

39th Annual Researchers Meeting

*Upper Colorado River
Endangered Fish
Recovery Program
&*

*San Juan River Basin Recovery
Implementation Program*

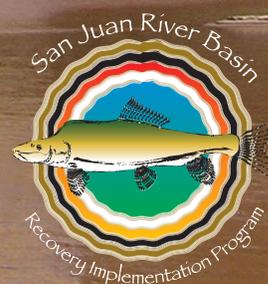
January 23-24, 2018

Upper Colorado River



Endangered Fish
Recovery Program

Uintah Conference Center
313 E. 200 S.
Vernal, Utah



**The Upper Colorado River Endangered Fish Recovery Program and
The San Juan River Basin Recovery Implementation Program**
would like to thank **Uintah County** and the **Uintah Conference Center**
for providing the use of their facilities for this meeting.



There is no registration fee this year, but donations for break refreshments and the social are requested to help defray the cost. Donations can be made to Tildon Jones.

Day 1, Tuesday January 23, 2018

Time	Presenter	Title
		Moderator: Tom Chart
8:00	Jones	Housekeeping/logistics/welcome
8:10	Chart/Whitmore	Welcome
8:20	Melanie Fischer	Information and education update
8:40	Donald Anderson	Review of 2017 Hydrologic Conditions in the Upper Colorado River Basin
9:00	Julie Stahli	STReAMS Update 2018 – an update on the online PIT-tag database
9:20	Chris Wolff	Adventure Hydrology
9:40	Break	
		Moderator: David Speas
9:55	Jack Schmidt	Stream flow, sediment supply, and geomorphology of the Green River— What have we learned and what do we need to know?
10:15	David Topping	Drivers of sand transport and storage, with implications for fish habitat, in the Yampa and Green rivers
10:35	Rebecca Diehl	Insights into the sensitivity and resilience of the Yampa and Green rivers’ riparian ecosystems to flow regime shifts through a coupled eco-geomorphic model
10:55	David Waterman	Influence of Channel Width and Formative Discharge on Sandbar Dynamics in the Middle Green River, Utah
11:15	Alex Walker	Twentieth century channel narrowing of the Green River in Canyonlands National Park--How much? When did it happen? Why?
11:35	Lunch	
		Moderator: Katie Creighton
1:00	Benjamin Stout	Determining fish status from mobile PIT antenna detections: Preliminary study results
1:20	Edward Kluender	Vermillion Creek: A habitat of unanticipated importance for Colorado pikeminnow in the Green River
1:40	Christian Smith	If You Sink It They Will Come: PIT Tag Antennas at Spawning Bars in the Upper Green River Basin of Utah and Colorado
2:00	Travis Francis	Monitoring endangered humpback chub in Black Rocks from 1998-2016, including incorporation of PIT tag antenna detections of tagged fish into mark-recapture
2:20	David Speas	Use of the Dolores River (Utah) by endangered fishes, 2013-2017
2:40	Break	
		Moderator: Matt Breen
3:00	Anya Metcalfe	Shedding light on aquatic insects of the Colorado River Basin with citizen science
3:20	Kevin Bestgen	Designer flow releases from Flaming Gorge Dam benefit Green River endangered fishes and ecosystem health
3:40	Kirk LaGory	Evaluating Backwater Habitat Availability and Condition in the Middle Green River, Utah
4:00	Toby Minear	Deployment and Testing of In-situ and Mobile Hydrophones for Coarse Bedload Sediment Mobilization Studies on the White River, Spring 2017
4:20	Sonja Jahrsdoerfer	Wetland Management at Ouray National Wildlife Refuge
5:00	Adjourn	
5:30		Social at the Quarry Steakhouse and Pub, 29 S. Vernal Ave.

Day 2, Wednesday January 24, 2018

Time	Presenter	Title
		Moderator: Brandon Albrecht
8:00	Ron Kegerries	Razorback Sucker Research and Monitoring in the Colorado River Inflow Area of Lake Mead and the Lower Grand Canyon, Arizona and Nevada
8:20	Adam Barkalow	Patterns of razorback sucker and associated Colorado River fish community reproduction and development within the Grand Canyon
8:40	Casey Pennock	A barrier to recovery? Movement and early life-history of razorback sucker downstream of the Piute Farms Waterfall
9:00	Catherine de Vlaming	Effectiveness of Light Traps for Detecting Razorback Sucker Larvae
9:20	Koreen Zelasko	Abundance and survival of razorback sucker in the Green River basin, Utah, 2011–2013
9:40	Break	
		Moderator: Dale Ryden
9:55	Richard Staffeldt	Highs and lows of razorback sucker recovery in a managed wetland: maintenance considerations to facilitate forward progress
10:15	Brian Hines	Population Estimate for humpback chub and roundtail chub in Westwater Canyon, Colorado River, Utah, 2016-2017
10:35	Zach Ahrens	Small and Persistent: Monitoring Humpback Chub in Cataract Canyon, UT
10:55	Maria Dzul	Integrating data to improve understanding and management of rainbow trout and humpback chub in the lower Colorado River
11:15	Adam Barkalow	Evaluating the relationship of temperature and growth of a larval Colorado River catostomid, <i>C. latipinnis</i> through otolith aging and stable isotopes ($\delta^{18}O$)
11:35	LUNCH	
		Moderator: Melissa Trammell
1:00	Adam Hansen	Biological effectiveness of incentive-based harvest tournaments for controlling nonnative piscivores in fluctuating coldwater reservoirs
1:20	Kevin Bestgen	Response of the native fish community of the Yampa River to nonnative fish removal and flows
1:40	Ben Felt	Evaluation of Nonnative Fish Escapement Prevention Strategies at Rifle Gap Reservoir and Highline Lake, Colorado
2:00	Michael Fiorelli	Opportunistic fish community sampling in the lower Duchesne River reveals high densities of problematic nonnative species
2:20	Break	
		Moderator: Kevin McAbee
2:30	John Caldwell	Upper Colorado River Basin Smallmouth Bass Removal 2017
2:50	Travis Francis	Managing walleye expansion in the Upper Colorado River Basin with education, eradication and escapement prevention: version 4.0
3:10	Edward Kluender	Northern pike management in the Upper Colorado River Basin: Green and Colorado rivers subbasins – 2017 Update
3:30	ADJOURN	
4:00pm		BC Meeting to follow

Abstracts

Review of 2017 Hydrologic Conditions in the Upper Colorado River Basin

Don Anderson
Upper Colorado River Recovery Program

Hydrologic conditions varied considerably across the Upper Colorado River Basin in 2017, from near-record runoff conditions in the upper Green River basin to significantly drier-than-normal conditions in the Yampa and White river basins. This presentation will recap how the 2017 water year evolved, what impacts this had on flow management decisions for the endangered fish, and what outcomes were observed with respect to meeting (or not) the Program's instream-flow objectives.

STReaMS Update 2018 – an update on the online PIT-tag database.

Julie Stahli¹ and Amy Greenwell²
1 U.S. Fish and Wildlife Service, Upper Colorado River Recovery Program, Lakewood, Colorado
2 Colorado Natural Heritage Program, Ft. Collins, Colorado

The Species Tagging, Research and Monitoring System (STReaMS) is an online database of all stocking, capture, and detection data occurring in the Upper Colorado and San Juan river basins. The database has grown in both complexity and amount of data over the past year and is available for program partners to use. STReaMS currently holds 1.8 million encounters from almost 1.1 million fish between 1979 and 2017. We will review database structure, outline the updates that occurred in 2018 including the addition of a flagging system, implementation of revision tracking, batch upload tools, changes to the downloads and more. We will also provide information to researchers who both provide and download data on proper use.



Chris Wolff

When I tell people that I am a hydrologist I am usually met with a tilted head, a blank stare and inevitably get the “That’s something to do with water right?” comment. Mind you, I enjoy taking the time to explain what a hydrologist is and what a hydrologist does, but truth be told I often default to saying that I am a “water scientist” and leave it at that. As a hydrologist, I always seem to run into the same problem when I try to use science and data to tell the story of water and its impact on both people and our environment. I lose my audience. I lose them to technical detail, lack of “why does this affect me” mentality and sometimes I think I lose my audience to boredom.

Instead I began describing what I do for fun (i.e. - mountain climb, trail run, white water raft, rock climb, etc.) and tied those experiences to science, earth dynamics and of course, hydrology. Then it happened... people actually engaged in the conversation. People started asking questions like, “How was the hike to get there?”, “Was the climb tough?”, “What happened to the river? “How is snowpack tied to drought again?” and “Do you drink tap water?”

I realized that people enjoyed quick lessons on hydro-science and short bursts of new knowledge, but they also seemed to want something more. They wanted a story... they wanted an adventure. They wanted to know how hydrology affects them. I changed my approach. Science and knowledge became something I inserted into the story I was telling and, unbeknownst to my audience, they were actually learning what hydrology is and what I do. All that time I was developing how to reach people through something I now call “Adventure Hydrology”.

Adventure Hydrology (AH) is a dynamic social engagement platform that uses adventure, exploration and a first-person perspective to connect the world of science and learning to a broad and diverse audience. Taking a video forward approach, the goal of AH is to make people feel like they are a part of the adventure as the AH videography team engages with scientists, conservationists, researchers and other explorers. Through this unique and experiential approach, AH will help people better understand how human interactions are changing our planet, for better or for worse, and how this planet is changing us in return.

Stream flow, sediment supply, and geomorphology of the Green River—What have we learned and what do we need to know?

John C. Schmidt and Alex Walker, Department of Watershed Sciences, Utah State University
Erich Mueller, Department of Geography, University of Wyoming
Paul E. Grams, Grand Canyon Monitoring and Research Center, U.S. Geological Survey
Rebecca Manners, Department of Geosciences, University of Montana

Among the three headwater branches of the Colorado River, the Green River is the least developed and retains many of its natural stream flow and sediment supply characteristics. Although the upper Green River is dammed at Flaming Gorge and the natural stream flow of the Duchesne, Price, and San Rafael rivers are diverted onto farm fields or to the Great Basin, the intact flow regime of the Yampa River maintains the annual snowmelt flood pulse of the middle and lower Green River. The sediment supply to the Green River is less perturbed than is the flow regime, because fine sediment is delivered from Colorado Plateau tributaries where unregulated flash floods still occur. Nonnative tamarisk, sandbar willow, and other plants have invaded channel banks and bars during periods of drought, and these new riparian plant communities prosper with the higher base flows created by summer releases from Flaming Gorge Reservoir.

In response, the channel of the Green River has narrowed and simplified throughout its course, and in-channel and floodplain habitat has been altered. There is no good evidence for channel incision, but there is abundant evidence for vertical floodplain accretion, aggradation of eddy sand bars, abandonment of secondary channels, attachment of in-channel alternate bars to nearby floodplains, and inset floodplain formation. The rate and style of channel change differs in river segments perturbed into sediment deficit and into sediment surplus and depends on whether segments are debris fan-affected canyons, canyons with fixed meanders, or valleys with restricted meanders.

To the degree that today’s native fish habitat depends on the geomorphic organization of the Green River that was characteristic of the early and mid-20th century, maintenance of these characteristics requires that attributes of the magnitude and variability of the natural stream flow and sediment supply regime are maintained. Perhaps the fundamental question asked of the scientific community is whether a slightly smaller and simpler Green River provides sufficient and desirable physical habitat attributes for the native fish community. The specter of climate warming implies decreased runoff from the Rocky Mountains and increased demands for trans-basin and agricultural diversions. If the total annual stream flow of the Yampa River decreases in a warming climate, then continued narrowing of the Green River is inevitable unless releases from Flaming Gorge Reservoir compensate and maintain larger floods at the expense of lower base flows. River scientists are challenged to define the desirable geomorphic form of the Green River throughout the river’s length and identify the potential path to such a form.

Drivers of sand transport and storage, with implications for fish habitat, in the Yampa and Green rivers

David J. Topping¹, Erich R. Mueller², John C. Schmidt³, Ronald E. Griffiths¹, David J. Dean¹, Paul E. Grams¹, and Christina Leonard³

¹Grand Canyon Monitoring and Research Center, Southwest Biological Science Center, U.S. Geological Survey, Flagstaff, AZ

²Department of Geography, University of Wyoming, Laramie, WY, USA

³Department of Watershed Sciences, Utah State University, Logan, UT, USA

Fine sediment (i.e., sand, silt, and clay) forms the physical template for the aquatic and riparian ecosystems in the segments of the Yampa and Green rivers extending from upstream of Dinosaur National Monument through the Ouray National Wildlife Refuge. Most of the riverbed in these segments is composed of sand (with lesser amounts of silt and clay), and the banks are generally composed of a mixture of fine sediment. Because the majority of the riverbed and banks are composed of fine sediment, the morphology of the river channel(s), bars, banks, and associated fish habitat is determined by the interaction of the streamflow and the upstream supply of sediment. In cases where the upstream supply of sediment exceeds the downstream export of sediment from a river reach, channel simplification with infilling of secondary channels will occur resulting in a net loss of available habitat. Conversely, in most cases where the downstream export of sediment exceeds the upstream supply of sediment, channel complexity will be maintained. Thus, a critical step in determining the combinations of streamflow and sediment supply that may maintain the channel complexity associated with suitable fish habitat is monitoring the sediment transport into and out of key river segments/reaches. To this end, the National Park Service began funding the USGS-Grand Canyon Monitoring and Research Center in 2012 to operate a sediment-transport monitoring network in and around Dinosaur National Monument. In 2017, the Upper Colorado River Endangered Fish Recovery Program provided additional funding to expand this network to encompass the reach of the Green River between Split Mountain and Ouray, UT. This network monitors the status of sediment on the bed and in suspension. There are now six stations in the Dinosaur-Ouray network. Four are co-located at the USGS gaging stations on the Yampa River near Maybell, CO (09251000), Little Snake River near Lily, CO (09260000), Yampa River at Deerlodge Park, CO (09260050), and Green River above Gates of Lodore, CO (404417108524900), and two are located near the USGS gaging stations on the Green River near Jensen, UT (09261000) and Green River at Ouray, UT (09272400).

Sediment transport is controlled by the interaction of the flow with the grain-size distribution of the bed sediment. In rivers with a relatively unlimited upstream supply of sand, the grain-size distribution of the bed sand will be relatively constant over time, and simple relations may be developed between water discharge and suspended-sand concentration. This is not the case in any of the segments of the Yampa and Green rivers in the study area. At the stations in the Dinosaur-Ouray network, systematic changes in bed-sand grain size exert a substantial, and sometimes dominant, control of sand transport. These changes in grain size arise from changes in the upstream supply of sand caused by floods in upstream tributaries. Although tributary floods occur quasi-annually and cause annual variation in bed-sand grain size, extremely large tributary floods may cause changes in the bed-sand grain size that occur over much longer timescales. For example, the bed-sand grain size (and thus sand transport) in the Little Snake River and downstream segments of the Yampa and Green rivers is still evolving after large floods in tributaries to the Little Snake River that occurred ~50 years ago. Because of the large influence of changes in the upstream sediment supply, continuous monitoring of sediment transport that does not rely on water discharge as a proxy for sediment transport is required at all stations in the Dinosaur-Ouray network. Each station in this network therefore employs multi-frequency acoustical methods and conventional sampling methods to measure suspended-silt-and-clay concentration, suspended-sand concentration, and suspended-sand median grain size at 15-minute intervals. Continuous mass-balance sediment budgets are then constructed for the river reaches between these stations by differencing the sediment loads calculated using the 15-minute suspended-sediment measurements. These sediment budgets allow tracking of the amount of silt and clay and the amount of sand that have been either eroded from or deposited in these reaches, which affect channel complexity and habitat. The data from the stations, user-interactive plots of the

data, and user-interactive sediment budgets are available at either https://www.gcmrc.gov/discharge_qw_sediment/ or https://cida.usgs.gov/gcmrc/discharge_qw_sediment/.

Results from our monitoring network indicate that the patterns of erosion and deposition vary spatially along the Yampa and Green rivers, with some reaches gaining sediment (and losing channel complexity) while other reaches lose sediment during the same time period. For example, sand was eroded from the Deerlodge Park reach of the Yampa River in every year during 2013-2017. In contrast, sand was deposited in downstream reaches of the Yampa and Green rivers within Dinosaur National Monument during the lower-discharge years of 2013 and 2015, with no demonstrable change in sand mass in these downstream reaches during 2014 and 2016. In addition, a large amount of sand was eroded from the Jensen-Ouray reach (i.e., Unitah Basin reach) of the Green River during the high Flaming Gorge Dam releases of 2017; a period without a major change in the amount of sand in the upstream reach of the Green River in Dinosaur National Monument.

Insights into the sensitivity and resilience of the Yampa and Green rivers' riparian ecosystems to flow regime shifts through a coupled eco-geomorphic model

Rebecca Diehl¹, Andrew Wilcox¹, David Merritt², Dustin Perkins³

(1) Department of Geosciences, University of Montana, (2) USFS, National Stream and Aquatic Ecology Center, (3) NCPN, NPS

Management of river systems relies on an understanding of the relationship between flow and ecosystem properties. Flow response curves formalize this relationship by empirically linking the form and/or function of the biota or physical template of a river system to a change in flow properties. To gain insight into the coupled nature of riparian ecosystems, and make predictions about their response to a change in discharge, we built an ecogeomorphic model from a series of flow response curves based on data collected on the Yampa and Green rivers in Dinosaur National Monument. These curves relate attributes of the flow regime to the 1) presence/absence of groupings of functionally similar plants (riparian response guilds), 2) plant cover density, and 3) plot-scale topographic response to a single flood event. Our model successfully identifies the spatial distribution of suitable plant guild habitat and has moderate success predicting the magnitude and direction of the geomorphic response to flood events.

The shape of the resulting response curves are non-linear and exhibit clear thresholds. These features suggest that ecogeomorphic processes that shape riparian communities are at times highly sensitive, and at other times highly resilient, to the magnitude and direction of shifts in the flow regime. We explore this observation by comparing the trajectory of riparian ecosystem adjustment for three future flow scenarios. The six plant guilds we model all show sensitivity to shifts in some part of the flow regime, and resilience to others. Erosional and depositional patterns respond in part to the shifts in guild distributions, but also in part in response to changes in flow hydraulics. The linkages among environmental conditions, riparian plant community dynamics, and morphodynamics represented in our ecogeomorphic model makes this approach a powerful tool for understanding the impact of changes to the flow regime on the form and functioning of riparian ecosystems.

Influence of Channel Width and Formative Discharge on Sandbar Dynamics in the Middle Green River, Utah

David Waterman¹ and Kirk LaGory, Environmental Science Division, Argonne National Laboratory, Argonne, Illinois

¹ Current affiliation: Civil and Environmental Engineering Department, South Dakota School of Mines and Technology

The abundance of sandbars in the middle Green River provides important backwater habitat for juvenile Colorado pikeminnow (*Ptychocheilus lucius*). The modified hydrology and sediment load regimes due to the upstream Flaming Gorge Dam have caused modifications to general sandbar geometry and dynamics in the evaluation reach, which encompasses the Ouray National Wildlife Refuge. Research attempting to ascertain the influence of habitat modifications on Colorado pikeminnow is ongoing. Our analysis examined the influence of

channel width and formative discharge on sandbar dynamics, under the guiding principle that understanding sandbar dynamics increases understanding of backwater habitats. First, we analyzed aerial photographs, and determined that the rapid channel narrowing that occurred in the fourteen years after Flaming Gorge Dam closure had slowed dramatically. Secondly, we analyzed the aerial photographs and Landsat imagery, and found that bank accretion sites were concentrated in a few localized areas, and prior to vegetation colonization, these areas consistently contained emergent sandbars. Thus, although channel narrowing has slowed dramatically, the potential remains for future width modifications. Thirdly, we used Landsat imagery, field data, and a mathematical predictor and determined that narrower channel widths can be expected to yield less complex sandbar configurations; furthermore, the influence of channel width cannot be decoupled from the formative discharge. Although the influence of these factors on Colorado pikeminnow is uncertain, the findings do provide a framework for river managers to understand the general effects of specific formative discharge conditions and potential channel narrowing on sandbar dynamics.

Twentieth century channel narrowing of the Green River in Canyonlands National Park--How much? When did it happen? Why?

Alexander E. Walker¹, John C. Schmidt¹, Paul E. Grams², Johnnie N. Moore³

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Channel narrowing of the lower Green River since the late 1800s is well documented; however, the rate, timing and magnitude of channel change are only partially understood. To determine these elements of channel change and to understand whether or not the Green River in Canyonlands National Park continues to narrow, we use aerial imagery, dendrogeomorphology exposed in a 50-m long, 2-m deep trench excavated in the floodplain, sediment transport data and bathymetric surveys. These techniques are applied to determine magnitude, timing and processes of floodplain formation at multiple spatial and temporal scales. Our results show that the contemporary floodplains began forming in the late 1930s, and continued to form and vertically accrete in the second half of the 20th century. Analysis of aerial imagery shows that changes to the floodplain identified in the trench occurred across the extent of aerial imagery.

The most recent phase of floodplain formation began during a period of drought that followed the unusually high runoff years from 1983 to 1985. From the mid-1980s to present, active channel width decreased by 9%. Floodplain formation occurs during spring peak floods, which are the only flows large enough to inundate the floodplain. Inset floodplain formation within the banks of the previous river channel was the primary mechanism of narrowing. Widespread establishment of invasive tamarisk (*Tamarix spp.*) did not play a primary role in channel narrowing, though dense stands stabilized banks and likely promoted sediment deposition. The most recent episode of channel narrowing reflects changes to flood magnitude and timing resulting from water development and climate change.

Determining fish status from mobile PIT antenna detections: Preliminary study results

J. Benjamin Stout – Department of Watershed Sciences, and Ecology Center, Utah State University

Phaedra Budy – US Geological Survey, Utah Cooperative Fish and Wildlife Research Unit, Department of Watershed Sciences, and Ecology Center, Utah State University

Mary Conner – Department of Wildland Sciences, Utah State University

Peter Mackinnon – Department of Watershed Sciences, Utah State University

Mark McKinstry – US Bureau of Reclamation, Salt Lake City, Utah

Accurate estimates of organisms' vital rates are essential for tracking and understanding the successful recovery of endangered species such as the razorback sucker and the Colorado pikeminnow. Passive Integrated Transponder (PIT) tags to allow researchers to track movement and estimate vital rates of fishes. Mobile PIT tag antenna systems (e.g., on a floating raft) have recently been developed to increase resight rates and reduce handling stress, in order to provide robust estimates of survival and population trend and to identify influential management actions. Although promising, mobile systems present new challenges to estimation techniques. Tags, not fish, are detected, thus increasing the chance that shed tags or dead fish with tags (referred to as ghost tags) are being included as live fishes, which can lead to dramatic over-estimation of survival and under-estimation of abundance. Because the number of PIT tags is constantly increasing, the detection of more dead/shed tags is a given. Classification of tags as live or dead is essential and in part motivated this study. Our overall goal for this component of our study is to develop an approach for classifying a detected PIT tag as live or dead/shed. We conducted our study on 273 kilometers of designated critical habitat in the San Juan River over two field seasons. We seeded PIT tags into the river to quantify dead/shed tag movement (900 were resighted); live fish (302 were resighted) movements were identified by matching tag detections with live capture data from electrofishing and stationary antenna data. Explanatory variables including distance and direction moved, and habitat and river complexity at detection locations were used to classify tags. We report on preliminary results, as our analysis is ongoing. For our first set of models, there was very low error for dead/shed tags (2.27% incorrectly classified as live tags) and higher error for live tags (30% incorrectly classified as dead/shed tags). The three most important variables for the classification of tags were distance moved, direction moved, and meters moved per day. Future models will incorporate additional variables such as overwinter and high flow movements.

Vermillion Creek: A habitat of unanticipated importance for Colorado pikeminnow in the Green River

Edward R. Kluender and Kevin R. Bestgen

Colorado State University, Larval Fish Laboratory

The northern extent of Colorado pikeminnow distribution in the Green River of the Upper Colorado River Basin has retracted by more than 185 kilometers as a result of closing Flaming Gorge Dam in 1963. Mainstem Green River water temperatures below the dam are now much colder than pre-dam temperatures, and few Colorado pikeminnow have been documented in Browns Park between Flaming Gorge Dam and the Canyon of Lodore since that time, especially when flows were cold and stable. Increased use of the Green River in Brown's Park by Colorado pikeminnow has been documented in recent years, despite suboptimal thermal and hydrological conditions, and may be a result of flow and water temperature recommendations to favor imperiled native fishes. Vermillion Creek, a small tributary to the Green River confluencing approximately 71 river kilometers downstream of Flaming Gorge Dam in Brown's Park National Wildlife Refuge (BPNWR), is the focus of increased use by Colorado pikeminnow. The greatest numbers of Colorado pikeminnow in BPNWR, including tuberculate individuals, have been captured there annually since 2011, prompting a PIT tag antenna study during 2017 sampling. We detected 75 individual Colorado pikeminnow, 11 native suckers, and 9 unknown individuals, comprising over 29,000 detections between 11 April and 13 July 2017. Peak activity in Vermillion Creek occurred between 11 May and 31 May, in terms of both total daily detections and daily number of individuals detected. Spring water temperatures in Vermillion Creek were warmer than those in the mainstem Green River, and similar to pre-dam mainstem temperatures. The mouth of Vermillion Creek is also anomalous in the reach during spring high flows because it provides a low-velocity refuge from high-velocity main channel flows. Warm, low-velocity water as well as forage fish may be attracting Colorado pikeminnow, as at least 15 small-bodied fishes were detected in lower Vermillion Creek. The large number of Colorado pikeminnow individuals observed in Vermillion Creek, the duration of their use immediately prior to spawning, and subsequent detection of nine of the same individuals near a known spawning location in the Yampa River indicate the creek provides key resources for pre-spawning conditioning and gamete development. Present-day Vermillion Creek is likely relatively similar to pre-dam conditions in that reach of the Green River, and monitoring and protection of such habitats, including flows, throughout the basin may assist with recovery of Colorado pikeminnow.

If You Sink It They Will Come: PIT Tag Antennas at Spawning Bars in the Upper Green River Basin of Utah and Colorado

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Extensive electrofishing throughout the upper Green River basin typically yields low native fish recapture rates, yet native and endangered fish recovery efforts in this system rely on recapture rate driven population estimates to assess populations. Spawning bars and complexes provide a relatively reliable place to find fish, but electrofishing can be deleterious to spawning fish and therefore counterproductive to their recovery. Starting in 2012, the Green River Basin Fish and Wildlife Conservation Office has set PIT tag antennas at well documented spawning locations in the Green and Yampa rivers. PIT tag antennas provide an unobtrusive way to record PIT tagged fish twenty four hours a day, seven days a week. Along with the refinement of antenna technology, the number of detections of endangered fish have increased each year, yet the question still remains: What do we do with all of this data?

Monitoring endangered humpback chub (*Gila cypha*), in Black Rocks (Colorado River, Ruby Horsethief Canyon), from 1998-2016, including incorporation of PIT tag antenna detections of tagged fish into mark-recapture parameter estimation

Francis, T.A.¹, K.R. Bestgen², and G.C. White²

¹ U.S. Fish and Wildlife Service, Grand Junction Native Fish and Wildlife Conservation Office, Grand Junction, Colorado, 81501 USA

² Colorado State University, Department of Fish, Wildlife, and Conservation Biology, Larval Fish Laboratory, Fort Collins, Colorado, 80523 USA

The humpback chub (*Gila cypha*) is a long lived (up to 30 years) moderate-sized cyprinid (minnow) endemic to the Colorado River basin that is currently listed endangered under the Endangered Species Act. Humpback chub reside mainly in canyon-bound river reaches. Populations in Debeque Canyon (Colorado River) and the lower Gunnison River are small and only detectable by the occasional capture in the nearest fish trap (Grand Valley Water User's Fish Ladder in Debeque Canyon, Redlands Fish Ladder in the lower Gunnison), and the Whirlpool-Yampa Canyon (middle Green/lower Yampa rivers) population is thought extirpated. The five remaining populations include: one in the lower Colorado River basin (Little Colorado and Colorado rivers in the Grand Canyon; the largest population), and four in the upper basin (Colorado River in Black Rocks, Cataract and Westwater canyons and the Green River in Desolation Canyon). All populations are spatially separate and the smallest geographical reach to support a discrete population of humpback chub is Black Rocks. Black Rocks is a 1.4 km section of deep-water habitat formed by erosion-resistant black metamorphic rocks (gneiss and schist) that were intruded by veins of molten rock (igneous materials), in the river channel. This unique area is about 6.4 km upstream from the Colorado-Utah state line. The river channel is narrow and turbulent eddies, pools and runs are located throughout the reach. Deep areas along the rock faces provide important habitat for humpback chub. Black Rocks is substantially deeper than other parts of the Colorado River, with an average depth of about 5 m and maximum depth of about 18 m. Mark-recapture studies for humpback chub in Black Rocks were initiated in 1998 and are ongoing. From 1998 to 2012, primary sampling techniques included 23-m-long trammel nets set during crepuscular periods and jet boat-based electrofishing during the day. In 2012, experimental use of baited modified turtle hoop nets and submersible "wagon-wheel" type PIT tag antennas yielded more recaptures, which may improve statistical estimates. Thus, beginning in 2016 we began using all four techniques. We report trends in capture data over time, including robust-design multi-state statistical modeling in Program MARK to estimate survival, transition rates of chubs between Black

Rocks and Westwater, capture-recapture probabilities, and abundance. We also discuss incorporating antenna detections of tagged fish with data collected using more traditional gear types to enhance abundance estimates, as well as use of antenna tag detections to evaluate sampling designs.

Use of the Dolores River (Utah) by endangered fishes, 2013-2017

David W. Speas, U.S. Bureau of Reclamation

Peter MacKinnon, Utah State University

Jim White, Colorado Division of Parks and Wildlife

Daniel Keller and Zane Olsen, Utah Division of Wildlife Resources

In 2013, a passive interrogation array was installed in the Dolores River about 13 km above its confluence with the Colorado River (UT) to monitor use of the tributary by PIT-tagged non-listed native and endangered fishes. As of October 2017, the facility has detected 1,017 individual PIT-tagged fish consisting of 658 bonytail (*Gila elegans*), 134 bluehead sucker (*Catostomus discobolus*), 74 flannelmouth sucker (*Catostomus latipinnis*), 30 razorback sucker *Xyrauchen texanus*, 26 Colorado pikeminnow *Ptycocheilus lucius*, 16 roundtail chub *Gila robusta* and 8 flannelmouth/razorback sucker hybrids. An additional 68 unidentified fish were also detected. Colorado pikeminnow were detected in the Dolores River primarily during the months of June through September, whereas razorback sucker tended to appear in the river during the months of March through May. Except for anecdotal observations, detections of Colorado pikeminnow during 2015-2017 represent the first substantiated evidence of this species occurring in the Dolores River since 1991. Colorado pikeminnow and razorback sucker capture histories prior to recent detections are complex and geographically extensive. Bonytail detections appeared to be most frequent immediately following stocking events in the Dolores River, however there were a few examples of individual fish detected in the tributary up to three years after stocking.

Shedding light on aquatic insects of the Colorado River basin with citizen science

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Ecological studies of big rivers are often confined to small, potentially inadequate spatial scales due to the logistical challenges of sampling these large and remote environments. To overcome these challenges, we collaborated with hundreds of river runners to quantify the abundance and diversity of adult aquatic insects throughout the Colorado River basin. These citizen scientists deployed light traps each night in camp along more than 2,500 river kilometers on the Green, Colorado, Yampa, Gunnison, Dolores, and San Juan rivers. This collaboration yielded 3,462 light trap samples from 1,667 unique sites from 2015–2016. We use these data to describe patterns of aquatic insect distribution and abundance on local and regional scales. We found that total abundance of aquatic insects, especially non-biting midges and caddisflies, was highest in Colorado River basin tailwaters (0-100 km downstream of a dam) and declined with distance from dams. In contrast, species richness of aquatic insects was low in tailwater segments and increased with downstream distance from dam. Additionally, we found aquatic insect diversity was significantly higher in the dendritic river network upstream of Lake Powell relative to the linear and heavily dam-regulated Colorado River through Grand Canyon. Our results provide insight into the diversity, distribution, and dispersal of aquatic insects in a fragmented riverscape and demonstrate the power of citizen science as a tool for ecological investigations in big rivers.

Designer flow releases from Flaming Gorge Dam benefit Green River endangered fishes and ecosystem health

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Abstract: Flow releases from dams can be used to benefit specific resources as well as improve ecosystem health. In altered river systems such as the Green River, where restoring ecosystem health and endangered fishes is a goal, strategically constructed flow regime prescriptions can assist with achieving multiple objectives. Such “designer flows”, in which certain ecological functions are enhanced with specifically-tailored flows, can be implemented while also meeting other demands and uses of water, and often result in hybrid or novel ecosystems. These flows retain only elements of historical environmental attributes and are purposefully managed to provide specific benefits. In the Green River downstream of Flaming Gorge Dam, one spring high flow and two summer base flow releases have been proposed for Flaming Gorge Dam to benefit downstream native and endangered fishes. A spring high flow release is timed with presence of razorback sucker larvae, which is designed to entrain early life stages into productive floodplain wetlands. A flow spike in early summer is proposed to reduce smallmouth bass abundance by reducing their reproductive success, which will enhance native fish survival. Summer baseflows are proposed to enhance survival of young Colorado pikeminnow, where flows mimic patterns that have produced larger year classes in past years. Recommendations implemented to benefit endangered fishes have returned more natural flow attributes to the system and proposed modifications have potential to further enhance the native fish community and other ecosystem attributes. Proposed flow recommendations are needed immediately to assist with conservation of native fishes, and additional longer-term conservation actions needed to stop or reverse large-scale issues such as channel narrowing should focus on root causes and their remediation.

Evaluating Backwater Habitat Availability and Condition in the Middle Green River, Utah

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In-channel backwaters are connected, low-velocity aquatic habitats associated with emergent sandbars that serve as important nursery habitats for the endangered Colorado pikeminnow (*Ptychocheilus lucius*). Because sandbars can change dramatically from year to year depending on the magnitude and duration of annual peak flow, the abundance, spatial distribution, and characteristics of backwaters are highly variable from year-to-year. Using aerial and satellite imagery, annual availability of in-channel backwater habitats was studied by various researchers in the middle Green River, Utah, in the late 1980s (Pucherelli and Clark 1990), middle 1990s (Bell 1997), and the 2000s (Grippo et al 2017) enabling an evaluation of changes in availability through time (Grippo et al 2017). In addition, we undertook a study from 2003 through 2015 to examine changes in the topography of backwater habitats over this period. Although this latter study was useful for identifying the great amount of intra- and inter-annual variability in these parameters and the effect of flow variability on habitat conditions (depth, surface area, and volume), its limited focus (four to six backwaters each year) did not allow for reach-wide determinations of condition. To overcome these shortcomings, we developed and applied an approach for estimating backwater depth from available aerial and satellite imagery for 2006, 2013, and 2014, to the entire 68-mi Jensen-to-Ouray reach. Limitations of this approach included the variability and sometimes low quality of the aerial images for developing relationships between spectral values and backwater depth and the limited groundtruthing information we had from our topographic surveys. To overcome these shortcomings, we tasked WorldView2 and GeoEye1 satellites for collection of panchromatic and multispectral images in August 2017. We improved groundtruthing by using GPS-enabled sonar to collect bed elevations of 37

backwaters between Jensen and Ouray. We are currently in the process of developing relationships between spectral values and surveyed depths to determine reach-wide availability of suitable backwater nursery habitats. The ultimate goal of this work is to develop a procedure that enables efficient, reliable, and cost-effective monitoring of habitat availability and condition through time.

Deployment and Testing of In-situ and Mobile Hydrophones for Coarse Bedload Sediment Mobilization Studies on the White River, Spring 2017

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Traditional methods for measuring coarse bedload sediment transport by discrete physical sampling tend to be slow, labor intensive and expensive. As such, bedload samples often are collected too infrequently to capture the temporal and spatial variability inherent in bedload transport. For river restoration programs, having accurate estimates of where and when bedload transport is occurring are key components for determining successful restoration strategies.

To help support river restoration and sediment mobilization studies, we have developed a mobile hydrophone system that measures in-water sediment-generated noise (SGN) when sediment transport is occurring. The mobile hydrophone system is mounted on a boat for performing long-profile large spatial surveys (up to 20 river miles / day) and is operated in tandem with a survey-grade GNSS and an acoustic Doppler current profiler (ADCP) for continuous measurements of water-surface elevations, water depths and water velocity profiles. The sound files are converted to frequency space using a Fast Fourier Transform (FFT) and then averaged over frequencies that have previously been found to be dominated by coarse sediment transport (0.6 – 3.7 khz).

In this talk, we will describe the results of field activities using the mobile hydrophones on the White River below Kenney Reservoir during spring peak flows in 2017.

Wetland Management at Ouray National Wildlife Refuge

Sonja Jahrsdoerfer

Lower Green River NWR Complex, U.S. Fish & Wildlife Service

The reach of the Green River that occurs in Ouray National Wildlife Refuge (NWR) occurs in a priority reach for razorback sucker reproduction and larval habitat, and contains 62 percent of the floodplain habitat on the Green River (Valdez and Nelson 2004). Ouray NWR was established in 1960 and in its early years, dikes and levees were constructed in much of the floodplain and wetland habitats to control seasonal Green River flow (USFWS 2000). Construction of Flaming Gorge Dam significantly reduced the frequency, magnitude, and duration of flooding from the Green River. The initial management focus on waterfowl production evolved with publication of the Comprehensive Conservation Plan in 2000 to emphasize migratory birds, threatened and endangered species, and wildlife-dependent public use. This management shift involved the use of seasonal overbank flooding to restore the function of riparian and floodplain wetlands, which entailed levee removals/breaches and alterations to water control structures and canals. Many areas on Ouray NWR retained parts of historic community structure and ecological processes despite considerable alterations to hydraulic conditions, extensive development in some areas, and nonnative plant invasions. Restoration goals include improving connectivity between the Green River and floodplain wetlands and emulating natural hydrological regimes in floodplain wetlands where possible (Heitmeyer and Fredrickson 2005). In 2015 and 2017, Ouray NWR constructed habitat restoration projects in Johnson Bottom and Sheppard Bottom to create nursery habitat for larval razorback sucker. These floodplain wetlands also must be managed to benefit other important species (e.g., migratory birds) and to minimize cattail encroachment.

Razorback Sucker (*Xyrauchen texanus*) Research and Monitoring in the Colorado River Inflow Area of Lake Mead and the Lower Grand Canyon, Arizona and Nevada

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(¹ BIO-WEST, Inc.; ² American Southwest Ichthyological Researchers, LLC; ³ U.S. Bureau of Reclamation, Upper Colorado Region; ⁴ U.S. National Park Service; ⁵ Lower Colorado River Multi-Species Conservation Program)

For more than 20 years, razorback suckers were thought to be extirpated within the Grand Canyon. However, based on past studies and movements of sonic-tagged razorback suckers from Lake Mead into the Grand Canyon, there were renewed questions regarding the presence of wild individuals and their relationship between the river and reservoir. This collaborative study which began in 2014 included efforts to continue research of razorback sucker (all life stages) within the Colorado River inflow of Lake Mead (CRI) combined with sonic telemetry, small-bodied fish community, and larval fish community sampling within the Grand Canyon. The specific objectives outlined for these efforts included; (1) conducting larval and small-bodied fish community studies to quantitatively assess annual fish reproduction, spawning, and nursery areas for native fishes within the Grand Canyon, (2) determining if razorback suckers are present in the study area and if they associate with specific habitats found within the Grand Canyon through the use of telemetry, and (3) identifying habitat associations, relative spawning and reproductive effort, and population trends of razorback sucker in the CRI. Specifically, this paper presents findings from the CRI portion of this multi-faceted study, particularly regarding natural recruitment observed within this population, with additional results from the Grand Canyon, as informed from small-bodied fish community sampling. This research has also provided a means for fairly extensive documentation of young humpback chub (*Gila cypha*) throughout the riverine portions of the study area, as well as adult razorback sucker movement and habitat use within both a lentic and lotic environment.

Patterns of razorback sucker (*Xyrauchen texanus*) and associated Colorado River fish community reproduction and development within the Grand Canyon.

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Larval razorback sucker (*Xyrauchen texanus*) surveys in the Colorado River within Grand Canyon National Park have been conducted for four consecutive years 2014–2017. Following detection of larval razorback suckers in the first survey month of the 2014 (April), the study period was shifted to begin in March in subsequent survey years (2015–2017) in an attempt to detect the initiation of larval razorback sucker occurrence. Similarly, because razorback sucker larvae were detected in the most upstream sampling localities (immediately above Lava Falls) the study area was expanded 90 miles upstream to Phantom Ranch (river mile 88.6) in 2016. In 2016 and 2017 captures of razorback sucker larvae were documented downstream of a warm water tributary (Havasu Creek). Initial captures of both common suckers like the bluehead sucker (*Catostomus discobolus*) and flannelmouth sucker (*Catostomus latipinnis*) larvae initially followed the same pattern but were detected throughout the study area in subsequent survey months (190 river miles). Razorback sucker larvae have not been detected upstream of Havasu Creek. Further, bluehead sucker, flannelmouth sucker, and

endangered humpback chub (*Gila cypha*) are collected in all phases of larval development and as juveniles while juvenile razorback sucker have not been detected and late phase larvae are rare. The distribution of developmental phases of larval bluehead and flannelmouth suckers appears nonrandom exhibited by an increased proportion of larvae in later stages of development from collections made further downstream. Results from the expanded study area surveys in 2016 and 2017 have begun to illustrate patterns that may indicate the location for initial catostomid spawning and conceivably how a thermally graded system may influence the spawning and development of common and endangered fishes within the Grand Canyon.

A barrier to recovery? Movement and early life-history of razorback sucker downstream of the Piute Farms Waterfall

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Documentation of razorback sucker (*Xyrauchen texanus*) occurrence in the San Juan River arm of Lake Powell dates back to the 1980s, when the reservoir first filled to capacity. Interactions between reservoir water level changes, sediment deposition, and floodplain topography have led to the formation of a waterfall on the San Juan River over two separate occasions since 1989. The Piute Farms Waterfall has remained in its current position since 2000 and is a barrier to fish moving upstream from Lake Powell. To investigate razorback sucker movement dynamics in and use of the San Juan River-Lake Powell inflow area, we designed a telemetry tagging study using dual acoustic-radio transmitters implanted into adult fish captured at riverine, inflow, and reservoir locations. In spring of 2017, a total of 91 fish were surgically implanted with telemetry tags. We tracked fish movement in the San Juan River upstream of the waterfall and in the inflow area using a combination of active tracking trips, passive receivers, and PIT tag antennas. Additionally, to assess fish community use of the inflow area we conducted sampling trips downstream of the waterfall and into the inflow area. Seining trips collected 274 age-1 Colorado pikeminnow (*Ptychocheilus lucius*) (average TL: 50 mm, range: 32-200) during trips in March/April and 15 young-of-year razorback sucker (average TL: 40 mm, range: 26-63 mm) in July. Future efforts will continue tracking movements of tagged fish, sampling of fish communities in the inflow area, and estimating population size of razorback sucker in the inflow area.

Effectiveness of Light Traps for Detecting Razorback Sucker Larvae

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Detection of endangered razorback sucker (*Xyrauchen texanus*) larvae by light traps is used to prompt flow releases to inundate Green River floodplain wetlands, habitat which may increase survival of those early life stages. However, little is known about the efficacy of light traps to capture or retain larvae. In the laboratory, we investigated effects of trap set time, release distance from trap, light presence, and turbidity on capture and retention rates of three early life stages of razorback sucker. Mean capture rate of mesolarvae (11-17 mm total length [TL]), the most commonly captured life stage in field sampling, was 86% (82-90%) over the various treatment effects. Capture rates of metalarval (mean = 42%, range 21-63%; 15-24 mm TL) and juvenile (mean = 24%, range 20-28%; 22-37 mm TL) life stages were lower. Retention rates were generally > 75% and increased to 97% for juveniles. Relationships between set time and distance on capture rates should be investigated, along with field testing. Light traps may be a useful gear to detect razorback sucker larvae in the wild and trigger flow releases from Flaming Gorge Dam.

Abundance and survival of razorback sucker (*Xyrauchen texanus*) in the Green River basin, Utah, 2011–2013

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Population dynamics of Upper Colorado River Basin (UCRB) razorback sucker (*Xyrauchen texanus*) were unknown for many years because limited recapture data precluded a structured monitoring effort. However, increases in razorback sucker captures during Colorado pikeminnow (*Ptychocheilus Lucius*) abundance estimate sampling from 2011–2013 prompted further investigation. We used closed population robust design, multi-state models in Program MARK to estimate razorback sucker abundance, as well as survival, transition, capture, and recapture rates among three reaches of the Green River basin: upstream middle Green River, intermediate Desolation-Gray canyons, and downstream lower Green River. The final dataset consisted of 4,145 capture events of 3,932 unique razorback suckers, 5.3% of which were captured more than once during the study period. The few recaptures resulted in very low capture probability estimates (mean: 0.02, range: 0.002–0.056) and imprecise estimates of other parameters. Abundance estimates increased from 2006–2008 to 2011–2013 (likely a product of continued or increased stocking through time), were highest but least precise in middle Green River reach, and declined downstream. Annual abundance varied greatly, to a degree not likely for relatively longer-lived fish, such as razorback sucker. The only significant factor affecting survival estimates was time at large from stocking to first capture during this study, with higher survival for those at large > 1 year in middle Green River and Desolation-Gray reaches. The effect supported results from our previous studies of stocked razorback sucker survival, which showed that fish stocked more recently had lower survival rates. Total length at capture or at stocking did not strongly influence parameter estimates, contrary to our previous analyses, likely due to increased size uniformity. Meaningful transition rate estimates were precluded by too few among-year movements between reaches. However, most of those few movements (and highest transition rates) were out of the Desolation-Gray reach and most movement was upstream, as opposed to overwhelmingly downstream movement described in our previous, more robust movement analyses for hatchery-reared razorback suckers. All parameter estimates for lower Green River reach in 2013 were compromised by low captures due to reverse polarization of electrofishing equipment. Ultimately, recaptures of razorback suckers during Colorado pikeminnow abundance estimation sampling in the Green River basin were inadequate to produce precise population parameter estimates. The razorback sucker population in the UCRB consists almost entirely of hatchery-reared individuals, so survival analyses accounting for recent changes in propagation and rearing protocols may be sufficient to describe dynamics at present. However, studies in the UCRB have documented successful spawning by those stocked fish, as well as survival to the juvenile life stage of wild-produced larvae entrained into floodplain wetlands. Thus, the potential for self-sustaining populations is increasing, and the need for precise and reliable parameter estimates to evaluate recovery efforts will be essential.

Highs and lows of razorback sucker (*Xyrauchen texanus*) recovery in a managed wetland: maintenance considerations to facilitate forward progress

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Operation of the Stewart Lake wetland for razorback sucker (*Xyrauchen texanus*) recovery has continued to evolve and improve since 2012. Using a cooperative effort between State and Federal agencies called the Larval Trigger Study Plan, light trapping is used to detect the presence of larval razorback suckers in the middle Green River during high peak flow events, triggering an increased release of water from Flaming Gorge Reservoir to help with the entrainment of larvae into the Stewart Lake wetland through manually operated flood gates. Once larval razorback suckers are detected and entrained within the wetland, they face an onslaught of ever-growing challenges to overcome before being released back into the river. Following 2016, the most successful year to date, where 2,110 age-0 wild-spawned razorback suckers were released back into the middle Green River, 2017 represented the lowest production thus far; only a single age-0 razorback sucker was released back to the river. Here we will consider the on-going challenges of proliferation of nonnative fishes, encroaching cattails and bulrushes, the expanding dense aquatic submergent macrophyte beds that ultimately result in the loss of open water habitat and loss of in-wetland production. Finally, we discuss upcoming habitat restoration efforts to reduce cattail and bulrush expansion, ultimately helping agency personnel operate Stewart Lake to reach full potential for age-0 razorback production.

Population Estimate for Humpback Chub (*Gila cypha*) and Roundtail Chub (*Gila robusta*) in Westwater Canyon, Colorado River, Utah, 2016-2017.

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Abstract: Westwater Canyon on the Colorado River contains one of the five remaining populations of the endangered humpback chub in the Upper Colorado River Basin. Westwater Canyon also contains a large population of roundtail chub, which are listed as a species of concern throughout their range. Recovery goals require maintaining several populations of humpback chub within the Upper Colorado River Basin. Monitoring efforts are essential to evaluate the population of humpback chub in Westwater Canyon and meet the recovery goals. Trammel nets, electrofishing gear, and submersible antennas were used to sample humpback and roundtail chubs in Westwater Canyon in 2016 and 2017. Important metrics including catch rates, size structure, and population size were calculated for humpback and roundtail chub. Catch rates of humpback chub in 2016 and 2017 were 0.3 and 0.5 fish/hr, respectively. Catch rates of roundtail chub in 2016 and 2017 were 1.37 and 0.98 fish/hr, respectively. The population size of humpback chub in 2016 and 2017 were estimated at 2,002 (95% CI 1118-2886, SE=430, CV=0.23) and 3,656 (95% CI 1,177-6,133, SE=1,097, CV=0.30), respectively. The population size of roundtail chub in 2016 and 2017 were estimated at 7,916 (95% CI 6,320-9,512, SE=811, CV=0.10) and 11,300 (95% CI 8,055-14,545, SE=1,645, CV=0.15), respectively. In this presentation, I will describe recent monitoring activities of humpback and roundtail chub in the context of historical data for the Westwater population.

Small and Persistent: Monitoring Humpback Chub in Cataract Canyon, UT.

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Recovery goals for the endangered humpback chub (*Gila cypha*) include a criterion of “no net loss” to the population inhabiting the Colorado River in Cataract Canyon, Utah. From the late 1970s to present, data describe a population which persists in spite of limited abundance, size structure and geographic distribution, and basin-wide threats such as altered flow regimes and competition and predation by nonnative fishes. In 2017, Utah Division of Wildlife Resources recorded evidence of continued adult recruitment by *G. cypha* and the highest overall annual catch rates of the species since our agency’s sampling began in 1991. Additionally, refined juvenile sampling methods yielded unprecedented numbers of young *Gila spp.*, offering a more complete view of this population.

Integrating data to improve understanding and management of rainbow trout and humpback chub in the lower Colorado River

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The largest current population of humpback chub is found in the lower Colorado River basin and inhabits both the lower 13.6 km of the Little Colorado River (LCR) and the adjacent Colorado River. Humpback chub dynamics in this population are driven by a number of environmental and biotic factors. Recently developed joint mark-recapture models applied to mark-recapture data for juvenile humpback chub are beginning to elucidate the relative importance of these factors in the mainstem Colorado River portion of the population. Rainbow trout abundances negatively affect survival, growth and capture probabilities of juvenile humpback chub. However, temperature and turbidity are equally important drivers of juvenile survival, growth and capture probabilities and biotic and environmental factors together only explain a modest proportion of variation in survival and growth, suggesting that other important factors have yet to be identified.

While rainbow trout can affect the dynamics of juvenile humpback chub in the Colorado River, the number of rainbow trout in the Little Colorado River portion is thought to be negligible. However, between October 2013 and April 2014, PIT arrays in the Little Colorado River recorded a 36 tagged rainbow trout moving into the LCR. To quantify the total flux of rainbow trout, and estimate the risk that rainbow trout may pose to juvenile humpback chub in the LCR, we developed a model that integrated traditional mark-recapture data from the mainstem with continuous detections on the PIT array. Our modeling approach translated these 36 unique detections to a monthly movement probability of 1.0% and an estimate of 226 (95% CI: 133-367) rainbow trout entering the LCR during this period. We end by emphasizing the need for wildlife conservation science to develop statistical methods that can combine multiple data types and include multiple forms of uncertainty.

Evaluating the relationship of temperature and growth of a larval Colorado River catostomid, *C. latipinnis* through otolith aging and stable isotopes ($\delta^{18}\text{O}$)

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Isotopic analysis of otoliths (bony structures of the inner ear) from larval flannelmouth suckers (*Catostomus latipinnis*) obtained from the Colorado River in Grand Canyon could greatly facilitate understanding of thermally regulated growth rates, thermal preferences, and potentially ontogenetic habitat use by these fishes. Cold water as result of Glen Canyon dam and hypolimnetic releases from Lake Powell are predicted to slow growth and development of ectothermic fish larvae unless young fish can occupy warmer aquatic microhabitats (i.e., channel margins or shallow backwaters) within the river. Isotope ratio mass spectrometry (IRMS) is a technique that reveals integral aspects of an individuals' life history that are often difficult to infer with traditional sampling methods. We developed and evaluated IRMS of oxygen isotopes ($\delta^{18}\text{O}$) of larval fish otoliths as a means to reconstruct water temperatures experienced by fish during early developmental phases. Stable isotope analysis of larval fish otoliths allowed for confident determination of average water temperatures experienced by individual larvae. Water temperatures experienced by larval *C. latipinnis* closely mirrored the seasonal temperature variation and on average were slightly warmer $\cong 2^\circ\text{C}$ than the temperatures present in the mainstem river. Further, this research has identified potential impacts to the interpretation of growth rates of wild caught catostomid larvae spawned in cold-water temperatures. This unforeseen result may indicate an adaptive response to colder temperature by changes in resource provisioning to eggs and changes in early developmental ontogeny.

Biological effectiveness of incentive-based harvest tournaments for controlling nonnative piscivores in fluctuating coldwater reservoirs

Adam G. Hansen, Eric I. Gardunio, Tory Eyre, Colorado Parks and Wildlife

Nonnative piscivores often have substantial negative effects on native fish and their natural or assisted dispersal from reservoirs can undermine efforts to recover endangered species. Conflict with anglers can arise if agency programs curtail the threat of nonnative sport fish in reservoirs; particularly if such programs exclude anglers and reduce fishing opportunity. Lack of cooperation may perpetuate conflict, which could undermine long-term conservation efforts. Therefore, it is important to evaluate alternative solutions that harmonize conservation efforts and sport fisheries by incorporating anglers. The Upper Colorado River Basin (UCRB) is at the forefront of this issue. There are no documented attempts to suppress invasive smallmouth bass using a cost effective angler incentive program. Yet, this approach allows anglers to support management and could be effective in small systems alone or in conjunction with other methods. The primary objective of this study was to evaluate the efficacy of this approach at the onset of a removal program to inform future efforts and calibrate expectations for the UCRB and elsewhere. We quantified the harvest dynamics of anglers during a series of incentive-based fishing tournaments designed to suppress a population of smallmouth bass illegally introduced into Ridgway Reservoir, Colorado (this work is also underway in Elkhead Reservoir). The tournaments on Ridgway occurred annually from 2015-2017, and varied in duration (9 days vs. 24 days) and timing (spawn vs. mostly post-spawn), so we were able to estimate angler effectiveness (represented by age-specific catchability) and quantify harvest rates under alternative physical and biological conditions and logistically feasible tournament structures. The catchability of smallmouth bass was highest in July, after fish had spawned, and when reservoir conditions (surface elevation, inflows, and water temperatures) were stable. An age-structured

population model incorporating multiplicative process error in stock-recruitment dynamics, uncertainty in natural survival rate, and variation in angling effort (hours fished during each tournament) indicated that observed fishing mortality rates accruing during an annual incentive-based harvest tournament occurring in July could reduce the abundance of age-1 and older smallmouth bass by 62% (95% CI = 37-79%) in ten years, or 90% (95% CI = 80-96%) in ten years assuming catchability varies inversely with abundance as well demonstrated for other fish stocks. Results from preliminary modeling simulations indicate that a cost effective angler incentive program can produce significant levels of fishing mortality on invasive smallmouth bass in small coldwater reservoirs, and should not be overlooked as a suppression method available for use alone or in conjunction with other methods.

RESPONSE OF THE NATIVE FISH COMMUNITY OF THE YAMPA RIVER TO NONNATIVE FISH REMOVAL AND FLOWS

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Mechanical removal of several nonnative fish predators has been implemented in several rivers of the Upper Colorado River Basin in an effort to restore native fishes. Estimating response of the fish community to removals is a key element to evaluate efficacy of removal actions. From 2003-2017, we sampled small-bodied fishes in low-velocity habitat in treatment (small-bodied piscivorous fish removal) and control (no removal) reaches of the Yampa River, Colorado, with a variety of gears to assess whether predator removal benefited the fish community. From 2003-2007, when flows were typically low and warm, main channel fish communities were dominated by nonnatives, particularly young-of-year (YOY) smallmouth bass. Native fishes were rare in main channel habitat, and were usually present only in isolated pools where smallmouth bass were uncommon. Although still relatively uncommon, higher frequencies of native fishes in main stem samples since 2008 were coincident with increased removal of YOY smallmouth bass, particularly in the treatment reach. Native fish abundance in main channel samples in both the control and treatment reaches increased after 2008-2011 and was particularly high in the high flow and cool year 2011. In the warmer and lower flow years 2012-2017 native fish abundance declined from 2011 levels likely as a result of higher bass abundance and larger bass body size. An exception was in 2015, when native fish presence and abundance was the second highest recorded since sampling began, a year when a summer thunderstorm and associated increased flow and turbidity reduced YOY smallmouth bass abundance in mid-summer. Positive native fish responses observed in this study were likely due to synergistic effects of smallmouth bass removal and density reductions and to a higher, non-drought year hydrologic regimes, which delayed bass spawning, growth, and abundance in the Yampa River, Colorado. Suppressing smallmouth bass abundance and maintaining adequate stream flows are key elements to long-term conservation of the native fish assemblage in the Yampa River.

Evaluation of Nonnative Fish Escapement Prevention Strategies at Rifle Gap Reservoir and Highline Lake, Colorado

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Colorado Parks and Wildlife (CPW) is committed to managing western slope fisheries to maximize angler satisfaction, while also precluding escapement of nonnative fishes from recreational reservoirs into downstream native fish habitat. In addition to the stocking of compatible fish species (where approved) and taking steps to disadvantage non-compatible fish species in western slope waters, CPW has installed and maintains anti-escapement devices at a number of waters, including a spillway net at Highline Lake (northwest of Loma, Colorado) and an in-channel screen in Rifle Creek downstream of Rifle Gap Reservoir (northeast of Rifle, Colorado). The Highline Lake spillway net is a large block net with a mesh size of less than 0.25 inches which

stretches from the surface of the water to the bottom of the lake immediately above the outlet. Monitoring the status of the spillway net at Highline Lake is completed through annual surveys between the net and the spillway, in addition to frequent underwater net inspections and cleanings. The Rifle Creek fish screen is an in-stream concrete structure which directs all incoming water from Rifle Creek through one of two large Coanda screens on either side of the structure. These screens divert 100% of all solids ≥ 2.0 mm in diameter into troughs that are inspected and cleaned daily. During these inspections, nonnative fish species entrained in the structure are removed and documented. CPW crews also conduct annual electrofishing surveys at multiple stations on Mack Wash, downstream of the Highline Lake spillway, and on Rifle Creek, downstream of the fish screen to monitor the effectiveness of these anti-escapement devices. This presentation will focus on evaluating the effectiveness of these anti-escapement devices through a historical analysis of in-stream electrofishing data, fish entrainment data from the Rifle Creek screen, and survey data from Highline Lake between the spillway net and the spillway.

Opportunistic fish community sampling in the lower Duchesne River reveals high densities of problematic nonnative species

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The Duchesne River in Northeastern Utah is a highly fragmented system with large irrigation demands. Historic sampling documented presence of flannelmouth sucker (*Catostomus latipinnis*), bluehead sucker (*C. discobolus*), roundtail chub (*Gila robusta*), Colorado pikeminnow (*Ptychocheilus lucius*), and razorback sucker (*Xyrauchen texanus*). Contemporary sampling using raft electrofishing in 2009 determined that invasive species comprised the majority of catch, mainly white sucker (*C. commersonii*); however, native species including flannelmouth sucker, roundtail chub, Colorado pikeminnow, and bonytail (*Gila elegans*) have persisted. In 2017, we had the opportunity to conduct five boat electrofishing passes on the lower 15 miles of the Duchesne River from 1-22 June 2017 during high flow events. A total of 511 juvenile and adult fish were captured during 30.5 hours of effort; 15.8 % were native species including flannelmouth sucker, bonytail, Colorado pikeminnow, and roundtail chub. Of particular interest were the seven Colorado pikeminnow, six of which were untagged. Invasive species dominated catch, mainly consisting of smallmouth bass (*Micropterus dolomieu*); mean total length [TL] = 222.4 ± 7.4 mm; catch-per-unit effort [CPUE]= 6.0 fish per hour), and white sucker (TL = 191.3 ± 9.0 mm TL; CPUE= 5.0 fish/hr). Other invasive species included black crappie (*Pomoxis nigromaculatus*), green sunfish (*Lepomis Cyanellus*), largemouth bass (*Micropterus salmoides*), northern pike (*Esox lucius*), yellow perch (*Perca flavescens*), and walleye (*Sander vitreus*). Walleye numbers increased drastically in comparison to 2009 when only one walleye was captured. Sampling in 2017 captured 38 walleye (TL = 456.1 ± 10.9 mm TL; CPUE= 1.24 fish/hr; 2nd highest rate in Upper Colorado River Basin) and one individual captured was under 250 mm possibly signifying successful recruitment in this system. With the large presence of invasive species and the increase and possible recruitment of walleye removal efforts should be pursued but will depend greatly on annual flow conditions, and access.

Upper Colorado River Basin Smallmouth Bass Removal 2017

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Smallmouth bass were rare in the Upper Colorado River Basin until the early 1990's when a population became established in the Yampa River. This population likely originated from fish that escaped from Elkhead Reservoir during draw downs. Smallmouth bass then spread to the Green River and appeared in the Colorado River. Targeted removal of smallmouth bass began in 2003 and was expanded basin wide in 2009. In 2011 bass began appearing in the White River. Currently, established populations of smallmouth bass occur in the

Green, Yampa, White, Duchesne, and Colorado rivers. Ongoing removal efforts occur in all but the Duchesne. The 2017 removal resulted in reduced catch rates in the Yampa River and the Desolation and Gray Canyons Reach of the Green River. However, there were high catch rates near the confluences of the Green River with the White and Duchesne rivers. The White River population appears to be well established despite control efforts. In the Colorado River there was an increased capture of young-of-the-year and age-1 bass, and a concentration of large bass in lower Westwater Canyon. Recommendations are to continue removal efforts and abundance estimates. Possible early runoff in 2018 may necessitate an increased effort to reduce spawning success of bass.

Managing walleye expansion in the Upper Colorado River Basin with education, eradication, and escapement prevention: version 4.0

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Introductions (by government agencies) of highly desired nonnative fishes for angling opportunities and watershed management have been a tenet of fishery management; in fact the culture of government agencies that manage fisheries has shifted through time. The U.S. National Fish Hatchery System was developed in 1872 leading to the beginnings of Interstate transport of desirable sport fish. However, fisheries management began to shift directions with the onset of an Environmental Era that began in 1960. Unfortunately, before the societal shift towards environmental stewardship and native species conservation, nonnative and invasive fishes had contributed to deleterious effects on native fishes. The Colorado River Basin, home to a unique assemblage of endemic fishes, has an ever growing number (> 50) of nonnative fish species competing with and preying upon the 13 native species. Walleye (*Sander vitreus*) have been present in the system since 1959, thought to have come from a reservoir spilling them into the Duschene River. Walleye collections were fairly rare, in the main-stem river until the early 2000's. Two major mechanisms are most likely the culprits to the walleye population expansion in the Colorado River basin. One mechanism is the illegal introductions of these fishes to Colorado River basin reservoirs, and the second mechanism could be the accidental stocking of gizzard shad (*Dorosoma cepedianum*; Morgan Lake, San Juan River Drainage, 1998) which is a pivotal management tool (prey item) used by fishery managers to bolster walleye condition and populations where they are desired. Chemical fingerprinting (strontium isotopes laser ablated from otoliths), conducted by CSU (Johnson et al, 2014), identified three reservoir sources of walleye (Redfleet and Starvation (Green River), and Rifle Gap (Colorado River)) as well as in river reproduction from samples collected through 2008. Both the states of Utah and Colorado have been proactive in containing these sources. Reservoir outlet screens have been installed, piscicide treatments have been deployed, and public education messaging has been disseminated. Beginning in 2010, researchers documented a substantial increase of walleye in their catch in the lower portions of the Green and Colorado rivers, the primary nursery areas for endangered Colorado pikeminnow (*Ptychocheilus lucius*) and razorback sucker (*Xyrauchen texanus*). Beginning in 2013, a focused mechanical removal effort began and 1,564 walleye have been removed (2013-2017) from the entire Green River (> 350 river miles) and 844 have been removed (2013-2017) from the lower Colorado River (> 112 river miles).

Northern pike management in the Upper Colorado River Basin: Green and Colorado rivers subbasins – 2017 Update

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Northern pike (*Esox Lucius*) remain a substantial threat to native and endangered fishes in the Upper Colorado River Basin, because of presence in nearly all critical habitat reaches and adjacent areas. Mechanical removal, a known effective management technique for northern pike in the basin, was carried out during 2017 by Colorado Parks and Wildlife, Colorado State University Larval Fish Laboratory, U.S. Fish and Wildlife Service, and Utah Division of Wildlife Resources personnel in the Green, Yampa, and Colorado rivers. Sampling was accomplished with a variety of gears throughout the season, including boat electrofishing and gill, fyke, trammel, and other nets, both as specific, focused removal efforts and during other projects when pike were sampled incidentally. In the upper Green River, early and prolonged high flows from Flaming Gorge Dam supported a longer than normal reproductive season, especially in Browns Park National Wildlife Refuge and Dinosaur National Monument, and catch rates for young-of-year (YOY) northern pike increased substantially over previous years. Northern pike removal rates increased for tributary electrofishing and decreased for tributary netting at modest rates in middle Green River reaches. Catch rates generally declined throughout the Yampa River compared to 2016, with a moderate increase only near Steamboat Springs, the most upstream reach. High exploitation of northern pike in backwaters of the Yampa River indicated removal should be extended later into the season in 2018 as feasible. In the Colorado River mainstem, captures in the Silt-to-Debeque reach remained low, and catch rates in the Mamm Creek pond complex, a high-density northern pike habitat, declined substantially. Removal in 2018 should continue consistent with past efforts throughout the basin, and focus on mainstem reaches and backwaters known to hold high densities of northern pike during spring and early summer. Investigators should monitor overwinter survival of YOY northern pike in locations where increased 2017 production was noted, so removal efforts can be increased if needed.

