In Meadow Creek, only 3 of 18 PIT-tagged resident Bull Trout entering a beaver dam complex were found to have moved upstream of dams, and no fish moved through the entire complex. In Morrison Creek, migratory Bull Trout redds were found throughout the study reach during years without noted beaver activity but were clustered below dams in years they were present. These results suggest caution when using beaver restoration techniques in streams with Bull Trout but cannot distinguish between inhibition of fish passage and selection of beaver-created habitats by fish.

Reproductive phenology and hermaphroditism of western pearlshell mussels in two watersheds in Montana

Cook, Kristen; Zale, Alexander; Stagliano, David; Anderson, Michelle; Guy, Christopher; Albertson, Lindsey

The Western Pearlshell mussel is the only native freshwater mussel inhabiting trout streams of western Montana; it has been designated a state Species of Concern because of declines in abundance and distribution. Fundamental information on the reproductive biology and life-history of the species needed to conserve it is currently lacking. We investigated the timing and duration of reproductive events (gonadal development, fertilization, brooding of eggs and embryos, larval release, and larval infestation of hosts) at frequent intervals and the incidence of hermaphroditism in Western Pearlshells in the Big Hole and Rock Creek watersheds in western Montana in 2019 and 2020. The reproductive phenology of Montana Western Pearlshells differed among populations and from that of populations in coastal states. Western Pearlshells brooded embryos for

several weeks starting by mid-May or mid-June, and released larvae in mid-May to mid-July, depending on the population. Fish hosts were infested with larvae from mid-May to early-September, depending on the stream. Infestations persisted for about 7 weeks during which larvae grew about five-fold in size before excystment. Of 31 mature mussels histologically examined, all but one were gonadal hermaphrodites. Mussels reached sexual maturity at about 11 years old. Our findings will inform future propagation and conservation efforts in Montana.

The highs and lows of upper Clark Fork River trout populations

Cook, Nathan

The Upper Clark Fork River (UCFR) is home to a trout population that is highly variable in both time and space. Once completely devoid of fish, past improvements in water quality facilitated the establishment of a brown trout fishery. However, this fishery still exhibits a boom and bust pattern and continues to be impacted by legacy mining contamination and other water quality issues. Over the years Montana, Fish, Wildlife, and Parks has partnered with other agencies, NGOs, and Montana Universities to study factors limiting trout and other aquatic life in the UCFR. With trout abundance currently lower than is has been in almost 50 years, what do we know about the causes for the decline and what restoration actions can be taken to reverse the trend?

Restoring the Upper Clark Fork: integrating public perceptions of the Warm Springs ponds & conducting collaborative research for successful river restoration

Crootof, Arica

To support river restoration of the Upper Clark Fork, a final clean-up plan is needed for the Warm Springs Ponds. The Warm Springs Ponds are a series of water treatment settling basins along Silver Bow Creek that trap copper, arsenic, cadmium, lead, and zinc, and limit these heavy metals from entering the Upper Clark Fork River. As a result, these ponds contain an estimated 19 million cubic yards of contaminated sediment. Despite the contamination, the Warm Springs ponds are locally known for supporting trophy-sized trout and providing critical habitat for migratory birds. Given the recreational use and local attachment to the Warm Springs Ponds, there is a need to understand and integrate public use of and perceptions of the ponds into future reclamation plans. Undergraduate students at the University of Montana Western are engaged in a collaborative research project to integrate public perceptions into future restoration plans. A public survey was co-developed in collaboration with Montana Fish, Wildlife & Parks, U.S. Environmental Protection Agency, Clark Fork Coalition, and Atlantic Richfield Company. Students are also conducting interviews with key stakeholders and participant observations at the ponds to capture the range of uses and diverse perspectives of the ponds. Integrating public interest into the final clean-up plan can enhance public acceptance and thus long-term success of restoration efforts for the Upper Clark Fork.

Evaluating the effects of selective passage of Westslope Cutthroat Trout on non-native admixture in the Jocko River, MT over 15 years

Dangora, Anthony; Barfoot, Craig; Whiteley, Andrew; Eby, Lisa

We evaluated the relative influence of environmental variables and a selective fish passage management action on spatial and temporal patterns of hybridization between Westslope Cutthroat Trout (*Oncorhynchus clarkii lewisi*; WCT) and non-native Rainbow Trout (*O. mykiss*; RBT) in the Jocko River watershed. In 2010, Confederated Salish and Kootenai Tribal (CSKT) biologists began selectively passing phenotypic WCT above an irrigation diversion in the upper Jocko River with the goals of maintaining life history diversity and protecting upstream conservation populations. Previous research suggested that selective passage of migratory individuals, which could be nonhybridized or have low levels of admixture, into the upper Jocko had a low likelihood of increasing admixture, given that populations above the barrier were already hybridized. To monitor the outcomes of this management action, CSKT biologists sampled 23 sites across the watershed over time. Samples (n ~1,300) were collected from 2005-2008 and again from 2016-2019. We used RAD-Capture (1,100 species diagnostic loci) to

evaluate the admixture in fish passed above the barrier and individuals from across the sample sites. Over this time, 424 out of 439 genotyped fish passed above the barrier were >95% WCT. Genomic monitoring metrics varied, but overall, we observed little change in site-level admixture in the upper Jocko, suggesting that the management action did not further jeopardize conservation populations.

Relative-condition equations for Montana fishes

Eckelbecker, Robert; Guy, Christopher; Schmetterling, David; Heili, Nathaniel

Body-condition indices are commonly used in the management of fish populations and are used as a surrogate to physiological attributes such as tissue energy reserves. In Montana, Fulton condition factor (K) and relative weight (Wr) are typically used to describe and compare indices of condition. Each method has its use and limitations. Though less common, relative condition factor (Kn) describes the condition of species relative to populations in a geographic area and may be a better index for comparing body condition among fish populations statewide. We developed models to allow for Kn in Montana, by using the expansive weight-length data collected by Montana Fish, Wildlife, & Parks. We generated log10 weight-log10 length relationships to obtain Montana specific parameter estimates for relative-condition equations (W') for 50 species. Furthermore, to allow for better comparisons we developed separate models by water type (e.g., lotic and lentic) and sex for five species. Relative condition offers the advantage in describing body condition relative to a species in Montana and provides a condition index for species that do not have standard-weight models developed for Wr (e.g., Arctic Grayling).

Disentangling the impacts of multiple stressors in the Upper Clark Fork food webs

Feijo de Lima, Rafael; Colman, Ben; Cross, Wyatt; Gold-Quiros, Taylor; Ruiz-Sanchez, Jose; Shaw, Joe; Valett, Maury; White, Dylan; Witzowskey, Chelsea

The UCFR headwaters suffer from mining legacy impacts and also nutrient enrichment caused by land use and other natural features of the watershed. These impacts historically led to a major decline in riverine integrity. The Montana EPSCOR-CREWS project has as one of its main objectives to determine how heavy metals contamination, coupled with nutrient enrichment alter aquatic ecosystems, acting as subsidies and stressors in the UCFR. The form and size of the metals in question can determine the propensity for uptake by primary producers and transfer to higher trophic levels. Through its influences on primary production, nutrient enrichment can exacerbate contaminant effects via increased resource availability during algal blooms or diminish such effects by distributing contaminants more broadly within autotrophic biomass. The timing and location of algal blooms might affect the quality and availability of basal resources that modulate the transfer of pollutants to higher trophic levels. Lastly, the health of the fish communities in the river might not only be affected by trophic interactions and metal concentrations, but also by habitat availability and other important features of the system also currently impaired by human activities. Here we showcase the ongoing multidisciplinary efforts to disentangle the effects of these multiple stressors and provide information to restoration efforts and stakeholders in the UCFR.

Case study of six intentional migration barriers to protect cutthroat trout. Some lessons learned at what it takes to be successful.

Gardner, Beth

This is a case study of six intentional, upstream migration barriers on the Flathead National Forest to conserve cutthroat trout. The barriers are either stand-alone cement structures or modified road culverts. Some appear to be working well, others not so much. For each barrier, I will provide a quick overview of the objective, design, cost, and unique circumstance for each location. I will also share what I consider to be lessons learned about how to create an effective and efficient upstream barrier.

A Toolbox, Prybar, and Megaphone for your Fisheries Data: Don't Miss How We Built an User-friendly, Interactive, Cost-Efficient Reporting Platform Utilizing Data Visualizations, Dashboards, and Story Maps to Facilitate Analysis and Promote Sharing of Stream Temperature Data

Gaut, Kate; Syltie, Traci; DeArment, John; Thompson, M.

With budget limitations a difficult reality, agencies must find more efficient ways to house, analyze, share, and display data to guide complex management questions. Since 2011, the Lolo National Forest and Clark Fork Coalition have been collecting stream temperature data at 72 locations. This large multi-agency dataset, along with historic stream temperature data, has been made into an *Interactive Reporting Platform* that puts substantial data at the fingertips of managers. The Platform has statistical analysis, querying, and visualization capabilities, and dovetails seamlessly with other digital communication tools to present the story of a project to funders, partners, and the general public. But its greatest asset is its open door. As we display, the data collected can easily be combined with other agencies' stream temperature data, compounding both the utility and the value of everyone's monitoring investments. This is an extremely cost-effective approach that puts the maximum amount of data into the hands of biologists across multiple agencies. The data resides within tools that are simple, intuitive, powerful, and easily updated. And the software is low-cost, no-cost, or potentially already included in current agency subscriptions. Let us show you how to easily leverage value from your data with the tools you didn't know you had.

Presence of microplastics in the food web of the largest high-elevation lake in North America

Glassic, Hayley; Driscoll, Stephanie; Guy, Christopher; Koel, Todd

Microplastics have been documented in aquatic and terrestrial ecosystems throughout the world. However, few studies have investigated microplastics in freshwater fish diets. In this study, water samples and three trophic levels of a freshwater food web were investigated for microplastic presence: amphipods (Gammarus lacustris), Yellowstone cutthroat trout (Oncorhynchus clarkii bouvieri), and lake trout (Salvelinus namaycush). Microplastics and other anthropogenic materials were documented in water samples, amphipods, and fish, then confirmed using FTIR (Fourier-transform infrared) and Raman spectroscopy. Our findings confirmed the presence of microplastics and other anthropogenic materials in three trophic levels of a freshwater food web in a high-elevation lake in a national park, which corroborates recent studies implicating the global distribution of microplastics. This study further illustrates the need for global action regarding the appropriate manufacturing, use, and disposal of plastics to minimize the effects of plastics on the environment.

Ospreys as environmental sentinels

Greene, Erick

Ospreys sit at the top of aquatic food chains, and so they are an ideal species to help us monitor the health of aquatic systems. For over 12 years, Erick Greene and his colleagues have been sampling the blood and feathers of Osprey chicks throughout the Clark Fork River basin and other watersheds. He will discuss the results of an ecotoxicology study to track changes in contaminants before, during and after the restoration of the Upper Clark Fork Watershed.

Silver Bow Creek: 100 years as a copper mine — Can it be restored?

Griffin, Joe

Silver Bow Creek, devastated by a hundred years of mining and ore processing, was devoid of all but the most metal and acid tolerant life forms. But the first Earth Day in 1970 marked the inception of an environmental awareness that even infected the Anaconda Copper Mining Company. From the Companies early work to reduce metals discharging from the mine in the 1970s, through the Superfund cleanup era that extends to the present and beyond, the concentration of copper in the Creek has been reduced by over four orders of

magnitude. Is that enough progress to meet Superfund's legal and enforceable measure of "clean enough" — Montana's water quality standards? I will present the history of the cleanup and explore the practicable limits of meeting water quality standards. Finding practicable limits to restoring Silver Bow Creek's ecosystem is a complex endeavor that goes beyond Superfund and begs the question, "why is restoration taking so long?"

Investigating the effects of streamflow and non-native Brown Trout (*Salmo trutta*) on native Yellowstone Cutthroat Trout (*Oncorhynchus clarkii bouvieri*) in Duck Creek, MT, USA

Heinle, Kadie; Al-Chokhachy, Robert; Sepulveda, Adam; Verhille, Christine; Bouwes, Nicolaas

Native salmonids (Salmonidae spp.) are highly valued as an ecological and socio-economic resource across the Northern Hemisphere, but are facing population declines from a variety of synergistic threats, including climate change and non-native species. Across the western United States, changing climatic conditions are likely to increase the frequency of drought/low flow events, yet our understanding of how these changes may exacerbate the impacts of non-native species (e.g., through competition for limited resources) remains poorly understood. Here, we used mark-recapture methods to investigate the effects of changing environmental conditions (e.g., streamflow, temperature) and the abundance of brown trout (*Salmo trutta*) on Yellowstone Cutthroat Trout (*Oncorhynchus clarkii bouvieri*; YCT) in the Duck Creek watershed, a tributary of the Yellowstone River in the Crazy Mountains, MT. Brown trout density exceeds YCT density by 77.5% in sympatric reaches, while allopatric YCT density matched brown trout density (1.36 individuals/m). Also, allopatric YCT grew at similar rates to brown trout (0.0009 and 0.0007 mm/mm/d, respectively), while sympatric YCT exhibited reduced growth (0.0003 mm/mm/day). Given these trends, it is imperative to understand how changing climatic conditions (e.g., low flow events) may exacerbate the negative effects of brown trout. We investigate this question further by quantifying how summer growth rates vary with abiotic and biotic variables in this system.

A developing approach for restoring cottonwood communities from seed

Ingelfinger, Franz

Riparian communities are in decline due to land-use conversion and dam-altered fluvial processes that eliminate conditions for cottonwood establishment. We present a developing methodology to restore cottonwood communities from seed. We used artificial disturbance, natural and supplemental seed dispersal, and irrigation to create a window for cottonwood establishment. Over four growing seasons, we explored questions of production scale, and increased capacity to several acres, with expansion of restoration footprint limited largely by irrigation equipment availability. Key components of the approach include site preparation using herbicide and thatch removal to create a seedbed of bare soil, and competition control using a suite of herbicides to target herbaceous plants and grasses. Seeded stands develop quickly, and appear resistant to browse due to high stem density, setting the stage for natural community development. This developing approach provides an alternative to planting containerized seedlings and physical channel work, and can be implemented at a fraction of the cost. Initial work focused on transforming hay fields within the pre-dam floodplain of the Flathead River. Today we look to broaden the hydrogeomorphic setting of our applications, including work on gravel islands along the Kootenai River and floodplains dominated by reed canary grass. We are cautiously optimistic this approach can be applied broadly across floodplains impacted by dam-mediated flow regimes.

Factors contributing to present and future occurrence of relict headwater bull trout populations in the northern Rocky Mountains

Isaak, Dan; Young, Mike

Bull trout declined significantly during the 20th century—leading to federal protections under ESA in 1997. Although the species remains widespread in headwater populations, climate change is reducing and fragmenting remaining habitats. Using a dataset of species occurrence results from 9,908 eDNA and electrofishing sites in 991 bull trout patches across Idaho, Montana, and Oregon, we developed occupancy models to assess the

importance of 24 covariates representing patch size, connectivity among patches, hydroclimatic regimes, internal patch refugia, geomorphic attributes, wildfire prevalence, road densities, and brook trout prevalence. The best model correctly predicted occupancy in 82.6% of the patches and included significant effects for patch volume, length of patch reaches <9 °C mean August temperature, distance to nearest occupied patch, road density, brook trout prevalence, and winter high flow frequency. Subsequent analyses are using the model to create future scenarios of bull trout occurrence and to perform sensitivity analyses to understand where occurrence probabilities are most likely to change. In particular, we are interested in whether habitat geometry (i.e., patch size and connectivity) might buffer the effects of climate change, and whether realistic assumptions about habitat restoration and management interventions could effect meaningful mitigation to enhance the persistence of some populations or bull trout as a species in the northern Rocky Mountains.

Westslope cutthroat trout conservation in the Missouri River headwaters

Jaeger Matt; Bateman, Lucas; Berry, Jed; Breen, Lance; Pat Clancey, Coleen Detjens, Mike Duncan, Chris Edgington, Tommy Franklin, Tim Gander, Michael Gatlin, Travis Horton, Paul Hutchinson, Todd Koel, Ryan Kovach, Ryan Kreiner, Carter Kruse, Nick Larsen, Eric Leinonen, Angela Lodmell, Travis Lohrenz, Patrick Luckenbill, Matt McCormack, Jim Olsen, Sally Painter, Coltan Pipinich, Ron Spoon, Allison Stringer, Nathan Thomas, Andrew Whiteley, Kevin Weinner, Nathan Korb

Our approach to Westslope cutthroat trout (WCT) conservation in the Missouri River headwaters has been refined over the past 20 years. Until relatively recently declines in distribution and abundance, especially of genetically unaltered fish, have outpaced gains from conservation actions. While our overarching conservation goals remain unchanged, adjustments to priorities and how they are attained have occurred based on our experiences to date. Standardization of data collection and reporting among agencies and sub-basins has facilitated identification and prioritization of conservation needs over a broader area. Isolating extant populations from non-native trout is the primary limiting factor and will be the conservation focus for WCT in the Missouri River headwaters for the foreseeable future. Fish barrier type or cost will dictate pursuit of future projects and whether we conserve populations in place or include them in newly established populations. Piscicide treatment and evaluation approaches to increase the likelihood of project success have been identified. Re-population approaches that rely on translocation will allow us to achieve conservation priorities more efficiently. Within the next ten years, large (7-40 miles), unaltered brood populations re-founded with local genetics will be developed in each of the major sub-basins. We expect that ongoing work and refinements to our approach will allow us to protect or secure all remaining genetically unaltered WCT populations in the Missouri River headwaters in the next 5 years.

Genetic variation in westslope cutthroat trout reveals that widespread genetic rescue is warranted

Kovach, Ryan; Leary, Robb; Bell, Donovan; Painter, Sally; Whiteley, Andrew

Although human fragmentation of freshwater habitats is ubiquitous, the genetic consequences of isolation and a roadmap to address them are poorly documented for most fish. This is unfortunate because management actions, namely genetic rescue, could help mitigate potential problems. We used genetic data from 204 populations of westslope cutthroat trout to (1) document the effect of fragmentation on genetic variation and population structure, (2) identify potential candidate populations for genetic rescue attempts, and (3) quantify the potential benefits of strategic translocation efforts. Human-isolated populations had substantially lower genetic variation and elevated genetic differentiation, indicating that evolutionary dynamics in many populations are now dictated by random genetic drift. Based on simple criteria, 23 populations appear to be candidates for genetic rescue attempts. Population genetic theory suggests that a single translocation of a small number of individuals (~5 to 10) from nearby populations could dramatically increase genetic variation by, on average, 33%. As the risk of outbreeding depression is expected to be low, the large increases in genetic variation through translocations are likely to correspond with reduced extinction risk in these populations (i.e.,

genetic rescue), by alleviating inbreeding depression and increasing adaptive potential. This effort provides a clear template for future conservation of westslope cutthroat trout.

Status and future assessment of Burbot (*Lota lota*) in the Missouri River Drainage

Krebs, Jared; Dalbey, Steve

Burbot (*Lota lota*), a State Ranked S4 species, are native to all major river drainages in the state of Montana including the Missouri River. To effectively manage this species, previous research has identified the need to obtain more information regarding population characteristics and general status of Burbot at a state-wide level. Specifically, in the Missouri River drainage, little effort has been expended to effectively sample or manage Burbot and conclusive population trends have not been determined. Due to the uncertainties surrounding the status of Burbot in the Missouri River drainage, we aimed to summarize available historical trend data of Burbot catches in the Upper Missouri River, Fort Peck Reservoir, Lower Missouri River, and Milk River. Additionally, we propose standard sampling procedures targeting Burbot in Fort Peck Reservoir and Lower Missouri River sections of the Missouri River drainage.

Quantifying the effects of beaver dam analogs on fish habitat and movement

Lahr, Andrew; Eby, Lisa

Beaver mediated restoration has shown to be an effective restoration strategy for reconnecting incised streams with their floodplains. However, there are still uncertainties regarding the pros and cons of beaver and beaver dam analogs (BDAs) as they pertain to whole system effects. Concerns focus around whether these impoundments increase temperatures beyond thermal tolerances of cold-water species, reduce stream connectivity, and exacerbate negative effects of non-native species. In order to provide more context regarding these concerns, we began a multiyear Before-After-Control-Impact (BACI) study on three pairs of streams (one restored with BDAs and one control) across Western Montana. In each stream we measured changes in physical habitat (e.g., summertime water temperature, hydrologic residence time, instream habitat) and fish community characteristics (e.g., movement, species composition). Thus far we have completed one season of pre-restoration (2019) and one season of post-restoration (2020) data collection. Generally, the effects of the restoration varied by site. In one set of sites, there was evidence of increased residence time of water post-restoration leading to increased baseflows downstream of the BDAs. We also observed more variation in temperatures, as well as warmer temperatures, in the restored sites post-restoration compared to controls. Here we present these and other preliminary findings from our field efforts.

Responding to public doubts: what about the habitat?

Leone, Alex

As a watershed advocacy organization, landowner and water rights holder, the Clark Fork Coalition (CFC) has been deeply engaged in Superfund cleanup activities on the upper Clark Fork River for over a decade. As an advocacy organization, the CFC also often serves as a conduit for public grievances. With trout populations at all-time lows in the recently remediated reaches, many long-time recreationists are beginning to point fingers at the cleanup itself. As one Anaconda local put it, “the agencies are creating a fish desert in the upper Clark Fork”. In response to the public’s concerns, the CFC partnered with MT FWP in 2019/2020 to investigate and quantify available fish habitats in both restored and unrestored reaches of the upper Clark Fork River. Floodplain remediation activities result in severe disturbances to riparian ecosystems and recovery of streamside vegetation and other types of fish habitats (such as undercut banks) may take years or decades. In an attempt to catalog and quantify those changes over time, the CFC is hoping data gleaned from the habitat assessment will be used to inform management decisions in the future. This talk will cover the lifecycle of an advocacy-driven research project, from its critique-driven inception, to results and potential implications for management.

Landscape resistance mediates native fish species distribution shifts and vulnerability to climate change in riverscapes

Mike LeMoine; Eby, Lisa; Clancy, Chris; Nyce, Leslie; Jakober, Mike; Isaak Dan

A broader understanding of how mobility and landscape resistance influences climate change vulnerability is needed for stream fishes. Previous studies have focused on climate change vulnerability of larger more mobile salmon, trout, and char, yet smaller less mobile fishes are rarely used to demonstrate the effects of climate change, but they may be vulnerable to climate change. We revisited 280 sites over a 20-year interval throughout a warming riverscape. We described change in site occupancy (i.e., site extirpation and colonization probabilities) and associations between site occupancy and environmental conditions for four fishes spanning a range of body sizes and thermal preferences. Bull trout experienced a 9.2% (95% CI = 8.3%–10.1%) reduction in occupancy, mostly in warmer stream reaches, and westslope cutthroat trout experienced a 1% increase. Slimy sculpin experienced a 48.0% (95% CI = 42.0%–54.0%) reduction in occupancy associated with warmer stream reaches and areas subject to wildfire. Longnose dace primarily occupied larger streams and increased its occurrence in barrier free stream reaches as water temperatures warmed. Sculpin and dace were constrained by instream barriers limiting their ability to respond to climate drivers. Aquatic communities likely exhibit a range of responses to climate change, and that improving fluvial connectivity for the least mobile fishes will be important climate adaptation tactics for conserving aquatic biodiversity.

Individual characteristics, population density, and environmental conditions explain temporal variation in out-migration dynamics of juvenile Bull Trout

Lewis, Madeline; Guy, Christopher; Oldenburg, Eric

The fragmentation of rivers through anthropogenic modifications poses an imminent threat to the persistence of migratory fish. Direct actions, such as trap-and-haul programs, will be necessary to restore and conserve the migratory life-history component in populations of partially migratory species such as Bull Trout Salvelinus confluentus. These actions require an understanding of the factors that contribute to a population producing out-migrants, as opposed to functioning as a resident population. We investigated factors that influenced the out-migration dynamics of juvenile Bull Trout in two tributaries to the lower Clark Fork River, Graves Creek and East Fork Bull River. Using a PIT-tag system, we tracked the out-migration of juvenile Bull Trout from summer of 2019 through autumn of 2021. In Graves Creek, the largest fish within a cohort were five times more likely to out-migrate at age-1 when compared to smaller fish within the cohort. The magnitude of out-migration appeared positively related to intra and inter-cohort densities. Relative changes in environmental conditions, including discharge, water temperature, and photoperiod, also triggered out-migration. These results highlight the complex interplay between individual characteristics, population dynamics, and environmental conditions, that lead to the production of out-migrants, and can be used to inform management actions to conserve the migratory component in Bull Trout populations.

Long Shot: the potential to restore fluvial native trout in a fragmented, contaminated basin

McDowell, Will

The Upper Clark Fork (UCF) river basin is the subject of both a massive Superfund clean-up of metals contamination in the mainstem, and an ambitious Aquatic Restoration Plan in its tributaries. Montana agencies (FWP and NRDP) have long-term goals to restore a fishery which has a salmonid density similar to reference streams, high species diversity, characteristics of healthy reproduction/recruitment, and includes species which are less tolerant to metals contamination. Brown trout make up 99% of the trout fishery in the uppermost reach of UCF (Reach A). But FWP has set the goal to re-establish native trout as 10 percent of the sport fishery in

Reach A, as well. This will require dramatic improvements in both recruitment and survival of native trout, particularly fluvial westslope cutthroat trout, or re-establishment of fluvial populations where only headwater resident fish remain. Although westslope cutthroat trout are still widespread in tributary headwaters, the opportunities for restoring fluvial cutthroat life histories in this environment are scarce, complex and expensive. Brief case histories of early restoration efforts in three native fish tributaries (ONeill, Cottonwood, Dry Cottonwood), and their potential to enhance the westslope cutthroat population in Reach A, are examined.

What we've learned from 40 years of hybridization research in Montana

Muhlfeld, Clint; Kovach, Ryan; Strait, Jeff; Leary, Robb; Allendorf, Fred

In this presentation, we will review over 40 years of research examining the ecological and evolutionary impacts of hybridization between native westslope cutthroat and invasive rainbow trout in Montana. We will also explore how climate change has influenced these dynamics as rainbow trout continue to expand their range, underscoring the importance of pro-active conservation strategies that prevent genomic extinction of additional populations and eventually entire lineages.

Validation of the use of behavioral assessments in identifying wild origin westslope cutthroat trout vulnerable to artificial selection at Sekokini Springs Hatchery, MT

Preul, Taylor; Verhille, Christine; Bourret, Sam

Conservation hatcheries are used to rear native fish to replace lost populations, but current protocols may not be sufficient to rear all life-history strategies of captive stock, necessitating novel approaches to identify fish vulnerable to artificial selection. Behavioral measurements may be informative to identify vulnerable fish and remedially modify rearing protocols. The pace of life (POL) paradigm theorizes that life-history strategies of individuals are a fixed trait existing on a spectrum from slow to fast. Slow fish are more stress-responsive than fast fish and thus, may fail to thrive in a hatchery setting due to chronic stress. As stress responsiveness is linked to behavioral boldness in POL, temporally stable risk-taking behaviors (e.g., exploring novel environments) may be predictive of long-term performance under hatchery rearing conditions and allow early identification of individuals requiring modified rearing protocols. To test if a suite of behaviors related to exploring a novel environment is temporally consistent for individual fish relative to their cohorts, I repeatedly quantified behaviors in 40 captive westslope cutthroat trout (Oncorhynchus clarkii lewisi) over 17 months at Sekokini Springs Hatchery, MT. By tracking rank within the experimental population over time, I could test if each behavior trait is fixed and potentially a predictor of performance under chronically stressful hatchery conditions.

Status of Westslope Cutthroat Trout and Arctic Grayling following conservation translocations in Yellowstone National Park

Puchany, Andriana; Zale, Alexander; Koel, Todd; Shepard, Brad

Restoration of Westslope Cutthroat Trout (WCT) and fluvial Arctic Grayling (GRY) in Yellowstone National Park is a high priority for fishery managers. Restoration of the East Fork Specimen Creek (EFSC) and Grayling Creek watersheds included construction of fish barriers to isolate watersheds, application of rotenone to eliminate nonnative and hybridized fish, and translocations of native fish. We sampled these watersheds in 2018 and 2019 to estimate population recovery, compare pre- and post-restoration population metrics, and determine contributions of WCT donor sources to the recovering population in EFSC. As expected, WCT had reached later stages of population recovery in EFSC than in Grayling Creek but downstream dispersal in both watersheds was limited. Few GRY were captured in Grayling Creek, probably because of low survival and downstream emigration. However, we unexpectedly documented the first evidence of natural reproduction of fluvial GRY in YNP in decades—a group of 10-15 fry were confirmed as GRY through genetic analysis. Whereas all WCT donor sources contributed to the recovering WCT population in EFSC, contributions were not proportional to numbers

stocked, suggesting differences in donor source fitness. Furthermore, hybrids were found in both watersheds, probably resulting from barrier failure or incomplete eradication. Our findings have already helped Park managers make adaptive management decisions and will help inform future conservation translocations.

Recovery of freshwater invertebrates in alpine lakes and streams following eradication of nonnative trout with rotenone

Schnee, Mark; Bourret, Sam; Clancy, Niall; Boyer, Matt

Nonnative fish eradication via the piscicide rotenone is an effective tool for fisheries management and conservation of native species. However, the long-term effects on non-target organisms, including benthic invertebrates and zooplankton, are under-studied and are poorly understood. As part of an 11 year landscape-scale Westslope Cutthroat Trout conservation project in Northwest Montana, we assessed the impacts of 50 ppb rotenone on the aquatic invertebrate community in 13 alpine lakes and their outlet riffle habitats. We compared pre- and post-rotenone treatment density and diversity metrics of benthic invertebrates and zooplankton to determine when the invertebrate communities recovered from rotenone exposure. Across study sites, decreases in density and diversity of some invertebrates, including Ephemeroptera, Plecoptera, and Trichoptera taxa, were observed the year following rotenone treatment, and within 3 years, density and diversity were similar to and sometimes higher than pre-treatment values. Our study showed the resilience of aquatic invertebrate communities in response to rotenone exposure in alpine lakes and streams and informs fisheries managers for planning rotenone projects and monitoring recovery of non-target organisms.

It's complicated…Environmental DNA as a predictor of trout and char abundance in streams

Sepulveda, Adam; Al-Chokhachy, Robert; Laramie, Matthew

The potential to provide inferences about fish abundance from environmental (e)DNA samples has generated great interest. However, the accuracy of these abundance estimates is often low and variable across species and space. A plausible refinement is the use of common aquatic habitat monitoring data to account for attributes that influence eDNA dynamics. We therefore evaluated the relationships between eDNA concentration and abundance of bull trout (*Salvelinus confluentus*), westslope cutthroat trout (*Oncorhynchus clarkii lewisi*) and rainbow trout (*O. mykiss*) at 42 stream sites in the Intermountain West (USA and CAN) and tested if accounting for site-specific habitat attributes improved the accuracy of fish abundance estimates. eDNA concentrations were positively associated with fish abundance but these relationships varied by species and site and there was considerable variation unaccounted for. Random site-level differences explained much of this variation, but specific habitat attributes of those sites explained relatively small amounts of this variation. Our results underscore that either eDNA sampling or environmental characterization will require further refinement before eDNA can be used reliably to estimate fish abundance in streams.

Contributions, inbreeding, and outbreeding of wild- and hatchery-origin stocks of Westslope Cutthroat Trout released as eyed embryos into vacant habitat

Shepard, Brad; Delomas, Thomas; Campbell, Matthew; Kruse, Carter; Taper, Mark; Zale, Alexander

Donor source selection is a critical component of fish translocations performed to establish conservation populations that preserve a portion of the species' genetic legacy and contain enough diversity to persist. We obtained gametes from 258 parental-pair crosses (164 females and 258 males) from four wild populations and two hatchery broodstocks. We released >35,700 eyed embryos into 129 remote site incubators (RSIs) at eight sites in Cherry Creek from 2007 to 2010 after using piscicides to remove nonnative fish. We used genetic analyses of 372 single nucleotide pairs (SNPs) to back-assign 82% of 2,241 first-generation progeny that left RSIs to parental pairs and another 2,071 progeny from subsequent wild reproduction in Cherry Creek back to their donor stock of origin. First-generation progeny represented 75% of all potential donor parental pairs and all six donor populations. Survivals of first-generation progeny of most donor stocks at most ages were lower than

those of a Washoe Park control. Second and third generation progeny of wild donor stocks did almost as well as those of hatchery stocks. Genetic material from all donor stocks was represented in the population after ten years. Progeny of crosses and backcrosses among donor stocks made up 70-80% of the population within ten years. Inbreeding among one wild stock appeared to be higher than among the other wild stocks.

A paradoxical knowledge gap in science for critically endangered fishes, species of special concern, and game fishes during the sixth mass extinction

Siemiantkowski, Michael; Guy, Christopher; Cox, Tanner; Williams, Jacob; Eckelbecker, Robert; Glassic, Hayley; Lewis, Madeline; Maskill, Paige; McGarvey, Lauren

Despite unprecedented scientific productivity, Earth is undergoing a sixth mass extinction. The disconnect between scientific output and species conservation may be related to scientists studying the wrong species. Given freshwater fishes have the highest extinction rate among vertebrate taxa, we assessed the paradox between science productivity and science needed for conservation by comparing global scientific output created for critically endangered fishes and game fishes. In addition, we compared scientific output for species of special concern and game fishes in Montana. We searched 197,866 articles (1964 – 2018) in 90 journals for articles on 465 critically endangered fishes and 296 game fishes. Only 3% of the articles in the final database were on critically endangered fishes; 81% of critically endangered fishes had zero articles. The difference between the number of articles on game fishes and critically endangered fishes increased temporally with more articles on game fishes during the extinction crisis. We searched the Web of Science for fishes in Montana, and the number of publications on game fishes was 200 times greater than those for species of special concern. We argue that the scientific knowledge created on fishes is not sufficient to meet the challenges of conserving fishes during the sixth mass extinction.

Natal stream characteristics associated with migratory Westslope Cutthroat Trout

Smith, Troy; Liermann, Brad; Eby, Lisa

Westslope Cutthroat Trout, hereafter cutthroat, are a native trout species of conservation concern in Montana that have historically exhibited diversity in life histories. This includes both migratory and resident fish from the same natal stream. Due to habitat degradation and hybridization, cutthroats are becoming rare in large river systems and increasingly occur as isolated resident populations in headwater systems. The loss of migratory individuals can lead to extirpation of these localized populations. Rock Creek in Western MT is of conservation and ecological interest because it has retained a population of migratory, non-hybridized cutthroat. Based on ecological theory, we hypothesized that factors such as stream habitat quality (temperature, flow, pool depth) and competition (fish density) would be associated with migratory life history. From 2018 to 2020, we implanted 77 radio telemetry tags and tracked cutthroat movements to determine their migratory life history and where they spawned. We collected habitat and fish abundance data on 37 streams within the Rock Creek. We used a generalized linear model to evaluate the relationship between the number of migratory individuals and tributary characteristics. Our results show that natal stream size is related to the abundance of migratory individuals. Understanding characteristics of streams that promote and sustain migratory life history would be useful to help prioritize habitats that maintain life history diversity.

Evaluating western pearlshell mussell populations for viability, reproduction and host fish glochidia Infestations across five watersheds in western Montana

Stagliano, David; Anderson, Michelle; Cook, Kristen

The western pearlshell (WEPE) has experienced significant state-wide declines in Montana. Hatchery propagation is being considered as a future prospect for recovering this species and understanding the reproductive timing and host fish requirements of their life-cycle is essential. This research will determine: 1) reproductive status and timing of WEPE gravidity, 2) which salmonid host fish WEPE are using to successfully

transform glochidia to juvenile mussels, and 3) whether host fish densities or benthic habitat conditions are limiting WEPE recruitment. We determined WEPE gravidity and timing of glochidia release by revisiting 25 populations during their spawning period. We electro-fished salmonids near mussel beds to document the abundance and timing of glochidia on salmonid gills. Earliest host fish infections were documented in the Kootenai watershed in 2019 and in the Big Hole in 2020. Host fish CPUE densities were positively correlated with viable WEPE populations, but this did not equate to higher percent of glochidia on gills. Differential host-fish glochidia infection rates indicate 2 types of species: 1) primary salmonid hosts (*Oncorhynchus spp*.) where rates of successful infestation and metamorphosis are high, and 2) marginal hosts (*Salmo, Salvelinus*) with low success rates. Even though westslope cutthroat trout are WEPE's native host fish in Montana, pearlshell populations across multiple watersheds are recruiting by exclusively using brook trout.

Diversifying conservation and management of Westslope Cutthroat Trout in the upper Flathead River System

Steed, Amber; Boyer, Matt

Westslope Cutthroat Trout are a focus of conservation and research throughout its range, including in the upper Flathead River system of NW Montana. Various management actions have aimed to protect this species' evolutionary legacy in a range wide stronghold dominated by public land and coldwater refugia. Proactive efforts have included hybrid suppression and movement studies, piscicide treatments, population abundance and genetic monitoring, angling regulation changes, and a range of life history research by managers and collaborators. Yet, threats to the species' persistence remain considerable, primarily from introgression and competition with nonnative Rainbow Trout and interactions with other nonnatives. Thus, isolation management has recently been pursued to further diversify our conservation portfolio. While often considered a last resort, fish passage barriers have been minimally used in the upper Flathead River system to date. Building on past efforts, Montana Fish, Wildlife & Parks has begun investigating if and where barriers might be appropriate using a multi-phased approach. Recognizing the tradeoffs between isolation and connectivity has been central to the process, balancing the potential loss of migratory life history from barrier isolation with the preservation of genetic integrity at risk from connectivity. By protecting remaining genetically pure populations, we diversify our conservation of this iconic species to help ensure its legacy outlasts our own.

Genome-wide SNP analysis reveals loci linked to fitness-related traits in a Westslope Cutthroat x Rainbow Trout hybrid zone

Strait, Jeff; Kovach, Ryan; Kardos, Marty; Amish, Stephen; Eby, Lisa; Boyer, Matt; Muhlfeld, Clint; Lowe, Winsor; Luikart, Gordon

Hybridization with introduced Rainbow Trout (*Oncorhynchus mykiss*, RBT) threatens all subspecies of cutthroat trout (*O. clarkii*). Understanding the genetic basis of traits associated with hybridization can help predict long-term effects of hybridization. We investigated the genetic basis of individual growth rate and migratory behavior in three hybridized populations in northwest Montana (2013-2016). We conducted a genome-wide association analysis using >2000 polymorphic and species-diagnostic single nucleotide polymorphisms (SNPs) to identify loci associated with growth and migratory behavior. Based on published literature, we expected that growth would have a complex genetic basis, but predicted that migratory behavior may be associated with one or several loci of large effect. Consistent with these expectations, we found no SNPs associated with growth; however, RBT diagnostic alleles on chromosome 29 were strongly associated with migratory behavior. The genetic basis of differences in migratory behavior between cutthroat trout and hybrids could help explain why hybrid dispersal appears to be a key mechanism for rapid expansion of hybridization in some systems. Conservation thresholds (i.e., 10% RBT admixture) may allow populations to harbor genes that facilitate further hybrid expansion. Finally, these results suggest evolutionary consequences of hybridization can be influenced by a relatively small number of genes.

Collaboration on the Upper Clark Fork River: a case study from the Montana CREWS project

Terwilliger, Michelle; Floyd, Theresa M.; Metcalf, Elizabeth C.; Mohr, Jakki J.

Ecosystem restoration projects are collaborative undertakings and often involve scientists and professionals from varied backgrounds working together across agencies, academia, and the private sector. Successful outcomes are a result of effective collaborative processes, and monitoring how collaboration evolves over the course of a project can provide important insights for management. We present a measurement tool for assessing team collaboration processes and discuss validation and results from a survey of the CREWS project, a large-scale research project in Montana focusing on environmental water quality. We adapted a survey instrument used in the health sciences for relevance to our large interdisciplinary science team and validated our scale for this context. This work is part of a larger project using social network analysis to explore social factors involved in collaborative science and their relationships to project outcomes.

Using large scale PIT arrays to monitor native species movements in a large prairie stream tributary to the Missouri River

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The development of passive integrated transponder (PIT) technology has proven to be extremely valuable in fisheries research and management. Stationary PIT arrays have mainly been used on small shallow mountain streams to monitor fish movements. However, recent technological advancements have increased the potential of stationary arrays. In this study we installed three stationary PIT arrays on two prairie streams. The first array was installed at RM 1.0 on the Marias River (a tributary to Missouri River near Loma Montana) from spring 2017 through 2020. Two additional PIT arrays were installed in 2020 in the Teton River roughly 0.4 and 11 river miles upstream from the confluence with the Marias River. Implanting PIT tags into Shovelnose Sturgeon and Blue Suckers began in 2016; a total of 2050 Shovelnose Sturgeon and 112 Blue Suckers have been tagged to date. Six hundred seventy-nine Shovelnose Sturgeon and 39 Blue Suckers were detected at the Marias River array in 2020. The majority of Shovelnose Sturgeon entered the Marias River between May 16 and June 1 when Marias River flows increased from 1,500 cfs to 3,000 cfs and temperatures increased from 12°C to 18°C. Blue Suckers entered the Marias River from April 14 to April 23 when flows increased from 750 cfs to 2,000 cfs, and temperature increased from 6°C to 14°C. This study provides compelling evidence that stationary PIT readers are effective at monitoring movements of native species in large prairie streams.

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